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CULTIVATION OF CHINESE PADDY RICE

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CHAPTER 1. DEVELOPMENT OF CHINESE PADDY RICE CULTIVATION AND GREAT ACHIEVEMENTS REALIZED SINCE LIBERATION

[p 1]

Agriculture is the basis of the national economy, and the development of agriculture must begin with grains. Among the grains, rice has the largest acreage in China, and its high unit yield makes it one of the most important grains. Therefore, the development of rice culture is extremely significant in the construction of socialism in China, in the promotion of the national economy, and in the improvement of the lives of the people.

China is one of the origins of rice plants. Currently, there are still wild-growing rice plants in Kwangtung, Yunnan, Taiwan, and some autonomous regions. For five thousand years, hundreds of millions of our hard working farmers have carried on their continuous struggle against nature. They have accumulated rich technical experience with regard to utilizing nature and improving nature for the cultivation of rice. A large number of varieties have been cultivated to suit the climate and the cultivation system of the various regions. Rice is planted all over China, from the lowlands around the lakes to some highlands in Yunnan, about 2,400 m above sea level. Wherever there is water there are rice paddies. Thus, in China, we have a variety of rice cultivating systems to form a good foundation for future development.

Before the liberation, due to the three-fold oppression of feudalism, imperialism, and bureaucracy, rice production, like all of our agriculture, suffered tremendously. Since the liberation, under the brilliant leadership of the Central Committee and Chairman Mao, the land reform and the agricultural cooperative movement have been accomplished, and on this basis, the people's communes have also become a reality. The victory of the social reforms in our rural villages unleashed productivity and raised the political

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consciousness of the farmers. Thence, we have had extensive development in agricultural sciences to open a pathway to a bright future for rice culture in China.

Since 1958, the party's three red flags of socialism: the general line, the great leap forward, and the people's communes are shining with ever increasing vigor. Works of all aspects of the national construction are leaping forward under the general line. The people's communes have marched onto a road of stability and healthy development. With respect to rice culture, the development of water conservation, deep plowing, and fertilizer accumulation have truly brought about the realization of the theory of "a culture system for each type of land," with obvious results of higher yields. New techniques and experiences have been continuously summarized by scientific research, and there have been improvements in the theoretical studies of the rules of maximum production. All the achievements point to a brilliant future of the modernization of rice production.

In this chapter, we shall give a brief description of rice production in China in the past thousands of years, the technique of its culture,and the tremendous achievements since the liberation.

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SECTION 1. BRIEF HISTORY OF THE DEVELOPMENT OF CULTIVATIONAL TECHNIQUES AND OUR NATIONS PADDY RICE PRODUCTION [p 2]

According to ancient literary records, as verified by ancient relics, paddy rice culture has had a history of more than 4,700 years in China. Ch'ing-ch'ung-p'ien /Chapter on Evalution/ of Kuan-tzu (about 700 B.C.), Tao-chi-p'ien /Chapter on the Fundamentals/ of Lu-chia Hsin-yu (between 300 and 200 B.C.), and Hsiu-fu-hsun /A treatise on economics/ of Huai-nan-tzu (200 B.C.) all recorded the fact that "the five grains" were planted at the time of Shen-nung (about 2,700 B.C.), and rice was listed as one of the five grains. At about 2,100 B.C., "China was covered with floods", and this deluge lasted 9 years. Our brave and hard working ancestors resolutely struggled with the deluge and finally they succeeded in dredging and clearing the nine rivers, and in the process, they utilized the low and wet lands for rice culture. This is the earliest record of our people's triumph in reforming and utilizing nature. The neolithic relics unearthed during the last several tens of years in the provinces of Honan, Hupei, Anwhei, Kiangsu, and Chekiang were discovered to contain rice grains. This discovery verified the authenticity of our ancient records.

At the time of Yin-shang (1,766-1,123 B.C.) rice occupied a definite position in agricultural production. The records in the language of Yin Dynasty unearthed in An-yang-Hsien, Honan /the oracle language of Yin-shang/ contained the word rice. There were also oracles predicting rice harvests. The folk songs (Shih-ching) of 2,500 to 3,000 years ago referred to "millet, rice, and kaoliang" as the farmers' delights, and the sentence "the good years have plenty of millet and rice" further proved that rice had become one of the important crops of that time. According to the record of Chou-li (300 B.C.) rice was distributed "in Yang-chou to the southeast, Chin-chou to the south, and Ch'ing-chou to the east; besides, it is also planted in Yu-chou, Tui-chou, Yu-cou, and Ping-chou." Thus, rice must have been widely planted in the valleys of Huang-ho and the Yangtze.

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During the thousand years from the Chou Dynasty to the first and second century B.C. more progress was made in rice culture. Chou-li recorded special officials who surpervised the planting of rice and the drainage of the paddies. At about the same time, there was a great reform in productive tools. Mencius mentioned "iron plows" together with metal cooking utensils; therefore, both must have been quite common at his time. The records and archaeological remains testified to the existence of such tools as the iron rake, plow, and cultivator. The development of production tools had raised agricultural production, which further improved productive technique. Kou-hsueh Chih /Hydrographical Records/ of Han-shu (after 100 A.D.) contained references to the irrigation system, and the design and management and even the long range plans of ultimate reconstruction of the large streams. Many large-sized water conservation structures were built during that period, such as the Yeh Dam of Hopei, the Cheng-kuo Dam of Shensi, and Tu-chiang Dike of Szechwan. Due to the improvement of the water conservation conditions, the production of rice became more dependable.

Meanwhile, the technique of rice culture was also improved. T'u-fang-ts'ao-jen of Chou-li, Yueh-ling of Li-chi, Ti-yuan of Kuan-tzu, and Jen-chien-hsun of Huai-nan-tzu all carried descriptions concerning the terrain, the humidity, the fertility, and the structure of the soil, the ground water positions, the vegetative cover, soil classification, soil improvement, and the varieties of rice suitable to each type of soil. The descriptions of rice cultivation methods may be found in the history books and the classics of the hundreds of years B.C., especially in Lu-shih Ts'un-ch'iu. The three chapters: Jen-ti, Pien-t'u, and Shen-shih of that book summarized the theories of that time concerning land leveling, deep plowing, fertilizer application, planting, cultivation, and weeding. Shen-shih chapter also gives a description of the method of differentiating good stands from bad ones. Besides, there was a discussion of climatic conditions and the relationship between timing and the growth and quality of grain plants. At that time, people already recognized the necessity of utilizing nature and of coordinating all farming activities with the seasons. With regard to natural calamities, Kuan-tzu pointed out in his Fei-ti-p'ien that all matters related to floods, wind storms, hail storms, and insect and disease damage were all natural calamities, yet were within the business of the state; that is,

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all measures concerning these matters are important politically and economically.

Throughout history the constant struggle against nature has caused our farmers to acquire very rich experience in transforming unfavorable natural conditions and in the cultivation of paddy rice. This rich experience is very useful to this day. For example, they built terraced fields on the slopes, diked fields on the deltas, and shelved fields on the lake or river swamps. They have special varieties of rice that are suitable for deep water. To meet the demands of different climatic and soil conditions, they created single season varieties, double and triple season varieties, biennial varieties, and many different systems of cultivation. They successfully bred many varieties of early and late rice in the various qualities of common, long-grain, and glutinous rice. In a word, throughout history, our laboring farmers kept abreast of many objective principles and summarized them into a rich rice culture which became our distinctively precious heritage.

There are many ancient authorities on the technique of rice culture. Aside from the ones we mentioned before, in the 6th century, Chia Shih-sai (6328 0013 7658) "gathered from all the classics, the folk songs, and the older farmers" (words from his preface) and wrote a theoretical summary of the experience of agricultural production and practice since the ancient times. His book, Ch'i-min Yao-shu, contained two chapters on rice culture, which dealt with the selection of soil, the leveling of land, seed treatment, planting and the amount to plant, cultivation, irrigation, harvest, and storage of rice. In Nan-sung, Ch'en Yung (7115 0516) wrote Nung-shu (1149 A.D.) in which he related the ways of storing water, treating the fields to stop leakage, cultivating to improve the seedlings, and irrigating techniques as practiced in the rice district of Chiang-nan /South of Yangtze/. During the Yuan Dynasty, Wang Chen (3769 4394) wrote Nung-shu (1313 A.D.) in which he described the rice seasons in Chiang-nan, and the methods of soaking the seedlings, cultivating, and fertilizing. The book, Nung-yeh She-yao (1314 A.D.) gave the important techniques of culture from planting to harvesting. In Ming Dynasty, in his book, Li-sheng Yu-ching Tao-p'in, Huang Sheng-tseng (7806 4164 2582) (early 16th century) described a great many varieties of rice. T'ien-kung K'ai-wu (early 17th century) related the experience of upland rice culture in the area of Hu-chou, Chekiang.

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In the beginning of the 19th century, in Ch'ing Dynasty, two books specializing in the technique of rice planting appeared. One was Wu Pang-ch'ing's (0702 6721 1987) Tse-nung Yao-lu (1824 A.D.) which summarized the experience of the time concerning timing, types of rice fields, rice varieties, land preparation, cultivation, fertilizer application, and rice storage. The other book was Li Yen-chang's (2621 1750 4545) Chiang-nan Ts'ui-keng K'o-tao Pien (1834 A.D.) which emphasized the early rice varieties and the method of growing two-season rice as practiced in the provinces south of Yang-tze. These books testify to the excellent tradition of intensive farming in rice culture in China. The following is a brief description of some of these books:

(1) Deep Plowing: Jen-ti-pien of Lu-shih Ts'un-ch'iu explained that deep plowing is the foundation of soil maturity, and encourages the elimination of weeds and insects for production increase. Ch'i-min Yao-shu pointed out that plowing in the autumn should be deep, but in the spring, it should be shallow. It further emphasized the fact that plowing should be done "as soon as the water drains off and the soil begins to turn white." If the plowing is delayed until the soil is dry, the soil is too hard for the plow. If the soil is too wet, it is too sticky for the plow. Plowing should be done in such a manner that it fully helps the maturation of the soil. In Nung-shu, Ch'en Yung (7115 0516) (1149 A.D.) pointed out that deep plowing in the fall and winter causes the soil to be loose. When the spring comes, the field is covered with weeds and grass; then, burning will cause the soil to be warm so that the seeds will sprout easily. Ma I-lung (7456 0001 7893) mentioned in his Nung Shuo (16th century A.D.) that if the soil is plowed to 9 ts'un, it is called deep plowing; if it is plowed to 3 ts'un, it is called shallow plowing. Ch'en-shih Nung-shu (early 17th century) pointed out that the deeply plowed soil holds water better, and preserves fertility better too. The root system of the plants may thus reach deep and far, and the stems are strong enough to withstand flood and drought, and they will not collapse easily.

(2) Transplantation: The method of transplanting rice is first seen recorded in Ch'i-min Yao-lu. Ch'en Yung (7115 0516) described in Nung-shu the methods of managing the seed bed and he emphasized the technique of irrigation and drainage during different types of weather. He also pointed out that the small seedlings like fresh water and that

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they dislike cold and still water; and if moss is allowed to grow in the seed bed, the seedlings will not do well. Wang Chen (3769 4394) in his Nung-shu (1313 A.D.) and Lu Ming-shan (7627 2494 0810) in his Nung-sang She-yao (1314 A.D.) recommended the methods of seed selection, soaking, and transplanting. Concerning the problem of planting the seedlings and the age of the seedlings at the time of transplantation, T'ien-kung K'ai-wu (1637 A.D.) pointed out that the seedlings are ready to be transplanted in 30 days. If the seedlings are too old at the time of transplantation, there will be fewer stands, and the heads will be small, and there will be fewer grains in each head. With regard to the density of the seedlings, Lu-shih Ts'un-ch'iu pointed out the relationship between growth, the straightness of the stands, and ventilation. Nung-sang She-yao pointed out that every four to five seedlings make a group, and every group should be planted about 5 to 6 ts'un apart. A person can only plant 6 groups before he has to move his position, and the lines must be straight to have best results. In Nung Shuo, Ma I-lung (7456 0001 7893) described the concrete method of planting seedlings, the density, and its relationship to soil fertility. He said that each mou may have 7,200 groups to more than 10,000 groups. If the soil is fertile, he said, the seedlings are planted densely, the yield may be double those fields which are planted sparsely.

(3) Cultivation: Cultivation was considered important long ago. In Jen-ti-pien of Lu-shih Ts'un-ch'iu, it is mentioned that "the good rice comes out first, then, comes the chaff. When the chaff is pulled out, the rice plants may grow." Apparently, at that time the technique of controlling undesired branches was already wellknown. Ch'i-min Yao-shu explained the method of weeding. In Nung-shu, Ch'en Yung (7115 0516) pointed out that cultivating is mainly to get rid of weeds, to loosen up the roots, to stir up the still water, and to prevent insects from growing near the rice plants. He also explained that cultivation and water drainage are to make the soil dry and warm. In order not to lose soil moisture, cultivation should be done from the higher areas to the lower areas. Ma I-lung (7456 0001 7893) explained that cultivation is mainly to stabilize the root system so that the roots will grow straight and deep to insure full heads. In his book Chih-pen T'i-kang, Yang Shan (2799 1472) (1747 A.D.) gave a very detailed description of how cultivation should be done.

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(4) Fertilizing: Hsun-tzu (2484 1311) said in his Fu-kuo-p'ien that "when the people are rich, the land is fertile, and the yield is high; when the people are poor, the land becomes barren and unproductive, and the yield is not even half of what it should be." We can see that the relationship between fertilizer application and high yield was recognized more than 2,000 years ago. Later, Fan-sheng-chih Shu (the later part of the 1st century B.C.) mentioned a method of cooking bones and animals and spraying the liquid on the fields. Kuo I-kung (6753 5030 1872) recorded the experience of planting Tecoma grandiflora in the rice fields to be used as green fertilizer in his book Kuang Chih (370 A.D.). Ch'i-min Yao-shu mentioned the fact that soil fertility varies from field to field and night soil should be used to add fertility to the soil. There was also a recommendation for the use of green fertilizer and crop rotation. By the 16th century, the basic principles of fertilizer application were known. In Wu-hsing Chang-ku Hsi, Hsu Hsien-chung (1776 3759 1813) (1560 A.D.) pointed out that "the night soil should not be applied too early. At the time of planting, silt from the bottom of the streams should be used to make a bed in the field. The fertilizing strength of silt is low but long lasting. In the summer, apply a small amount of ashes or residue from vegetable seed oil. Night soil should be applied after the beginning of autumn so that it may reach deep into the soil and not just to make the seedlings grow fast. If the land is not enriched by the silt at the beginning, then the later fertilizer will only cause the seedlings to grow tall but not cause the heads to be full of grains."

Ch'en-shih Nung-shu (early 17th century) emphasized "initial fertilizer" also. He also believed that it is after the beginning of autumn, when the initial fertilizer is all used up, that another fertilizer application should be added so that the plants will not turn yellow too fast." He also mentioned that when applying fertilizer in the fall, the color of the plants is a very important thing to watch. If too much fertilizer is applied there will be too much chaff; if too little fertilizer is applied the yield will not be good.

(5) Irrigation and Drainage: The earliest record of rice field irrigation appeared in Shih-ching. It says: "Pang-ch'ih flows northward and soaks up the rice fields there." Fan-sheng-chih Shu pointed out that when rice saplings are first planted, warmth is very important. The incoming water

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and the drainage must be on a straight line to preserve the warmth of the soil. In the summer, the flow should be diverted to reduce the temperature of the soil and keep the plants cool." Ch'imin Yao-shu has a discussion of the importance of timing in irrigation. Ch'en-shih Nung-shu emphasized the importance of exposing the fields to the sun. It quotes the old saying that "if the fields are not drained and sunned in June, don't blame fate if you have no rice to harvest." It is maintained that "this drainage of the field can cause the roots to reach deep and far, make the stems sturdy, and the heads full. Thus, the plants may withstand flood or drought." Ma I-lung (7456 0001 7893) mentioned in Nung Shuo that the rice blooms during the good weather days. It does not bloom when it rains. If the wind is strong, the plant may lose its flower, and there will be no heads. If the soil is too dry, the grains are few. If the soil is too wet, there will be black spots and the plant may become rotten. These books show the effect of moisture on the rice plants.

The above is only a preliminary summation of rice culture described in the ancient books of our country which exist today. This is by no means a full expression of the accumulated experience of thousands of years. However, the brief description above suffices to show that in the long process of production practice, our farmers struggled against heaven and earth and developed a very firm foundation of rice culture.

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SECTION 2. GREAT ACHIEVEMENTS IN OUR NATION'S PADDY RICE PRODUCTION SINCE LIBERATION

[p 5]

Since the liberation, the party and the government made the recovery and the development of rice production one of the important jobs in agriculture. A series of essential measures was adopted. Through the persistent leadership of the party and the diligent labor of the masses, brilliant achievements have been made in the last ten years. Both the acreage and the unit productivity have grown a great deal.

The recovery and the development of rice culture during the last ten years may be generally divided into three stages:

The first stage lasted from the birth of the country in 1949 to the year 1952. This was a period of recovery for our national economy. In the short three years, the land reform was completed, and agriculture production was put quickly on its way to recovery. In June of 1950, the party proclaimed "The Land Reform Law of the People's Republic of China" which led the farmers in the popular land reform movement. The feudal exploitation was thoroughly eliminated and the productivity of the rural villages was thus released. The farming masses became the owners of the land, and there was a general passion for production. Meanwhile, timely policies for the promotion of agricultural production were adopted by the party. The great farming masses were organized for the recovery and the development of agricultural production.

At the same time, a series of projects were undertaken by the party and the goverment to promote rice production. The masses were called upon to construct and to repair water conservation installations. Irrigation management was strengthened to reduce flood and drought damage. Old farm tools were repaired, and new ones added.

Aside from searching for more sources of organic fertilizer, the use of chemical fertilizer was increased every year. There was a movement to popularize the better varieties of rice seeds. The masses were asked to judge and to select the varieties of rice, and the scientific research

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agencies were also called upon to help with the selection and recommendation. Tools, medicine, and insecitides were supplied to control rice diseases and insects, and the preventive technique was steadily improved. The serious damage from insects and diseases was greatly reduced.

The party and the government also led the masses to hold many contests for higher production. There were efforts to improve the productive technique, to summarize experience, and to recommend advanced methods.

In Kiangsu, there was Ch'en Yung-k'ang (7115 3057 1660) whose dense planting method for his small saplings of "I-süi-ch'uan" was judged as a model of high yield practice. In Hunan, Li Ch'eng-kuei (2621 0701 2710) presented many advanced procedures of fertilizer application and irrigation. All of these achievements contributed to the increased rice production of the nation.

Due to the adoption of many effective measures, a great change occurred in our country's rice production. In the process of recovery in the short period of three years, there was a 14% increase in rice acreage, and 27.4% increase in unit production. The total production increase was 40.7%.

The second stage lasted from 1953 to 1957. This was the period of the first five-year plan for the development of the national economy. On the basis of the triumphant completion of the land reform, the central party and Chairman Mao proposed a general line for the transitional period. A procedure was formulated for the gradual realization of the socialist reforms in agriculture, handicraft industry, and the capitalist commerce and industries. In February of 1953, the party proclaimed a "Resolution concerning the Cooperative production of agriculture." In December of the same year, "A Resolution for the development of the Agricultural Cooperatives" was again proclaimed. Then, there were established a large number of year-long cooperative groups and preliminary farm cooperatives.

In the later part of 1955, another high tide of socialist revolution swept the rural villages. The preliminary farm cooperatives developed into the mature type of truly socialist agricultural cooperatives, which quickly promoted agricultural production.

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In January 1956, based upon the suggestion of Chairman Mao, the central committee proposed "A Draft Resolution for the Development of National Agriculture from 1956 to 1967," which encouraged the productive initiative of the masses, and large scale water conservation construction and a mass movement of fertilizer accumulation and production were launched. At the same time, there was a nation-wide reform in the system of rice culture. Single-season rice was changed to double-season rice, alternate rice crops were changed into continuous crops, common rice varieties were changed to long-grains, and many upland fields were turned into paddies. The success of these programs was tremendous. In 1956, the acreage that was turned from single to double crops amounted to 49.3% of the total acreage of the double crop rice fields of the days before the liberation.

The provinces of Szechwan, Anhwei, Hupei, and Kiangsu of the Yangtze Valley were originally single rice crop regions. Through these programs, large areas of double rice crops had been created in these provinces. In the provinces of Hupei, Kiangsu, Chekiang, and Anhwei, many areas of common rice varieties had turned to growing long-grain varieties. In the North, many of the meadow wasteland the marches, and the saline and soda soils had been used as rice paddies. All these projects proved that if the reformed system of cultivation was adopted to suit the local conditions, enlarging the rice acreage and increasing the number of rice crops are very effective means for the full utilization of our country's superior natural conditions.

During this period, the party and the government proceeded with large scale construction for water conservation, and with the establishment of plants for the manufacturing of chemical fertilizer and drugs for agricultural use. Measures were also taken to popularize the use of new farm tools such as the double-wheeled plow. Reasonable policies of taxation and price structure were adopted, and there was a series of economic policies such as rural loans and agricultural investments which supported the growth of rice production.

By 1957, rice acreage had increased 13.6% over 1952. The unit production was 8.7% higher. The total production was 26.9% higher. The achievements in rice production are largely responsible for the completion of the food production section of the first five-year plan ahead of schedule.

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The third stage began in 1958, when the great leap forward of agricultural production began. Through the Cheng-feng movement, a socialist victory was won on the political and ideological front. In the spring of 1958, the Second Conference of the Eighth National Congress of the Communist Party resolved "to exert all efforts to construct socialism more, better, and faster." With this general line, and a complete set of goals, the party resolved to extinguish superstition, to liberate ideas, and to enliven the spirit of communism in the bravery of thoughts, words, and deeds. Thus opened a new period of great leap forward of socialist construction. Under such a condition, rural communes were established throughout the nation in the later part of 1958.

With respect to rice production, the leaders of various ranks moved into production under the direction of the party with three way cooperation among the leadership, the technical staff, and the farming masses. With unprecedent vigor, the people moved to reform and to revolutionize farming techniques. There were many projects of experimental farms and high-yield fields. Although the many provinces and autonomous regions of the Yangtze Valley suffered a serious drought in 1959, and in 1960, there was a natural calamity all over the country, the people's communes demonstrated a tremendous power of production, superior to that of the farm cooperatives. The rice producing regions carried out many projects of basic construction, technical improvements, and mechanized farming, regardless of the natural calamities. The total production of rice was maintained at the level of 1957, and in some areas harvests were even better than that level.

2. ACHIEVEMENTS IN IMPLEMENTATION OF THE "EIGHT CHARACTER CONSTITUTION" IN AGRICULTURE TO DEVELOP THE SCIENCE AND THEORY OF CULTIVATION [p 8]

The party always emphasized technical reform and the development of scientific research work. At first, on the basis of the victory of the land reform, the party and the government led the people to push many measures to increase production. At the same time, the masses were directed to summarize experience. The draft resolution for agriculture from 1956 to 1967 specifically mentioned water conservation,

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construction, fertilizer increase, reform of farm tools and the introduction of new tools, the adoption of better seed varieties, the enlargement of acreage, the cultivation of high-yield crops, the practice of intensive farming, the improvement of cultivating methods, and the elimination of insects and plant diseases. In 1958, for the great leap forward of agricultural production, Chairman Mao proposed an eight-word constitution for agriculture: soil, fertilizer, water, seed, density, protection, management, and labor. With this constitution, Chairman Mao urged the masses to summarize the advanced experience of our farmers and the successful research works of our scientists, and a technical reform movement in rice culture was launched.

The agricultural research agencies and the agricultural colleges seriously carried out the party's directive of "combining theory with practice and making science serve production." Many scientific workers were organized to establish bases in the farm villages and to work in scientific projects with the masses. On the basis of the eight-word constitution, they experimented with large acreage of high-yield rice crops and gave theoretical verification to experience. Many of the basic problems of rice culture were studied. The following is a brief description of their achivements:

Concerning soil improvement, there was the mass project for national soil survey. In the various rice producing regions, the rich experience of our farmers regarding soil improvement of the rice fields was summarized. Brigade by brigade, commune by commune, soil utilization regulations were formulated, and on the basis of the soil survey, a mass movement of deep plowing for soil improvement was launched. At present, most of the rice fields are plowed 2 to 3 ts'un deeper. Deep plowing combined with the application of organic fertilizer caused the soil to hold moisture and fertility better, and thus created a condition for high yield. In the north, paddy rice was planted for the improvement of saline and soda soils. In the south, all the cold, heavy, clay soils were plowed and turned, and organic fertilizer was applied. In some cases, soils of a different region were brought over and mixed into the clay. Obvious results were obtained from all these projects.

The masses were encouraged to raise pigs, plant legumes, and to open up other sources of organic fertilizer. In addition, every year the state's supply of chemical

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fertilizer grew larger. Thus, the fertilizer applied to the rice fields was continuously increased.

It was decided that the application of fertilizer should primarily be organic fertilizer. It should then be supplemented by inorganic fertilizer and combined with deep plowing so as to continuously increase the productivity of the soil. This theory, and our farmers' historical experience of differentiating the soil, the climate, the seedlings and the fertilizer brought the technique of fertilizer application in rice culture to a new height.

The studies resulted in a clear differentiation of three stages of fertilizer application: the initial stage, the branching stage, and the heading stage. The growth period of the early rice is short, therefore, the initial fertilizer application should be of primary concern. The second important application for all types of rice is at the time when the heads begin to appear, because this is the time when the rice plants need more nutrients. However, in the humid and warm south, the organic fertilizer dissolves fast; therefore, it is very important that fertilizer should be applied in various stages. For the early rice, the temperature is low during the planting season, and the initial fertilizer takes longer to dissolve, and the second application is needed when the stands begin to divide.

In the matter of irrigation and drainage, many large, medium, and small water conservation constructions were built in the various areas to guarantee the increase of rice acreage. In 1950, there was a national exhibition of superior local varieties. Scientific research in selection and hybridization followed. The same program was carried out in each province. Tests and experiments were conducted on local seeds, seeds from other provinces and from abroad to find the varieties best suited to the local climate, soil, daylight, and other natural conditions.

Through the scientific experiments, many new rules were discovered. The amount of water needed by the rice fields of the various parts of the country was discovered and established to form a better irrigation technique. It was also discovered that southern varieties when transplanted to the north often did not have enough time to head or to ripen due to the short summer season.

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In many areas, rice was planted in rows more than one ch'ih apart, while only five to six thousand groups may be planted in one mou, with each group having 10 to 20 seedlings. This practice limited the amount of production. After the liberation, it was decided that experiments on reasonably dense planting should be conducted. At present, the average practice is twenty to thirty thousand groups per mou. Seedlings per mou were increased from about ten thousand in the past to twenty or thirty thousand. These experiments have proved that beyond certain levels the seedlings that are planted too close together will have adverse effect on the number of branches. Therefore, a reasonable density is a reasonable arrangement between the individual and the colony of plants, and this arrangement must be made on the basis of the local conditions, the soil fertility, and the characteristics of the special variety, so that the individual plant may have room for healthy growth while the colony may have maximum development.

With regard to the problem of rotten seedlings in the early seed beds, it has been discovered that the problem is largely due to rain and low temperature, and if instead of planting the seeds in the paddies, they are planted in damp seed beds, and ashes mixed with grass and night soil are used to cover the seeds, this problem may be successfully overcome. It has also been discovered that early planting is likely to result in higher yields for all the varieties of rice, if the above measures of protection are taken. At present, the planting period is moved up 10 to 15 days earlier than was the practice in the past.

Instead of using one type of drug to treat rice diseases and insects, at present, the practice is a combination of seed selection, planting technique, and drugs. In some areas, the fields are turned early, and the old roots are pulled out and burned to control rice borers. The 10% rice borer damage before the liberation has been brought down to about 2%. It has also been discovered that the weeds around the edge of the fields and furrows are the usual overwintering place for the beetles and weevils. An organic phosphorus compound, Ti-pai-ch'ung, which is relatively safe for man and domestic animals has been made to keep these insects under control.

For controlling rice diseases, the present practice is to select disease resistant varieties and to apply fertilizer and water reasonably so as to grow strong plants. On

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the other hand, sometimes, the seeds are disinfected with 0.1% organic mercury or 0.05% lime solutions. At present, rice diseases are basically under control throughout the country.

Now, field management always begins as early as possible. In the seed beds the seed beds the seedlings are protected against bad weather and decomposition. Before transplantation, the field is prepared properly with deep plowing and fertilizer application so as to make the soil mature. Then, the seedlings are planted in reasonable density at a suitable time. With subsequent fertilizer application and frequent irrigation with a small amount of water, the field is drained and sunned on time to promote strong roots and stems. From planting, transplanting, branching, heading, and fertilizing, to harvest, the rice plants are given protection and care so as to obtain the goal of high yield.

In the past, the work of the rice paddies was all done manually with very simple tools. Since the liberation, especially since the great leap forward, many types of machines have been adopted and created. For example, the transplanting machine, which is automatic yet of simple structure, is being popularized in several styles, among which the Li-ling, Hunan A-2, Kiangsi 59, and the South 105B are considered the best. The rope tractor may be operated by man, animal, or electricity and may be used for plowing, leveling, or planting. It is light, yet very efficient. The tractors used in Kiangsi, Kwang-tung, and Chekiang have leaf-like, or ball-like cogged wheels, and they have been successfully tested in the paddies. Besides, there are also internal combustion turbines, the hydraulic turbines, and the mechanized sprayers. The creation and manufacturing of these machines will make the mechanization of rice culture a reality in the near future.

The theoretical studies of agricultural sciences must be based upon the development of agricultural production. Through a summation of the rich experience of the masses, the agricultural scientists studied and solved many key problems of production. For example, they demonstrated the fact that density is not a simple problem of how dense the plants are planted. On the contrary, it must be studied on the basis of the individual versus the colony, and it is related to the growth regulations and harmony of every stage of the plant's life. A theory of dense planting for high yield has been coordinated with proper planting and management practices as a result of numerous experiments. The so-called "reasonable structure of the colony" actually means a set of objective rules which reflects in the growth of the plants to bring about maximum yield under certain conditions. When these objective rules are mastered, we begin

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to have a definite goal in our effort for high yield as well as a reliable pathway to that goal.

Through the summation and the study of the experience of the masses, we begin to understand the relationship of mutual promotion and control among the various parts of the plant body. The contradiction and unity and the division of labor among the various organs are thoroughly understood and are made to be the center theme of the high yield cultivation program. The "eight-word agricultural constitution" broke the past tradition of considering agriculture as many single and unrelated jobs, and pointed out a new direction of scientific development. The "constitution" induced the people to study the comprehensive rules of the objective reality and to manifest their own subjective initiative with a positive program for reforming nature instead of taking the passive position of "waiting for the blessings of nature" as they did in the past. The people are thus urged to struggle continuously for the high yield of rice and for the modernization of rice culture.

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CHAPTER 2. ORIGIN AND EVOLUTION OF PADDY RICE CULTIVATION IN CHINA

[p 13]

There are many types of wild-grown and cultivated rice varieties. Especially in China, the rice culture has had thousands of years of history, and covers a wide region of varied environment conditions. Through natural selection and human effort, many varieties of rice appeared to adjust to the different geographical zones, the different seasonal variations, and the different needs. We attempt to describe systematically in the following the long process of development of the various types of common rice, long-grains, early and late varieties, paddy rice and upland rice, and the glutinous varieties, so as to clarify the relationship between the cultivated varieties and the wild-grown varieties, and to offer some theoretical basis for the technical measures of selection and cultivation.

SECTION 1. ORIGIN OF PADDY RICE CULTIVATION [p 13]

1. CULTIVATED PADDY RICE AND WILD PADDY RICE [p 13]

Rice began with the wild-grown varieties. Our ancient books have many references of the naturally grown or the wild-grown rice varieties. Hsu Shen (6079 1957) included the word "ni" in his book, Shuo-wen (121 B.C.); and Chang I's (1728 2253) Pi-ts'ang (about 227 to 232 A.D.) included the word "lu."; Lu Ch'en (0712 1820) included the word "ts'u" in his book, Tzu-lin (419 B.C.) The three words all mean rice which falls in one year and grows up again the next, but are different from the rice which is wild-grown. In Wu-shu of San-kuo-chih there is the following reference. "In the third year of Huang-lung (231 A.D.) wild rice grew up by itself in Ch'uan-hsien (the area of today's Chia-hsing), it was therefore renamed Ho-hsing Hsien. In Fu-shui-chih of Sung-shu, it was reported that "in the 23rd year of Yuan-chia (446 A.D.)

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more than thirty different kinds of wild rice grew up by themselves in Chia-hsing Hsien of Wu-chun. The history of the 11th century has more than ten reports of the growth of wild rice or lu rice in the present area of T'ai-hu, Hsu-chou, and Ts'ang-chou. However, these reports were meant to be records of strange incidents, and therefore, cannot be used as the basis of the theory that rice originated in the Huang-ho or the Yangtze Valleys. Besides, to this day wild-grown rice is still seen in the valley of Pearl River.

The earliest and the most accurate record of wild-grown rice in our country is found in Shan-hai-ching which was written during the Period of the Warring States (207 B.C.). In the chapter of Hai-nei-ching of that book, it was stated: "In the southwest between the black waters, in the wilderness of Yu-tu, there grows smooth and starchy rice. It grows in the valleys by itself and spreads out during the summer and the winter." In 1917, E.D. Merrill discovered truly wild-grown rice at the piedmont of Lo-fou-shan in Kwangtung. In 1926, Ting Ying (0002 3379) also discovered wild-grown rice in the marshes east of Canton. Later, similar discoveries were also made in Hui-yang, Tseng-ch'eng, Ch'ing-yuan, and San-shui; then to the southwest in K'ai-ping, Yang-chiang, Wu-ch'uan; and to the south through Lei-chou to Hai-nan-tao. Wild-grown rice was also seen in Kwangsi in the valley of the West River. It was also seen in Taiwan, and the local people, just like the people of San-shui and Yang-chiang, call wild-grown rice the "ghost grains." These facts offered strong verification to the authenticity of Shan-hai-ching. In his book the Origin of Cultivated Plants, A. De Candolle (1884) also estimated that there should still be wild-grown rice in China, and confirmed the fact that in the southern part of Asia, from China westward to India, rice existed earlier than any other crop plants.

Aside from the fact that these wild-grown rice varieties grew up naturally in the marshes, the stems spread out, the pollens are often not completely developed, and the heads are few and easily fall out, these varieties are quite similar to the cultivated varieties of common rice. They are also easily hybridized with the latter. Therefore, we may assume that the two types are very close genetically.

All the varieties of wild-grown rice found in the vicinity of Canton and the various areas of South China grow in the deeper marshes. The stems lie flat in the water, and branch out from every node. These are perennial plants, and if transplanted into the paddies, they grow more like

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herbaceous weeds, and the same ones found in India are called O. perennis Moench.

There is another kind morphologically closer to the cultivated rice, and may be positively identified as the direct forerunner of the latter. This is called O. sativa var. fatua Prain in India, while R.J. Roschevicz called it O.sativa L.f. spontanea after he compared the various types of wild-grown rice found all over the world. Ting Ying (0002 3379) experimented with the hybridization of the wild-grown varieties and obtained three different types: the flat stemmed, the bushy stemmed, and the straight standing stemmed. All three types are observed in South China among the wild-grown rice varieties. There is a variety of cultivated rice called "Pu-kuei-chia", with stems lying flat in the water. Its heads are usually full of grains, but very easily fall. There is another variety called "Shen-shui-lien," the heads of which do not fall easily. "Sheng-hsu-ku" is another variety which grows straight in shallow water. All the three may be easily recognized as the products of the wild-grown varieties after many stages of development, and many years of human selection and cultivation. Thus, we are fairly certain that the annual varieties of wild-grown rice, widely distributed in South China are the wild-grown species of the cultivated varieties in our country.

Aside from the common varieties of wild-grown rice described above, there are also two species which belong to the genus Oryza (Rice); they are O.Meyeriana Baill and O.officinalis Wall. The former is an upland variety, with irregular nodes on the shell of the grain. It has been discovered in Taiwan and Hai-nan-tao. The type found in Szu-mao-hsien, Yunnan, in 1958, has also been identified as belonging to this species. The latter is used as a medicine. It has short and large leaves, and especially long stems (some as long as 83cm). It grows in the damp areas of the mountains. It was discovered in the Autonomous Region of Chuang Nationality in Kwangsi in 1954; and in Yu-lin-hsien, Kwangsi; and in Ying-te-hsien, Kwangtung in 1960. The morphology of these two varieties is very different from the cultivated varieties in China. We can scarcely say that there is any relationship at all.

Judging from the information we briefly stated, the distribution of wild-grown rice includes the region of South China from Taiwan in the east to the southwestern part of Yunnan in the west, north of the tropic of Cancer in the

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north, and the southern tip of Hai-nan-tao in the south. In this vast area, there are perhaps many more varieties of wild-grown rice than the ones we have mentioned. We need more extensive surveys to verify this assumption.

2. ORIGIN OF PADDY RICE CULTIVATION IN CHINA [p 16]

In may ways, our ancient books concretely reflect the development of agricultural production in ancient times. The more important ones, such as Ch'ing-ch'ung-fu-pien of Kuan-tzu (about the 7th century B.C.), Tao-chi-pien of Lu-chia Hsin-yu (195 B.C.), and Hsiu-fu-hsun of Huai-nan-tzu (122 B.C.) all mentioned the planting of the five grains. According to Chu-shu Chi-nien, rice culture obviously began at about 2700 B.C. in the age of Shen-nung (A social system of the clans). This fact makes China the oldest rice cultivating country in the world.

Szu-ma Ch'ien's (0674 7456 6692) Shih-chi (145-86 B.C.) which is generally considered as reliable history, stated that Huang-ti Yu-hsiung-shih (about 26th century B.C.) planted the five grains. It also mentioned that after Hsia-yu (about 21st century B.C.) dredged the nine rivers, he had Hou-chi and Pai-i help him to give rice seeds to the farmers and help them to plant the seeds in the low and damp areas.

The relic of the late Yin-shang period (about 14th to 12th century B.C.) which was discovered in An-yang-hsien, and from which the Shang oracle bones were found, contained the word "rice". (Some people believe that the word is neither tao which means cultivated rice, nor ni which means naturally grown rice.) However, it is also very obvious that people of that time knew the technique of digging irrigation ditches and bringing water to their fields, therefore, there must have been rice culture of a certain degree of development.

At the time of Chou Dynasty (1,122 to 249 B.C.) there had been a considerable amount of rice paddies in the Huang-ho Valley. The most reliable of the classics, Shih-ching contained many folk songs with descriptions concerning rice. The scripts on the bronze vessels of Chou Dynasty mentioned rice as a good food for travelers.

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During the period of Ch'un-chiu and Chan-kuo (722 to 221 B.C.) more progress was made in the irrigation of the rice fields. Judging from the aforementioned facts, we may safely assume that in China rice culture began about 4,700 years ago in the period of Shen-nung. It was more developed in the period of Hsi-yu, which was about 4,000 years ago. At the time of the Chou Dynasty, about 2,200 years ago, rice was being cultivated very extensively in the Huang-ho Valley.

Although the ancient books we mentioned before only reflected the legend of a nation, the archaeological discoveries of the last thirty years in the Huang-ho and the Yangtze Valleys strongly verified the authenticity of these so-called legends. The neolithic culture discovered in 1921 in Yang-shao Ts'un, Min-ch'ih Hsien, Honan Province contained imprints of rice plants and grains. The absolute age of this culture was considered to be around 2,000 B.C. In 1955, burnt rice grains were found in other neolithic cultures in Ling-pi-hsien, Honan and Hao-ch'eng-chen. From 1955 to 1958, the Institute of Archeology of Academia Sinica discovered a large amount of outer seed-coats of rice in such places as Ch'iu-chia-ling, Shih-chia-ho, and Fang-ying-t'ai of the Yangtze Valley. A close examination showed that these grains were the wide oval-shaped long-grains and these plants had long spikelets.

Early in 1953, outer-coats of rice grains were found in Hsien-li-teng, Wu-hsi, Kiangsu; in Ta-ch'en-teng, Fei-tung-hsien, Anhwei; in Miao-shan, Nanking; in Ch'ien-shan-Yang, Wu-hsing-hsien, Chekiang; and in Shui-t'ien-pan, Hongchow.

Besides, the red potteries of the neolithic relics of Kuan-tu and Shih-sai-shan in Yunan had imprints of shells and spikelets of rice, and a chunk of rice grains with spikelets on them was found in a pottery vase among the relics of an age when bronze and stone instruments were both being used, in Hai-men, Chao-ch'uan-hsien.

The age of the neolithic culture of Huang-ho and Yangtze valleys is not yet certain. However, research and exeavation of such areas as Pan-p'u, Hsi-an, and San-li-ch'iao, Shen-hsien showed that red potteries were the most special characteristic of this culture which was stratigraphically below the Yang-shao Culture, with the Lung-shan Culture which distinguished itself by gray and black potteries in between the two, and the bronze culture of Ying-chou on the very top. Therefore, the absolute age of the former is perhaps before

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the Hsia Dynasty.

In Yangtze Valley the relics of Miao-shan and Hsien-li-teng corresponded with the Yang-shao Culture of the Huang-ho Valley stragraphically, and were below the Lung-shan Culture of Kiang-huai. The remains of rice grains have also been found in the potteries with geometric designs in Fukien and Kwangtung, in the areas of the lower reaches of the Yangtze. These facts showed that the area of the Yangtze was the crossroads of the cultures of the north and the south during the prehistorical periods. It was here that rice culture had the opportunity of being popularized throughout the continent. It appeared that rice culture was more popular in the Yangtze valley and possibly began earlier than the Huang-ho Valley. Neolithic culture containing the remains of rice grains has not been discovered in the valley of the Pearl River. Future excavations should look for the signs of them carefully.

3. PROPAGATION OF PADDY RICE CULTIVATION IN CHINA [p 20]

According to ancient books, wild-grown rice was distributed in the valley of the Pearl River, and judging from the characteristics of the cultivated varieties of today, we may safely assume that rice culture spread from the south to the north. This assumption is also somewhat supported from a study of the present day languages of the various nationalities of the south and the north.

The character tao has the character ho (meaning that rice belongs to the grain family) on the left side and the character tao on the right to indicate the sound. The ancient Chinese sound of the character tao /rice/ was dau, tao, tau, or tu. Around 1,750 B.C. the people of Nan-hai called rice hao (at the time of I Yin (0122 1438), as recorded in Shuowen). Today, the people of T'ien-o-hsien and other places of the Autnomous Region of the Chuang Nationality also call rice hao. The people in Tien-yang-hsien call it ho and those of Pai-she call it hou. The people of the T'ai Nationality of Yunnan call it hao also, while the people along the coast in Kwangtung and Fukien call it deu or teu. It is obvious that the word for rice is pronounced very similarly all over the country. Therefore, we may assume that the pronounciation and the character of tao spread to the north from the south with the rice plant.

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Judging from the characteristics and classification of the rice plants, the common and the long-grain varieties of both the north and the south belong to the same species of Oryza sativa L. and all of them are capable of growing in the high temperature zone with short daylight periods. This fact indicates that all these varieties preserve the tropical characteristics of their ancestors.

There are three origins of rice culture in the world: the first is the Chinese system. According to related research the Chinese rice culture was spread to Japan in the first or the second century B. C. While as early as 1,000 B.C. the technique of cultivating rice was brought southward from China to the Philippines. The second is the Indian system. It spread from India in the 10th century B.C. through Iran to Babylon, and from there to Europe and Atrica; and when the new continent was discovered, to America. The words for rice of all these countries belong to the same sound system, such as Arishi, Oryza, and Rice. The third is the South Sea Islands. Rice was planted in Java, Indonesia in 1,084 B.C. while the technique of rice culture and the language of this field developed about 1,000 B.C. and were brought over by the Austronesian Tribe from the mainland. This is how the language system for rice such as Padi and Bvas was formed.

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SECTION 2. EVOLUTION OF THE UPLAND NON-GLUTINOUS AND LONG GRAIN NON-GLUTINOUS RICE VARIETIES

[p 21]

Judging from the origin and the process of development of the last several thousand years, the most significant rice products are the common and the long-grain. Geographically speaking, the different varieties were formed by the different climatic conditions (mainly temperature) of the various regions.

1. DIFFERENCES BETWEEN THE UPLAND NON-GLUTINOUS AND LONG GRAIN NON-GLUTINOUS RICE [p 21]

In China, the distinction between the varieties of rice was notice in ancient times. More than 1,800 years ago, Hsu Shen (6079 1957) made a distinction between the two major types of rice, the sticky and the non-sticky in his Shuo-wen, that is the common varieties (the hsien and the lien) are the non-sticky ones and the long-grains (the hang and the keng) are the sticky ones. Besides, ancient books often mentioned the difference in fragrance, the length of the growing periods, the length of the heads, the existence of the spikelets, and the size and the shape of the grains. Of course, judging from the difference of the common varieties and the long-grains, there are also differences in the size, the length, the texture, and the color of the leaves, the size, length, and texture of the stems, the size and the shape of the heads, and the length and density of the spikelets. The grains of the common varieties absorb less water than the long-grains. Then, the varieties are also different in the speed of sprouting and growth, in their tolerance of fertilizer and cold temperature as well as in their resistance against rice diseases.

In modern times, Kato and co-workers first classified rice according to its grain production and its serum reaction. He called the long-grains O.sativa L. subsp. japonica Kato and the common rice, O.sativa L.subsp. indica Kato. These names he gave are not really in keeping with the origin and development of rice culture as we have just described. Of course, at that time, Kato did not seem to be

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informed of the fact that the Japanese type of rice plants was introduced from China; neither did he know that rice plants were classified into the two large types of common and long-grain in Ancient China. Based upon the actual condition of the varieties of paddy rice in our country, we named the common varieties as O.sativa L. subsp. hsien Ting and the long-grains as O.sativa L. subsp. keng Ting.

2. DISTRIBUTION OF UPLAND NON-GLUTINOUS AND LONG GRAIN NON-GLUTINOUS RICE [p 22]

As we have mentioned before, the long-grains were distributed in large quantities in the Yang-tze Valley during the prehistoric ages. During the few hundred years B.C. the rice varieties of the Huang-ho Valley were primarily long-grain also, and it was long-grain that was introduced into Japan. In 1953, a Han tomb was dug up in the suburb of Lo-yang-shih (32 to 6 B.C.), and rice grains were found in the tomb. These rice grains were found to be long-grains. However, it appeared that there were already two types of rice at that time, such as mentioned in Shuo-wen. Yang-tzu Fang-yen stated that "in Chiang-nan people call long-grains common rice." The books of Wei and Chin Dynasties (220 to 427 A.D.) sometimes included long-grains in the common rice varieties (as Kuang-ya) and in other times long-grain may be directly called common rice (such as Sheng-lei). These facts indicated that at that time common rice /hsien tao/ were very important varieties in Chiang-nan.

In the fourth year of Ta-chung Hsiang-wu of Sung Dynasty (1011 A.D.) 30,000 hu /each hu is five to ten pecks/ of rice were shipped from Fukien to Chekiang and Kiang-huai as seeds. They were planted in the higher and dryer fields and since then there were more fields with early ripening common rice north of Kiang-huai.

Before the liberation, the common rice varieties were found from Han-chung to Shen-pei in Shensi, from Huai-ho to the north of Huang-ho in Honan, and from Hai-ho to Cho Hsien in Hopei. However, due to reasons of geographical environment and the adaptability of the plants, in the vast area from Huang-ho Valley to the highlands of Yunnan and Kwei-chow and the northwestern part of Kwangsi, long-grain is still the primary subspecies, with only very little common rice distributed. Other areas, such as the more fertile fields in Huai-nan, T'ai-hu, the mountainous regions of Hunan, Kwangtung

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Fukien, and Kiangsi, and the tropical regions of Hainan and Taiwan, with elevations from 500 to 2,000 m, are generally long-grain areas.

More than 1,000 varieties of the long-grain subspecies have been collected in the areas west of Ch'ien-chiang in Kwangsi, and more than 2,000 varieties of that subspecies have been collected in Yunnan. The abundance of these regions apparently surpasses that of the provinces in the Yangtze Valley.

Aside from a few individual regions such as Hainan, Kiangsu, Chekiang, and Taiwan, the plains of Central and South China produced mainly the common rice varieties before the liberation except for a small quantity of the glutinous varieties which belong to the long-grain subspecies. To the south beyond the border, there is only a small quantity of long-grains from Vietnam to Java near the equator. However, we must point out that aside from the regional characteristics of the two subspecies and their adaptability, due to the special characteristic of a special variety, the productive demands of the local people, and the difference in the planting techniques, the common rice varieties may also be distributed in the northern part of the North Temperate Zone, while the long-grains may also be distributed in the tropical plains.

3. EVOLUTION OF UPLAND NON-GLUTINOUS AND LONG GRAIN NON-GLUTINOUS RICE [p 23]

The common rice has the characteristics of resisting dampness, heat, and intensive light. Its grains are not very sticky, shaped thinner and longer, with smoother outer covering, and rougher leaves. All these make it morphologically similar to the wild-grown varieties. Therefore, we may assume that it was the first product of human cultivation from the wild-grown rice. That is to say the common rice is the basic type of the cultivated rice.

The long-grains are mainly distributed in the higher grounds in South China, in the region of T'ai-hu, in the cooler and lower areas north of Huai-ho, and in the highlands of Yunnan and Kweichow. It is more drought resistant, and can withstand lower temperature with less light. The grains are more sticky, shaped shorter and larger, with more spikelets and smooth leaves. It is different from the wild-grown varieties. It is very possible that when certain

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particular varieties of the common rice or the wild-grown rice after being cultivated and selected by man under a special environmental condition (mainly temperature), gradually changed into these varieties. This assumption is clearly verified by the vertical distribution of these two subspecies in the highland regions.

According to a survey conducted by the Yunnan Provincial Institute of Agricultural Sciences, the year's mean temperature of the area of the common rice averages above 17°C and that of the area of the long-grain averages below 16°C. Judging from the vertical distribution of the two subspecies, the areas below 1,750 m elevation are common rice zones, while the areas of 1,750 m to 2,000 m are transitional. The areas from 2,000 m up are long-grain zones. There are also exceptions. All the common rice varieties in Yunnan are called T'ao-ku or Pai-ku to mean that the grains fall very easily. This characteristic of the two subspecies is similar to the varieties distributed in the Huang-ho and the Yangtze Valleys. However, special varieties, such as that of the Autonomous Region of the T'ai Nationality in west of Yunnan have grains that do not fall easily.

The vertical distribution of the two subspecies in Kweichow is similar to that of Yunnan. The area below 1,400 m is common rice zone, from 1,400 to 1,600 m is the transitional, and from 1,600 up is the long-grain zone. There is very little common rice in this province (according to the information of Kweichow crop products of 1959). The long-grain plants of the highlands of the southwest part of the province are taller, with longer and wider leaves, which are in lighter color. The grains of this varieties are not very starchy, and are somewhat different from the long-grains of T'ai-hu and the areas north of Huang-ho. It is sometimes called the highland long-grain.

According to the observation of the Yunnan Provincial Institute of Agricultural Sciences, the rice varieties of the transitional zones are very complicated. It is difficult to distinguish the two morphologically or with the lime acid reaction test. According to the information of the combined survey of the China Academy of Agricultural Sciences, Kwangtung Provincial Institute of Agricultural Sciences, and Yunan Provincial Institute of Agricultural Sciences of September, 1960, the complex varieties are distributed in areas between 1,000 and 1,800 m. The tendency is to have the

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following changes:

(1) the shape of the grains is changing from thin and long to short and round.

(2) The hair of the hull changes from sparse to thick, from short to long.

(3) The hair on the leaves changes from thick to none (some varieties of common rice on the plains do not have hair on the leaves at all.)

(4) The grains are becoming harder to fall. The color of the hull changes from light yellow, to yellowish brown, reddish brown, and spotted brown.

(5) From the low areas to the areas of higher elevation, the number of varieties of common rice is gradually becoming less, while the number of long-grains increases.

Many of the varieties are not very easily classified. This situation occurs in the common rice zones also. For example,the Ling-an-tsao of Feng-i Hsien and the Ta-pai-tiao of K'un-ming Hsien do not change color at all when treated with lime acid, except for 10 to 28% of the seeds, while the Hung-mi-tsao-ku of Wei-shan Hsien never changes color.

In some cases, such as Leng-shui-tiao of K'un-ming the variety originally belongs to the subspecies of long-grain, but its grains fall easily, and 10 to 30% of them change color when treated with lime acid.

In the case of Feng-i-hung, which belongs to the subspecies of long-grain, the proportion between the length and the width of its grain is 1.93, while Chao-t'ung-hung which is also long-grain, has a proportion of 2.32. Common rice varieties with small proportion between length and width of the grain are also often seen. These facts prove that the varieties change with relation to environmental conditions.

In Yunnan, the temperature changes a great deal in relation to elevation. The areas below 100 m are the tropical plains, while paddy rice fields may be seen in areas above 2,600 m where the climate of the temperate highland prevails. It is understandable that the common rice varieties, originally

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the products of the tropical zone, change their characteristics when introduced to a higher, dryer, and cooler climate. As the geographical distribution of these subspecies is reflected in the characteristics of the plants, we may assume that the long-grain varieties were the results of natural and human selection since prehistorical ages as the plants were being introduced from the south to the north. Consequently, large areas of cultivated long-grains appeared in the valleys of Huang-ho and Yangtze. Therefore, we believe that two subspecies of rice appeared during the process of cultivation in China; the common rice is the basic type, and the long-grain is the variation. We named them accordingly.

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SECTION 3. EVOLUTION OF EARLY AND LATE SEASON RICE VARIETIES

[p 25]

The wild-grown rice plants of South China complete the light exposure period of growth in the middle of September when the daylight lasts about 12 hours. Then, the germination begins and the heads begin to appear in the middle of October, and become ripe after the middle of November. These plants react strongly to light treatment. The late rice varieties and the single season varieties behave the same way. However, if the early rice varieties of South China and the early or intermediate varieties are planted in Canton, then, they are no longer sensitive to daylight, and may grow, germinate, and ripen any season of the year. The relationship between these cultivated varieties and the late varieties which require short periods of daylight is a problem requiring close scrutiny.

1. CULTIVATION AND DEVELOPMENTAL PROCESS OF EARLY AND LATE SEASON PADDY RICE [p 25]

The early varieties of rice plants have had a long history in our country. Shan-hai-ching of the Period of the Warring States recorded the rice varieties of South China that were planted in the winter and the summer. Yang Fu (2799 1318) also said in I-wu-chih that "In Chiao-chih, rice is ripe in summer and in winter. The farmers plant it twice a year."

Yu-feng of Shih-ching (about 8th century B.C.) mentioned rice plants in October. The month of October in Chou Dynasty corresponds with the month of September now. Yu is located in the western part of Shensi. Today, in that part of Shensi rice is ripe and cut in September also. In that part of the country, the period of germination is in July, when the daylight is measured at about 14 hours a day. Therefore, we believe that if the rice plants of Chou Dynasty could complete the light exposure requirement in July, they must have been the early varieties which are not sensitive to long periods of daylight.

In the Chin Dynasty (266 to 419 A.D.), as Kuo I-kung

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(6753 0034 1872) mentioned in Kuang-chih,"there is a variety of rice called Shan-ming-tao in the south. It is ripe in July. Another called Kai-hsia-pai-tao, is ripe in May. After being cut, the stem grows up again from the root and the grain is ripe again in September. Tso Szu (1563 1835) also said in Wu-tu-fu (299 B.C.) that "the state imposes taxes on the double-crop rice fields."

These facts indicate that in the south, the early and the late varieties of rice existed since the days of the third century B.C. Later, Li Tao-yuan (6786 6670 0337) said in Shui-ching-chu (6th century A.D.) that "in Chiu-chen (the area bordering Kwangsi and Vietnam) the rice variety called Pai-ku is in the field from July to October, and the variety called Ch'ih-ku is in the field from December to April." It is stated in T'ang-shu that "in the year 19th of K'ai-yuan (731 A.D.), there were 2,800 ch'ing of double-crop rice fields in Yang-chou. We may conclude that the cultivation of the early varieties has been an established tradition for a long, long time.

2. DIFFERENT CHARACTERISTICS OF EARLY AND LATE SEASON RICE VARIETIES [p 25]

Morphologically, the early varieties of the valley of the Pearl River, the early and the intermediate varieties of the single and the double crop regions of the Yangtze Valley, and the single season varieties of the north may be considered the same type, genetically very close to the late varieties. Hybridization of the early and the late varieties did not clarify their relationship either. However, with regard to light sensitivity, the two are very different. When the late varieties of the Pearl Valley or the Yangtze Valley are treated with long periods of daylight, the growth period is unduly prolonged, and sometimes they do not germinate. The early and the intermediate varieties of the two river valleys do not show obvious reaction to the long daylight treatment. They may germinate with long periods or short periods of daylight if planted in the fields. The late varieties strictly require the daylight to be less than 13½ hours. However, the various late varieties also react differently toward the light treatment. It may due to the geographical location of the origin of a special variety, or perhaps it may be related to the special characteristics of the particular variety.

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3. EVOLUTION OF EARLY AND LATE SEASON PADDY RICE [p 26]

According to the observation of Ting Ying (0002 4481) (Growth Condition of Paddy Rice Planted All Through the Year, Mimeographed pamphlet, 1960.) sometimes the late varieties (Wan-chin-feng and two others) planted in the later part of September to the middle part of November come to a head in October of the next year, but a few of the individual plants come to a head in the spring like the early varieties. Some of the grains dropped in the field from the late varieties sprout in November, and if these sprouts are transplanted, the young heads may begin to develop in March or early May, and the grains become ripe from May to July. It is possible that when the late varieties are forced to accept the low temperature and short daylight of the winter and the spring, their characteristics change, and assume those of the early varieties.

We may thus infer that the early varieties are the variations of the basic type which is the late varieties. They are the products of selection and cultivation of the farming masses through their prolonged period of productive practice. The various types of late varieties through natural hybridization and human selection may also produce some varieties which are earlier than the others to come to a head. Besides, variations may also result from environmental conditioning and natural hybridization of the wild-grown varieties. For example, among the straight stemmed wild-grown rice around the marshes in Hui-yang Hsien and Kuang-szu Hsien of Kwangtung, there are often a few that come to a head earlier than the others.

Rice is originally a tropical plant, requiring the climatical condition of high temperature and short daylight. The early types retain the characteristics of the original late varieties, yet are suitable for areas of longer days and lower temperatures. Apparently, with human selection and cultivation, these varieties have become adjusted to the new environment. The successful formation of these varieties makes it possible for the high temperature zones to plant rice all through the year, and also makes it possible to plant rice in the high latitude zones and the highlands. This fact plays an important part in the development of rice production.

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SECTION 4. EVOLUTION OF PADDY RICE AND DRYLAND RICE VARIETIES [p 27]

The wild-grown rice is a plant of the marshes, therefore, the cultivated variety should first be the paddy rice. (The deep-water varieties may be considered as the outcome of careful cultivation as we have mentioned before.) That is to say that the paddy rice should be the basic type of the cultivated varieties, and the upland rice is the outcome of human selection and cultivation. However, opinions vary with regard to the genetic relationship of the two. In foreign countries, some believe that the upland rice varieties are related to the wild-grown rice varieties for medical use. Some others believe that the paddy rice originated with the upland varieties. However, judging from the long history of rice culture in our country, the earliest varieties must be the paddy varieties, not the upland rice.

1. CULTIVATION AND DEVELOPMENTAL PROCESS OF PADDY RICE AND DRYLAND RICE [p 27]

It is stated in Hsiu-wu-hsun of Huai-nan-tzu that: Shen-nung estimated the moisture and the fertility of the soil before he taught the people how to plant the five grains (the millet, Panicum miliaceum, rice, beans, and wheat). This indicates that planting was first done in low and damp areas, and the plants must undoubtedly be the paddy rice. Sui-hsing hsun said that "the water of Chiang is rich and very suitable for rice." Shuo-shan-hsun made it even more clear by saying that "rice grows in water but does not grow in the streams." In Shih-chi, Szu-ma Ch'ien (0674/7456 6692) said: "Yu dredged the nine rivers. Then, he ordered Pai-i to give rice seeds to the people to plant in the low and damp areas." Pai-hua of Shih-ching also said that "P'ang-ch'ih flows northward, and irrigates the rice fields there."

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Chou-li (the third and the fourth century B.C.) mentioned the special official Tao-jen who was in charge of the low and damp areas for rice culture, and there was also a description of a rather complete irrigation system.

The most precise statement,however, is found in Chan-kuo-ts'e,with the description of "the need of the Eastern Chou to plant rice, but the water is not available from the Western Chou." Yang Ch'uan (2799 3123) of the later part of Han Dynasty (219 B.C.) said in Wu-li-lun that tao [rice] was the name for all the crop plants which required irrigation. In Wei-tu-fu Tso Szu (1563 1835) (265 to 300 A.D.) said that rice plants grew in water. Irrigation ditches were in existence in the later part of the Yin-shang Period. During Ch'un-ch'iu and Chan-kuo periods (722 to 247 B.C.) there were even larger scale irrigation systems. Besides, the bronze language of the Chou Dynasty (1,123 to 247 B.C.) contained the character tao with a water radical on the lower part of the left side, to indicate that rice is a plant in the water. In all ancient books, only Ti-yuan-pien of Kuan-tzu and Nei-tse of Li-chi mentioned upland rice, and in both cases the character tao carried a modifier of either Ling [highland] or Lu [land]. It is very apparent that the terms ling-tao and lu-tao came from the original word tao which had the common connotation of a hydrophyte.

2. EVOLUTION AND DIFFERENT CHARACTERISTICS OF PADDY RICE AND DRYLAND RICE VARIETIES [p 28]

The upland and the paddy varieties do not differ very much in appearance, but are more different biologically. The paddy rice has the special ventilating system which makes it suitable to grow in the marshes. It absorbs air from the stem which helps to compensate the insufficient oxygen supply of the paddies. The upland varieties have this system also. The extent of development of the protective tissues of hair on the roots, stem, and leaves is different, however, and this difference may be used to distinguish the two types.

The difference in soil moisture may cause the plant to change its characteristics in order to adjust to the environment; thus, it is possible to train a basically hydrophytic variety into an upland variety suitable for dry soil planting. Meanwhile, with the ventilating system, the upland rice is more suitable for areas of frequent or seasonal rains

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than other upland crop plants. As a matter of fact, formerly in many places where irrigation presented a constant problem, there were many varieties which were suitable for either the paddies or the upland fields. When a drought resistance test was conducted, it was discovered that some of the young seedlings of the paddy rice varieties were more drought resistant than those of the upland varieties. Besides, it is also possible to transplant a wild-grown rice plant and directly train it into an upland variety.

Those varieties that grow in deep water such as the Pu-kuei-chia and Sun-shui-lien of Kwangtung look very similar to the wild-grown varieties of the marshes; perhaps, they were directly trained from the latter. The ventilating system of Ch'ien-shui-ku which is more suitable for shallow water is more developed than that of any other variety. The deep water varieties of Anhwei, Hupei, and Hopei may be planted as ordinary paddy varieties. They do not spread in the water, and therefore, may be considered as belonging to the same type as the ordinary varieties.

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SECTION 5. EVOLUTION OF STARCHY AND GLUTINOUS PADDY RICE VARIETIES [p 28]

Wild-grown rice grains are not sticky, and the first cultivated variety must have been that kind also. That is to say that the non-sticky ones are the basic varieties, while the glutinous varieties are the variations. An examination of the development process of the various varieties in China proved this point.

1. CULTIVATION AND DEVELOPMENTAL PROCESS OF STARCHY AND GLUTINOUS RICE [p 28]

Ancient books recorded that the rice that was planted in the Huang-ho Valley of ancient China was keng-tao (Heng), and the word for glutinous rice (Chi) did not appear until the beginning of Han (2nd century B.C.), and the common type of glutinous rice was seen only in the Ming Dynasty.

The glutinous rice of Han Dynasty did not have special names. The word chi used in Yueh-ling-pien of Li-chi was borrowed from the word for the grain of Panicum miliaceum. Later, Fan-sheng-chih-shu (32 to 5 B.C.) mentioned "planting Heng-tao in March, and planting chi-tao in April." Kuang-ya (227 to 232 A.D.) mentioned that "chi means glutinous rice." Ku-chin-chu (290 to 360 A.D.) said: "the rice that is sticky is called chi." In the Biography of T'ao-ch'ien (7118 3383) in Chin Shu, it is stated that "he ordered one ch'ing and fifty mou to be planted with chi, and fifty mou planted with Heng." The borrowed word chi was still used.

It was not until Ching-tien I-wen (533 to 588 A.D.) of T'ang Dynasty, that glutinous rice was named no, and a note was given to indicate that the word meant glutinous rice. It has been used to name that type of rice ever since.

However, by the time of the fifth and the sixth century A.D. there was still very little glutinous rice in Chiang-tung (the lower reaches of the Yangtze). T'ao Hung-ching (7118 1738 2529) of Liang Dynasty (436 to 546 A.D.) mentioned in his Ming-i Pieh-lu that "the keng rice used by the physicians of the Tao Tradition is white as frost. It is

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not found in Chiang-tung." "Keng rice is the ordinary rice. It comes in white, red, small, and large, and in four to five variations." The so-called frost-white rice is the glutinous rice. From the time there was first cultivated rice in China to the time of T'ao Hung-ching (7118 1738 2529), it had been more than 3,000 years, but the glutinous rice was still not planted in Chiang-tung. We may thus conclude that it came very late.

All reference to the glutinous rice before his time seems to belong to the keng subspecies (the long-grain). Not until Huang Sheng-tseng (7806 4164 2582) (the middle of the 16th century), was there mention of glutinous rice belonging to the hsien subspecies (the common rice.) He said in his Li-sheng Yu-ching that the glutinous rice had 13 varieties. Two were the early ripe varieties, and eleven were the late ripe varieties. Among the early ripe varieties, one was hsien-no, with very long grains. It was planted in April, and ripe in July. This is apparently the earliest glutinous rice of the common rice subspecies.

After the time of the Ming Dynasty, there was such an abundance of varieties of rice that they began to be divided into the two types of chan and no. The ordinary non-sticky varieties of hsien and keng are all called chan, and the glutinous varieties of both subspecies are all called no.

2. EVOLUTION AND DIFFERENT CHARACTERISTICS OF STARCHY AND GLUTINOUS RICE VARIETIES [p 29]

The difference between the chan and the no varieties is mainly in the glutinosity of the grains. With regard to glutinosity, the varieties of the hsien subspecies are very weak, those of the keng subspecies are better, while the no varieties are the strongest. The ordinary no varieties (those belonging to the keng subspecies, and called the big no in south and southwest China,) are still more glutinous than the hsien no (called little no in South China.) /The varieties of the keng subspecies taste like the long-grains of the United States, while those of the hsien subspecies taste like the common rice, although the grains of the keng are shorter and fatter than those of the hsien./

The color of the grains is also different. The grains of no are semi-transparent before they are dry. When

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they are dry, they are white like milk. The grains of the glutinous rice contain more than 80% of amylopectin. The grains of the chan rice contain none or very little amylopectin. They contain only amylose. This is why when treated with potassium iodide, the starch of the no rice turns red, while the starch of the chan rice turns blue. [The color of the no grains is related to the soluble starch [amylodextrin and maltose they contain. It has been reported that the chemical and the physical nature of the starch of the grains is related to the variety and the location from which they are produced (especially temperature.) P'an Hsi-lung (3382 6932 7893) conducted a study of the hsien, keng, and no varieties produced in Shao-wu, Fukien. He observed the speed with which the starch of the various types of rice become dextrin and its relationship to temperature. If time is constant, and the starch is turned into a certain standard gummy mixture, the no grains require the lowest temperature, the keng grains next, and the hsien grains the highest. If the temperature is held constant, then, the no grains require the shortest time, keng grains the next, and the hsien grains the longest. A 9 to 10 minute treatment of the starch of the hsien grains produces about the same result as a five minute treatment of the keng grains, or about the same as a four minute treatment of the no grains. This condition is related to the environmental conditions required to produce these grains, and is also related to the cold resistant and drought resistant characteristics of the varieties. That is to say that the no varieties generally are more cold and drought resistant than all the chan varieties.

Morphologically speaking, the no and the chan varieties are not very different. The yield of the two is also quite similar. Sometimes, a no variety may gradually change into a chan variety. [After a few generations, the grains cease to be sticky.] Sometimes, the grains of the chan varieties are so soft that they are like the no. Therefore, the no rice may only be considered as a variation of the chan due to the changes occurring in its starch content.

In the southern part of Kiangsu there are two kinds of keng: the thick and the thin. Thick keng ripens early, and its grains are rich with starch, and are used as ordinary food. The thin keng ripens late when the weather is cooler. Its grains contain more sugar, and may be used as a substitute for keng nou. It is specially good for making wines. Besides, all the varieties of hsien and keng may be distinguished by all degrees of softness and hardness of their grains. Future study is needed to differentiate the no varieties and the

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soft grains of the chan varieties.

We must point out here that the changes in the nature of the starch content are very obvious changes, and the classification according to the starch content of the grains is regarded as very important in rice research. And, these changes are considered as changes in the characteristics of a variety. However, if we compare this change with the change from hsien to keng and the change from late ripening to early ripening then, the changes between the no and the the chan are smaller matters. They are changes within a variety in one geographical zone, in one season, and under the same soil conditions. The classification of rice according to the nature of its starch content has its proper place in the development of our country's rice culture.

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CHAPTER 4. GROWTH AND DEVELOPMENT OF THE RICE PLANT

[p 53]

SECTION 3. SPIKE DIFFERENTIATION STAGE [p 75]

1. GROWTH STAGES OF THE RICE PLANT [p 75]

The life of a rice plant may be divided into the nourishing stage and the reproductive stage. From the germination of the seed to the beginning of inflorescence is the nourishing stage; from the inflorescence to the maturity of the karyopsis or grain is the reproductive stage. As the rice plant develops from the nourishing stage to the reproductive stage, its requirements for temperature and light are very strict. If the conditions are not just right, the plant continues to grow and receive nourishment but the stage of inflorescence does not begin. Once the requirements are satisfied, the plant develops from one stage to the next very fast, and once this change occurs, the plant no longer has strict demands for temperature and light. From then on, it will develop smoothly even if the light shines on it day and night and the temperature is low.

Figure 4-5 shows the two light sensitive varieties of Ch'uan-ta-yang-chien and Fei-lai-feng grow faster with short light period treatment. It is interesting to note that if the short light period treatment is applied for 10 to 20 days, starting immediately after the sprout appears above the ground, then the growth period is longer than that of the control group. For the variety of Ch'uan-ta-yang-chien, if the treatment begins 11 to 20 days after the sprout appears, the growth acceleration is most obvious, and as the treatment is delayed the growth is delayed also.

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Thus, it appears that before the rice plant enters the stage of requiring short periods of daylight, there exists another stage. Lishenko, in his study of wheat, calls the first stage the spring period; the second stage the light exposure period. These names have been adopted to describe the growth stages of rice also.

Experiments similar to the method used by Lishenko in his wheat study were conducted by T'ang Hsi-hua (0781 6932 5478) and Yu Lu-ch'i (0205 1462 0967) and co-workers in Nanking. They used 59 varieties of early and late ripening rice plants, and found that within the temperature limit of 15-30°C, all of the varieties may complete the spring stage of growth in 3 to 12 days (Table 4-20). Among the 20 varieties of early rice planted on the 20th of May, 9 were left with natural light condition and were treated with temperature method only. Their growth period was markedly shortened for 3 to 9 days. The effect was not obvious for the 11 remaining varieties; however, after additional short light period treatments (10 hours of light exposure a day), some of these varieties demonstrated some of the spring treatment effects.

Of the 22 varieties of medium ripening rice tested (planted on the 20th of July), 7 varieties came to a head 3 to 10 days ahead of schedule; a few were 15 days ahead of schedule. The effect of the treatment was not obvious for the remaining 15 varieties. Of the 17 varieties of late ripening rice plants (planted on the 10th of August) five varieties came to a head 3 to 10 days ahead of schedule, while the effect was not obvious for the remaining 12 varieties.

The most suitable temperature for the spring treatment of the 21 varieties which reacted favorable to the treatment is shown in Table 4-20.

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Figure 4-5 The Days from the Time the Sprouts Appeared to the Time of Heading

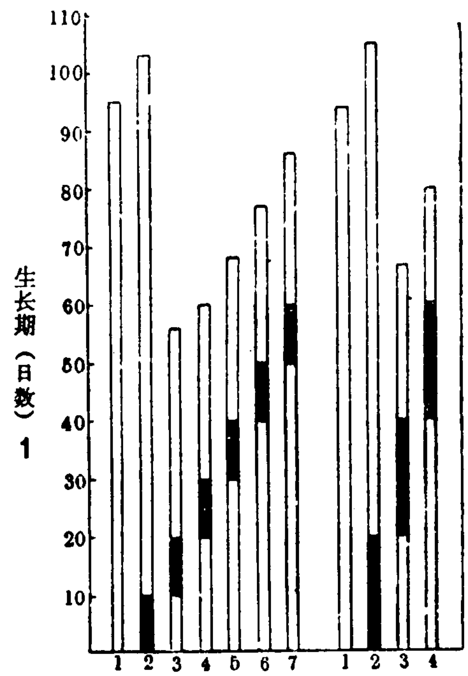

图 4—5 从出土至出穗日数

2 横座标上的左面数字 1—7 为川大洋尖的处理，右面数字 1—4 为飞来凤的处理。图中黑色部分即为短光处理期間。

1. Growth period (number of days).
2. The left points, 1-7, of the horizontal coordinates are treatment for Ch'uan-ta'yang-chien. The right points are for Fei-lai-feng. The black portions of the diagram indicate the periods of the short light exposure treatment.

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Table 4-20 The Most Suitable Temperature, the Duration of Treatment, and the Effect of the Spring Treatment of Sprouted Seeds of the Various Varieties of Paddy Rice

处理 (1)		南特号 (2)	朱早 (3)	胜利籼 (4)	帽子头 (5)	一线红 (6)	三朝齐 (7)	大头龟 (8)	大秸子 (9)	红脚早 (10)	洋籼 (11)	白早 (12)	白秋其 (13)	三十子 (14)	飞天早 (15)	浙场9号 (16)	314	早禾4号 (17)	万利籼 (18)	齐眉 (19)	金凤六 (20)	黄壳早廿日 (21)
(22) 15°C—20°C 处理	3-6天 (23)															V	V	V	V	V	V	V
	6-12天									V	V	V	V	V	V							
(24) 25°C—30°C 处理	3-6天 (25)						V	V	V													
	6-12天	V	V	V	V	V																
(26) 处理效果（比对照提早出穗的天数）	5月20日播种 (27)	6	8—9					3	5	4	4	3-5		7	3—4							
	7月20日播种 (28)			10	15	13	9											4—5	4—5			3
	8月10日播种 (29)												6—7			2—3	4—5			8-10	4	
备考 (30)	品种类型 (31)	早籼 (32)	早籼 (32)	中籼 (33)	中籼 (33)	中籼 (33)	中籼 (33)	早籼 (32)	早籼 (32)	早籼 (32)	早籼 (32)	早籼 (32)	晚籼 (34)	早籼 (32)	早籼 (32)	晚籼 (34)	晚粳 (35)	中籼 (33)	中籼 (33)	晚籼 (34)	晚籼 (34)	中粳 (36)
	原产地 (37)	江西南昌 (38)	福建长乐 (39)	湖南湘潭 (40)	安徽当涂 (41)	湖南长沙 (42)	安徽芜湖 (43)	江苏兴化 (44)	江苏兴化 (45)	湖南平江 (46)	江苏兴化 (47)	福建长乐 (48)	海南岛北部 (49)	江苏建湖 (50)	湖南浏阳 (51)	浙江宁波 (52)	江苏苏州 (53)	广西藤县 (54)	湖南萧县 (55)	广东广州 (56)	广东东莞 (57)	江苏江阴 (58)

1. treatment 2. Nan-t'e-hao 3. Chu-tsao 4. Sheng-li-hsien 5. Mao-tzu-chien 6. I-hsien-hung 7. San-ch'ao-ch'i 8. Ta-t'ou-kuei 9. Ta-chi-tzu 10. Hung-ch'u-tsao 11. Yang-hsien 12. Pai-tsao 13. Pai-ch'iu-ch'i 14. San-shih-tzu 15. Fei-t'ien-tsao 16. Che-ch'ang No. 9 17. Tsao-ho No. 4 18. Wan-li-hsien 19. Ch'i-mien 20. Chin-feng-liu 21. Huang-k'u-tsao, Kan-jih 22. 15°-20°C treatment 23. 3-6 days, 6-12 days 24. 25°-30°C treatment 26. Effect of the treatment (the number of days ahead of the control group for inflorescence) 27. Planted on 20 May 28. Planted on 20 July 29. Planted on 10 August 30. Notes 31. Type of variety 32. Early hsien 33. Medium hsien 34. Late hsien 35. Late keng 36. Medium keng 37. Origin of the variety 38. Nan-ch'ang, Kiangsi 39. Chang-lo, Fukien 40. Hsiang-t'an, Hunan 41. Tang-t'u, Anhwei 42. Chang-sha, Hunan 43. Wu-hu, Anhwei 44. Hsing-hua, Kiangsu 45. Hsing-hua, Kiangsu 46. P'ing-chiang, Hunan 47. Hsing-hua, Kiangsu 48. Chang-lo, Fukien 49. Northern part of Hai-nan-tao 50. Chien-hu, Kiangsu 51. Liu-yang, Hunan 52. Ning-po, Chekiang 53. Su-chou, Kiangsu 54. T'eng-hsien, Kwangtung 55. Hsiao-hsien, Hunan 56. Canton, Kwangtung 57. Tung-wan, Kwangtung 58. Chiang-yin, Kiangsu.

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Spring treatment tests of paddy rice conducted by others brought similar results. For example, the 30 varieties tested by Yang K'ai-ch'u (2799 7030 3255) and co-workers brought effective results to two of the varieties only. The Nan-t'e-hao Early rice and Ch'uan-ta No.1 medium early inflorescenced 3 to 9 days ahead of schedule. The effect of the treatment was not obvious for the remaining 28 varieties. Chao Chih-chih (6392 1807 2638) tested with the varieties of Yunan Pai, Tsao-ho No. 4, and Chung-ch'ien No.2, of the hsien subspecies. The treatment was effective with Yunan Pai only. It inflorescenced 4 to 8 days earlier. Northeast Institute of Agricultural Sciences tested with five varieties of the keng subspecies, and none of them showed obvious effects. In the Soviet Union, P. C. Yerigin and Ye. F. Tishina conducted a test with five varieties of keng rice. They treated the plants with temperatures of 15°-35°C for three to 28 days, and obtained only two to three days difference in inflorescence compared with the control group. They concluded that the treatment was ineffective.

The tests conducted in India pointed out that treatment with temperatures below 15°C is entirely ineffective. In some cases, inflorescence was delayed. But, if the temperatures of 20° to 37°C are used, the inflorescence of some varieties may be made ahead of schedule.

On the basis of the fact that in ordinary productive practice, the seedlings of rice require no special temperature conditions, normal inflorescence is not affected by a low temperature of 10°C or a high temperature of 30°C. This is the difference between the rice seedlings and the winter wheat.

Among the tests conducted in this country, only a few varieties showed any reaction. From Table 4-20, we can find no relationship between those varieties which showed reactions and their seasonal or regional characteristics.

In conclusion, we believe that there have not been enough studies regarding the first stage of development of the rice plant. It is still too early to confirm or to deny the existence of the spring stage for the rice plants. Due to the fact that various rice varieties grow in our country in various

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regions and seasons, we believe that a study of the first stage of their development should be very meaningful.

The following is a brief discussion of the light exposure stage of development of the rice plants.

(1) Our Country's Experience in the Introduction of New Varieties in Productive Practice

Within a particular region, the early varieties are planted early (planted generally in March or April, and harvested in June or July;) and the late varieties are planted late (planted generally in May or June, and harvested in October to November.) However, the early varieties may be used as the late varieties. (This method is called the "reversed autumn" in Kwangtung, and the "upside down spring" in Fukien." That is to say that the early varieties may be planted late for a late harvest, but the late varieties may not be planted early.

The varieties of the keng subspecies originated in the Northeast may be used as an early variety if planted in the Yangtze Valley. This is one of the important achievements of recent years. The medium varieties of the Yangtze valley may be used as early varieties in Kwangtung; on the other hand, the early varieties of Kwangtung may be used as early or medium varieties in the Yangtze Valley. The early varieties of the Yangtze Valley may be planted in North China but the late varieties of Kwangtung cannot bring a harvest in the north. Some of them cannot become ripe if planted in areas such as Heng-yang, Hunan. The late varieties of Fukien have too late a harvest to be used for continuous planting in the Yangtze Valley. The medium varieties of the keng subspecies seldom have time enough to grow seeds if introduced to North China from the southern part of Kiangsu. The same is true if the varieties of Tientsin are introduced to Chen-yang. Within the region of the Northeast, the varieties of Liaoning may not be introduced to Kirin, and those of Kirin may not be successfully introduced to Heilungkiang. This is the important experience of the farmers of our country, especially since the liberation.

This experience indicates that the time from the planting of the seedlings to inflorescence is variable, especially the period during which the tillers divide. For example, the late varieties of South China and the Yangtze Valley require a certain condition of short light periods. If they are introduced to the north, the temperature will be too

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cold when that certain short light period comes to North China. Thus, the objective condition will cause the plants to indefinitely prolong the period of dividing the tillers, and the period of inflorescence will never come. Under the high temperature and short daylight conditions of Kwangtung, the late varieties of the T'ai-hu region may be planted as early varieties. Of course the development and the successful introduction vary with the varieties.

(2) The Special Characteristics of the Light Exposure Stage of Chinese Rice Varieties

A large-scale study program has been carried out with regard to the light exposure stage of the various varieties of paddy rice. The result of these studies showed that almost all the early varieties have no strict requirements for th condition of short periods of light exposure, while the late varieties do.

The observation of Wu Kuang-nan (0702 0342 0589) and others confirmed the important effect of the environtal conditions (the latitude , the elevation, and the planting date) of the place of origin on the formation of the light exposure characteristics of the rice plants. The varieties of the low latitude regions have stricter demands of light exposure. The varieties of the high latitude regions react weakly toward the length of the period of light exposure.

The demands of light exposure are less strict with those varieties which are planted early normally. The varieties of different regions require similar light exposure conditions, if the light exposure conditions are similar during their normal growth period in regions of different latitudes. Based upon their different reactions toward light exposure, Wu Kuang-nan (0702 0342 0589) and co-workers divided the more than 800 varieties of paddy rice of China into five categories, which are showen in Table 4-21.

Table 4-21 basically explains the light exposure characteristics of the varieties of the different regions. and we can see very clearly that these characteristics are determined by the light exposure conditions these varieties have been submitted to systematically during their normal growth periods. In case of the early varieties of our major rice producing regions (the Yantze Valley and the South China regions), if they are habitually submitted to light exposure of more than 14 hours and the periods of light exposure change from shorter periods to longer periods during their light exposure stage of development, then, their light exposure requirements are not very strict. That is to say, if they are exposed to longer periods of light, the delay of their growth will be minor. On the contrary, if they are habitually submitted to 14 hours or less, and the variation of light exposure is from longer periods to shorter periods, then, their delay in growth becomes substantial, if they are exposed to long periods of light exposure; in other words, their requirements in the condition of light exposure are very strict. The late varieties of the Yangtze Valley and South China belong to this latter type. The early varieties of South China grow under the condition of less than 14 hours of light exposure, but during this vital stage, the period of light exposure changes from short to long; therefore, the light exposure requrements of these varieties are not very limited. On the other hand, the late varieties of North China grow under the condition of more than 14 hours of daylight, but the light exposure changes from long to short during their light exposure stage of growth; they are more suitable for shorter periods of light exposure, although their light exposure requirements are not very limited. That is to say, treatment of short periods of light exposure greatly accelerates their growth.

In practice, if the early varieties are introduced to an area to the north of their origin, if the temperature during the growth period is similar, there is no obvious difference in growth. When the medium to late varieties are similarly introduced, the period of light exposure is too long, and the temperature is too low. The inflorescence is delayed so much that the plants fail to become ripe.

If the northern varieties (including the early and the late) are introduced to areas south of their origin, they may grow through their stage of light exposure very fast, and they inflorescence and become ripe ahead of their habitual time. In other words all of them become early varieties. In the south, the northern varieties of the keng subspecies are often introduced to the south and planted as early varieties or as varieties for continuous planting. They are often planted sufficiently early, or the initial fertilizer is often more heavily applied to prevent the short period of growth from affecting the amount of yield. This is a precious experience of our farmers.

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Table 4-21 The Difference in Light Exposure Reactions of Chinese Rice Varieties

类别 1	粳籼 2	对光照长短反应的程度 3	4 对不同光照长度反应的特点			8 主要分布地区
			在9.5—18小时范围内出穗期差异日数 5	开始延迟出穗的临界光长范围(时) 6	出穗期有差异的光照长度范围(时) 7	
9 第1类	14 粳	15 极弱	0—12	—		黑龙江、台湾（双季稻早晚稻兼用品种） 20
	籼	极弱	0—12	—		华南各省(第一季稻)、华中各省(单季早中稻)、云贵高原(第一季稻或单季早稻)
10 第2类	14 粳	16 弱	13—30	13.5*—18.0	13.5—18.0	吉林、新疆、甘肃、河北北部、江苏、江西（极早粳稻） 21
	籼	弱	13—30	—	9.5—13.5	华南各省（第一季稻）、华中各省(早中稻)、云贵高原（第一季稻或单季早稻）
11 第3类	14 粳	17 中	>30	13.5—18.0	13.5—18.0	河北中部、江苏（早熟的中粳稻） 22
	籼	中	>30	—	9.5—18.0	四川、云南、贵州三省（单季早中稻或双季稻的早季稻）
12 第4类	14 粳	18 强	>30	12.5—13.5	12.5—18.0	江苏、浙江两省的太湖地区（单季晚稻） 23
	籼	强	>30	12.5—13.5	12.5—18.0	华中各省（单季晚稻） 云贵高原（单季晚稻）
13 第5类	14 粳	19 极强	>30	11.5—12.5	11.5—18.0	华南各省和云南（第二季稻的粳糯品种） 24
	籼	极强	>30	11.5—12.5	11.5—18.0	华南和云南（第二季稻品种）

25 * 该试验用黑布棚控制日照时间的长短，根据原文处理方法中记载，13时30分的处理是从每天晨5时开棚下午6时40分开始关棚，实际上从开始关棚至完全关闭約需20分钟，故曝光时间应为14小时。12小时30分同理亦应为13小时，11小时30分应为12小时，9小时30分应为10小时。

1. Category 2. Keng or hsien subspecies 3. Different reaction toward different periods of light exposure 4. Characteristics of the reaction 5. The delay in inflorescence (number of days) 6. The period of light exposure at the time when the plant begins to **come to a head (hours)** 7. The limit in the length of light exposure within which inflorescence is possible (hours) 8. Major areas of distribution. 9. First category 10. Second category 11. Third category 12. Fourth Category 13. Fifth category 14. Keng. hsien 15. extremely weak, extremely weak 16. weak, weak 17. medium, medium 18. strong, strong 19. extremely strong, extremely strong 20. Heilungkiang, Taiwan (double seasoned early and late varieties both used); the provinces of South China (the first season varieties), the provinces of Central

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China (single seasoned early and medium varieties), the highlands of Yunnan and Kweichow (the first season varieties or the single seasoned varieties)
21. Kirin, Sinkiang, Kansu, the northern part of Hopei, Kiangsu, Kiangsi (the very early varieties of the keng subspecies); the provinces of South China (the first season varieties), the provinces of Central China (the early and the medium varieties), the highlands of Yunnan and Kweichow (the first season or the single seasoned varieties)
22. The central part of Hopei, Kiangsu (the early rippen varieties of the medium keng); Szechwan, Yunnan, and Kweichow (single seasoned early and medium varieties or the early varieties of the double seasoned regions)
23. The T'ai-hu region of Kiangsu and Chekiang (the single seasoned late varieties); the provinces of Central China (the single seasoned late varieties), the highlands of Yunan and Kweichow (the single seasoned late varieties)
24. The provinces of South China and Yunnan (the second season varieties of the keng and the nou); South China and Yunnan (the second season varieties)
25. * For the tests, a black cloth is used to control the length of daylight exposure. According to the description of the original report of this experiment, the 13 hours and 30 minutes treatment is conducted from five o'clock in the morning, at which time the tent is opened, and at 6:40 in the afternoon the tent is closed. Actually it takes 20 minutes to close up all the tents, therefore, the daylight exposure is 14 hours. The 12 hours and 30 minutes should be considered as 13 hours. The 11 hours and 30 minutes should be considered as 12 hours. The 9 hours and 30 minutes should be considered as 10 hours.

(3) The Beginning and the End of the Light Exposure Stage

When the rice plant completes its first stage of growth, if the environmental conditions are suitable, it enters the second stage, that is the light exposure stage of development. This stage begins, prolongs, and ends in accordance with the environmental conditions. When tested under the short light exposure treatment of 10 hours, after the seed has been planted 15 to 20 days, and there are five to six leaves, the light exposure stage may begin. It ends in five to ten days. The inflorescence thus begins. This growth process is faster with the varieties of hsien subspecies and slower with the varieties of keng subspecies.

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For example, if planted under the conditions of an average of above 25°C temperature with a constant 10 hour-period light exposure, the variety Huang-k'o-tsao, which is a medium keng of the Yangtze Valley, begins to require short periods of light exposure on the 15th day after it is planted. Its light exposure period of growth ends on the 25th day. Under similar conditions, the light exposure stage of growth begins with Che-ch'ang No.9, a late hsien variety, on the 15th day, and ends on the 19th day. That of Lao-lai-ch'ing, a late keng variety, begins on the 18th day, and ends on the 24th or 27th day. Similar results were obtained with other varieties such as Mao-tzu-t'ou, I-hsien-hung, Sheng-li-hsien, Yin-fang, 10509, 314, Hu-k'o-tao, and Tuan-chung. Besides, during the light exposure stage of development, the rice plant also requires a certain temperature, or higher than that temperature suitable for its growth.

The above statistics of the length of the stage of light exposure are recorded under the conditions of high temperature and 10 hour-periods of light exposure. When the plant is left in a natural environment, the conditions of light and temperature cannot constantly satisfy the demands of the plant. According to the available information of the tests conducted, under natural conditions, the light exposure stage of growth for the late varieties begins in the early part of July when daylight is gradually changing from long periods to short periods. For example, the late varieties of Lao-lai-ch'ing and 10509 of Shanghai begin its stage of light exposure in the middle of July, if planted at the normal time of early May and left under natural daylight conditions; this period ends in the early party of August. Thus this stage of their growth lasts about one month, very obviously longer than that stage of growth under the condition of high temperature and 10 hour-short periods of daylight.

Temperature has obvious effect on the length of the period of light exposure stage of growth. This fact has been proven by much experience with practical and experimental results. Based upon the experiments of separate planting times and short period of light treatment, Yang K'ai-ch'u (2799 7030 3255) and co-workers believe that temperatures above 20°C are necessary for the growth of the plant during its light exposure stage of development.

At present, the research studies here and abroad uniformly agree that the inflorescence of the rice plant begins on the basis of the conclusion of the light exposure stage of growth. The difference of the early and the late ripening

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time of the various varieties is determined basically by the early or late conclusion of the light exposure stage of growth and the beginning of the inflorescence.

2. PROCESS OF SPIKE DIFFERENTIATION [p 81]

According to reports of observations here and abroad, there are several methods of dividing this stage of growth. After his observation of the four varieties of Pai-ku-nou No.16, Hsien-chan 305, Pai-chan No.3, and Han-ho, Ting Ying (0002 3379) divided the entire growth of the young inflorescence into 8 periods:

(1) The First Stage of Budding

At this stage, when the inflorescence of the rice plant begins, a base of the first bud appears at the summit of the stem, on the point of growth. During this first stage, the point of growth does not swell. As the terminal protuberance grows, the point of growth gradually beoomes puffy. When a crosswise line appears at the point of growth, the first budding stage comes to an end.

(2) The Evolvement of the First Bud

The crosswise line is the base of the leaf bud. Then, the point of growth is raised again to form the base of the first pedicel. This evolvement begins at the point of growth, with an upward direction. At the end of this stage, white colored bud hair appears on the bud.

(3) The Second Pedicel and the Evolvement of the Base of the Flower Bud

The leaf bud evolves in the lower part of the first pedicel; then the second pedicel appears in the sticky fluid of the leaf bud. Gradually, a flower bud appears directly atop the first pedicel. When the second pedicel grows larger, there appears a second flower bud. The evolvement thus described is all in the upward direction. White colored hair appears again on the leaf bud of the second pedicel. The hair-like growth is very dense, and covers the young bud completely. When the flower bud on the first pedicel completes its growth, and the growth of the flower bud on the second pedicel below has not been completed; when these flower buds

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have only secondary racemes and protective racemes, and when the ovule and pollen bearing organs have not yet evolved, this stage of growth ends.

(4) The Formation of the Ovule and Pollen bearing Organs

When the ovule and the pollen bearing organs of the flower bud on the first pedicel have completed their development, and the flower buds of the secondary pedicels are all evolved, the number of flowers for this stem has become definite. The entire compound inflorescence is now apparently longer. The ovule and pollen bearing organs begin to appear on all the flower buds. The pollen bearing organs are there, but the spores are not yet formed. This is the end of this stage of development.

(5) The Formation of the Spores

When the ovule and pollen bearing organs appear, the racemes begin to grow longer. The protective raceme grows faster than the inner and outer racemes, until it is 1-1/2 times the size of the latter. Then, the anther appears at the summit of the outer raceme. At that time, the pistil begins to divide into two chambers, and the center of the pistil grows into the shape of a ring. Soon as the outer and the inner racemes become closed, the stamen divides into four chambers. When the flower measures 0.1 to 0.4 cm, chlorophyll appears at the summit. The bud hair becomes more dense. At this time, the growth of the inner and the outer racemes is faster than the protective raceme, and the former gradually become twice as long as the latter. If the contents of the stamen are examined at this time, spores may be found. This is why this stage of growth is called the formation of the spores.

(6) The Division of the Spore Cell

After the spore cells are formed, the division begins. The cell is divided into two; then, it is divided again and again. This division takes about 1 to 2 days. The spore cells of the same inflorescence do not divide at the same time. At this time, the length of the inflorescence reaches half of its mature length. It begins to turn yellow in color, and very small protrusions begin to appear at the end of the inflorescence.

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(7) The Stamen Is Full.

When the spore cell completes its division, the small ball-like spores are formed, and gain in volume. At this time the inner and the outer racemes grow very fast, and the entire inflorescence becomes long and slender. After the outer shell of the stamen completes its growth, it continusly growsin volume, When the racemes stop growing, and become hardened, the chlorophyll increases, and the stamen and the pistil continue to grow longer.

(8) The Growth of the Spores is Complete.

About one or two days before the glumes appear at the top of the inflorescence, the stamen is full, and the growth of the spore is complete. At this time, a large amount of chlorophyll appears, and the glumes continue to grow. Within the spore, the gamete cell and the nourishing cell are beginning to divide, until the male gamete is formed just before the inflorescence blossoms. At this time the development of the young inflorescence has completed.

3. RELATIONSHIP BETWEEN EXTERNAL ENVIRONMENTAL CONDITIONS AND SPIKE DIFFERENTIATION AND GROWTH OF THE VEGETATIVE BODY [p 90]

The plant is an organic body, in which the organs have a mutual relationship and a mutual controlling function. In order to obtain well-developed reproductive organs, there must be well-developed nourishing organs. Under general conditions, the larger and the stronger is the nourishing part of the plant body, the larger is the inflorescence, and of course, the more grains for each inflorescence. That is to say, large inflorescences grow only on large and strong stalks. Table 4-22 shows the proportion between the size of the stalk, the weight of the stalk, and the number of grains. With regard to the colony of the rice plants in a field, the goal is to have the plants reasonably dense and to have such strong stalks as to obtain the maximum number of grains.

During the different stages of development of the inflorescence, the plant requires different environmental conditions, and reacts differently to them. Therefore, the understanding of the needs of the plant during the different stages

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of development may enable us to apply the most effective technical measures for maximum gains. The yield is determined by the number of inflorescences per mou. The number of grains per inflorescence and the weight per thousand grains improve the yield factor. Therefore, on the basis of the concept of the whole plant body, it is important to clarify the environmental needs of the plant during the various stages of development of its inflorescence.

Table 4-22 The Health Condition of the Stalk and the Size of the Inflorescence in Lao-lai-ch'ing, a Late Variety of the Keng Subspecies

基本苗（万/亩）(1)	(2) 单蘖干重（克，8月8日测）		茎粗（毫米，8月21日测）(5)		每穗粒数 (8)	
	具分蘖主茎 (3)	不具分蘖主茎 (4)	具分蘖主茎 (6)	不具分蘖主茎 (7)	具分蘖主茎 (9)	不具分蘖主茎 (10)
25	1.85	1.14	6.0	5.4	90.1	68.0
35	1.71	1.08	6.1	4.8	81.9	64.2
50	1.30	0.81	5.5	4.3	77.2	51.5

1. Basic seedlings (10,000/mou) 2. the dry weight of a single stalk (gram, tested on 8 August) 3. main stalk with tillers 4. main stalk without tillers 5. the size of the stalk (mm, tested 21 August) 6. main stalk with tillers 7. main stalk without tillers 8. number of grains per inflorescence 9. the main stalk with tillers 10. the main stalk without tillers

According to tests of varying degrees of light exposure on Lao-lai-ch'ing, if the source of light is weakened after the point of growth of the plant has begun to evolve, the effect is felt by the sex cells, the growth of which is delayed or stopped altogether. As a result, the number of grains per inflorescence is obviously less.

The tests conducted in the various areas show that temperature also has obvious effects on the plant during its process of inflorescence. High temperature accelerates this porcess and low temperature delays or stops this process. According to agricultural weather information, the most suitable temperature for the inflorescence of rice plants should

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be an average of above 20°C.

Yu Shu-wen (0151 0647 2429) and co-workers observed the delay in the process of inflorescence due to a shortage of moisture in the soil. It appears that the various varieties suffer different degrees of damage under the same conditions of drought. The late varieties of the keng subspecies such as Lao-lai-ch'ing suffer the most damage, while the medium hsien varieties, such as Sheng-li-hsien suffer the least. Besides, flood and salt may also effect the normal process of inflorescence. They may produce degraded or deformed inflorescences. This is due to the fact that flood and salt damage the metabolism of the plant, and the young buds thus receive less or no nutriment.

In the process of inflorescence, a large number of new organs are formed and therefore a great deal of material supplies are needed for their formation. Agricultural practice proves that with a normal level of initial fertilizer, a certain amount of additional nitrogen fertilizer during this period of growth may increase the length of the inflorescence and the number of grains in it. An additional application of nitrogen or potassium fertilizer may improve the mineral content of the plant's nutriment, and due to the increase of the nitrogen content of the leaves, the plant's photosynthesis may be invigorated, so that the supply of the organic nutrients may be improved.

Thus, it is important to emphasize the size of the leaves which is most closely related to the efficiency of photosynthesis. After the stage of fertilization, the area of the leaves has reached the maximum. If due to excessive density of the plant colony, or improper application of fertilizer, the leaves are shaded from light and their function of photosynthesis is thus affected, the development of the inflorescence and the later fertilization may be seriously damaged.

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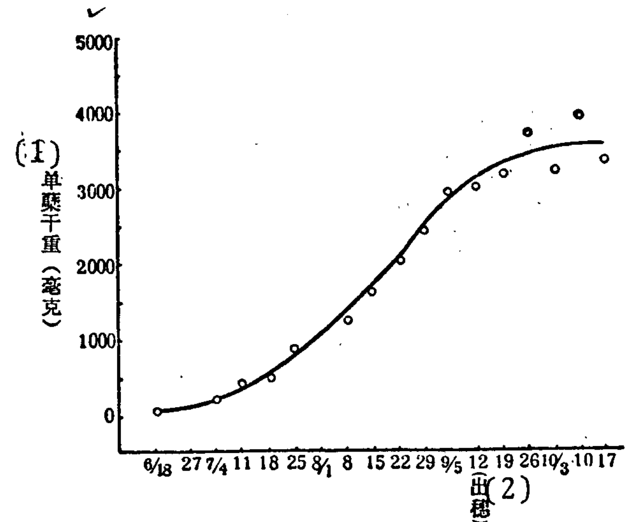
Figure 4-15 Variation of the Weight of the Dry Substance of a Single Stalk in the Growth Process, When the No. 853 Variety of Late Keng Rice Plants are Planted 330,000 Seedlings per mou



1. The weight of the dry substance of a single stalk
2. At the time the inflorescence appears

4. FIELD INSPECTION DURING SPIKE DIFFERENTIATION [p 92]

The small bud at the summit of each inflorescence grows the fastest, while those at the base grow slower. Therefore, the small buds in the middle part of the inflorescence should be used to judge the stage of development of the plant. Aside from the use of microscopes, the growth condition of other organs of the plant may also be used as a standard. The simple and indirect standards commonly used are as follows:

(1) In case of herbaceous crop plants, the point of growth of the stem begins to evolve at about the same time when the nodal growth of the stem itself begins. Conditions vary with the various varieties of rice plants. According to available materials, the early varieties begin the stage of inflorescence slightly before the stem begins to have nodes. These two stages of growth generally begin at the same time in the medium varieties. In case of the late varieties, the point of growth at the tip of the stem begins to evolve about 10 to 15 days after the stem has begun its nodal stage of growth.

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(2) Another method is to measure the distance between the top leaf bract and the one below. When the two bracts are at the same level, the coefficient is 0. When the former is below the latter, the coefficient is negative; when the former is above the latter, it is positive. Ting Ying (0002 4481) discovered the fact that when the spore cell begins its division in the No. 305 variety, the distance between the two is -3.2 cm; in the Han-ho variety, it is -1.5 cm. This is about 1 day before the top leaf makes its complete appearance.

(3) A few days after the evolvement has begun, it becomes easy for the naked eye to observe the length of the young inflorescence and judge its development. However, the size of the inflorescence also varies with the variety. Generally, when the pedicel completes its growth, it is about 0.3 to 1 mm in length. At the time when the flower begins to evolve, it is about 1 to 2 mm. When the spore cell begins to divide, the young inflorescence measures about 10 to 11 cm, about half of the length of the palea when the grains are ripe, and reaches that size when the pollen has completed its development.

(4) The number of days before the inflorescence is to appear is calculated normally from the day the plant is planted. For example, in Yin-fang variety, the tip of the stem begins to evolve about 34 days before the inflorescence appears, and the ovule bearing bud begins to protrude about 18 days before. According to the observation of Ting Ying (0002 4481), the summit of the stem begins to evolve and the bud begins to protrude about 30 days before the appearance of the inflorescence. It is sooner for the early varieties and slower for the late varieties. The stage during which the spore cells divide is about 10 to 12 days before the actual appearance of the compound inflorescence.

These methods of using the appearance of certain organs to judge the growth stage of the young inflorescence is rather convenient, however, due to the difference in varieties, planting conditions, and years, discrepancies may sometimes occur. When rules of technical measures are being formulated, it is important to combine theory with actual experience.

5. GROWTH OF THE STALK [p 93]

The stem not only supports the above ground organs, it also serves to store and to transport nutrients. A strong stem may bear heavy weight of the plant and resist the wind. It may carry a large amount of nutrients to supply the needs of the inflorescence.

The stem is made up of the nodes and the space between the nodes. The space closer to the base of the plant is the shortest, and

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it is longer toward the upper part of the plant. Generally speaking, the longer the plant grows the more spaces between the nodes it has. The growth condition of the stem is determined by the environmental condition and the harmonious relationship between the stem and the other organs of the plant body. In practice, reasonable density, fertilizer application, water, and field management are the measures used to improve the relationship between the stem, the leaves, and the root system. Based upon the actual conditions, the growth of the stem is either promoted or controlled for the purpose of obtaining strong and healthy plants.

Under certain conditions, if the density is too high, the dry weight of the plants, and the leaf area become smaller. There is a certain limitation in the formation and accumulation of materials. In these cases, the space between the nodes is too long, and the unit dry weight is low. These conditions do not happen, if the density is proper. Therefore, a reasonable density is beneficial to stem as well as to the inflorescence.

Table 4-23 The Growth Conditions and the Stem of Lao-lai-ch'ing in Various Densities

每亩基本苗数（万）(1)	50	30	25	15
叶面积（厘米²/蘖）(2)	85.0	91.3	97.5	107.0
干重（克/蘖）(3)	1.11	1.17	1.27	1.35
鞘重（毫克/蘖）(4)	673	705	788	877
第一节间长度（厘米）(5)	3.6	3.1	3.2	2.4
茎粗（毫米）(6)	3.	4.4	4.7	4.8
第一节间内外轮维管束数 (7)	24.9	26.8	26.6	27.0
基部0—10厘米茎秆单位长度干重（毫克/厘米）(8)	19.6	27.5	23.1	37.8

1. Number of seedlings per mou (10,000)
2. The area of the leaf (cm^2/stalk)
3. Dry weight (gram/stalk)
4. Gross weight (mg/stalk)
5. Length of the first space between the nodes (cm)
6. Diameter of the stem (mm)
7. Number of vascular bundles
8. Unit dry weight of the stem at the base 0-10 cm (mg/cm)

Fertilizer and moisture have obvious effects on the growth of the stem. Under similar density, with sufficient fertilizer, the individual plant grows better. This is verified by the larger leaf

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area, heavier weight, and thicker stems. Obvious improvement in stem growth may also be obtained with irrigation. However, the plants which grow in deep water have larger stems which are higher in water content and softer in structure, and the plants are more liable to fall. In production, during the time the nodes are growing on the stems, and before the inflorescences begin to appear, the field is properly drained, to let the soil be exposed to the sun. This is to control the growth of the above ground stems and to promote the growth of the root system. The stems may thus store more food, and their mechanical tissues may grow thicker. This practice is beneficial to the evolvement and the formation of the inflorescence.

Table 4-24 The Growth Conditions of the Stem of Late Rice Plants under Different Amounts of Fertilizer Application

施肥量（猪厩肥担/亩）(1)	95	72	50
叶面积（厘米²/蘖）(2)	31.1	30.8	29.6
干重（毫克/蘖）(3)	233	212	199.5
鞘重（毫克/蘖）(4)	133	119	112
第一节间茎粗（毫米）(5)	3.2	3.0	2.9
外轮维管束数 (6)	27.0	26.3	24.6
茎壁厚度（微米）(7)	766	746	734

1. Amount of fertilizer applied (tan of pig manure/mou)
2. Leaf area (cm^2/stalk)
3. Dry weight (mg/stalk)
4. Gross weight (mg/stalk)
5. Diameter of the first space between the nodes (mm)
6. Number of the vascular bundles
7. The thickness of the stem wall (micro-meter = 0.001 mm)

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Table 4-25 The Growth of the Stem in Relation to the Irrigation Methods

(1) 灌溉条件	(2) 茎粗（毫米）	(3) 机械组织厚度*	(4) 气室直径*	(5) 茎秆含水量（%）	(6) 抗折断力（克）
(7) 深水不晒田	4.0	3.0	13.1	76.2	—
(8) 浅水不晒田	3.5	—	8.1	—	28.3
(9) 浅水晒田	3.2	3.7	5.3	—	36.4

* 气室直径和机械组织厚度的单位为显微镜10×8接目测微尺的格数。(10)

注：品种853。(11)

1. Irrigation method
2. Diameter of the stem (mm)
3. Thickness of the mechanical tissues*
4. Diameter of the air holes*
5. Water content of the stem (%)
6. Ability to resist falling (g)
7. Deep water, and the soil is not sunned
8. Shallow water and the soil is not sunned
9. Shallow water and the soil is sunned
10. * The diameter of the air hole and the thickness of the mechanical tissue were measured with microscope 10x8.
11. Note: the test was conducted with the No. 853 variety.

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SECTION 4. SPIKE HEADING AND FRUITING STAGE [p 94]

1. PROCESS OF HEADING, FLOWERING AND FRUITING [p 94]

(1) The Flower

The inflorescence of rice plants appears two to three days after the pollen becomes mature, with the speed determined by the speed with which the stem grows. The plant generally flowers faster under higher temperatures, slower when the temperature is low. Liang Kuang-shang (2733 0342 0794) observed in Kwangtung that from the time the first inflorescence appears at the very top pedicel to the time the entire inflorescence completes its growth is about five days. During this period of time, according to the observation of Chuang Min-yu (1641 2404 3768), the stem grows an average of 1.2 cm.

Under normal conditions, after the inflorescence appears, the very day, or one or two days afterward, the flowers begin to bloom. The blossoming process varies with the variety, the region, the climate, and the environmental conditions. According to the observations of Ting Ying (0002 4481) and Liang Kuang-shang (2733 0342 0794), the early variety Tung-wan-pai No.23 begins to blossom about 40 hours after the small inflorescence appears above the pedicel. Due to water absorption, the flower becomes three times as big, and the filament is about 8.8 mm long when the flower blossoms. The anther breaks about four minutes after the flower blossoms, and the pollen spreads out. The flower withers in about eleven minutes, and at that time, the length of the filament is about 10 mm. The entire blossoming period is about 13 minutes. The outer and the inner racemes open to a maximum of 24 to 30°. After they are open, they remain open for about 9 minutes. Then, they begin to close, and it takes about 25 minutes for them to be completely closed. Therefore, for every inflorescence, from the beginning to the end, the process takes about 1 hour.

According to observations, in the various rice growing areas, the process lasts about the same. The inflorescence on the tip of the stem blossoms first. Then, all the

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inflorescences of the middle section blossom all at the same time. Those of the lower part blossom the latest.

Generally, rice plants blossom earlier in the south and later in the north. In the same region, the early and the medium varieties blossom earlier and the late varieties blossom later. For the early and the medium varieties, as soon as the inflorescence appears at the tip, some of the flowers blossom on the same day. The flowers are at their peak the second or the third day. For the late varieties, the flowers begin to blossom the second day after the first inflorescence appears, and the peak comes on the fourth or fifth day.

The most suitable temperature for the blossoming period is about 30°C, and the most suitable relative humidity is about 70 to 80%.

Table 4-26 The Blossoming Time in One Day in the Various Areas

地区 (1)	品种 (2)	开花时间 (3)	盛花时间 (4)
(5)广东广州	早籼稻(9)	上午6时半至下午4时半(16)	上午10时半至11时半(23)
(5)广东广州	晚籼稻(10)	上午9时至下午2时 (17)	上午11时至12时 (24)
(6)江西莲塘	早稻(11)	上午7时至下午3时 (18)	上午9时至11时 (25)
(6)江西莲塘	晚稻(12)	上午10时至下午3时 (19)	上午10时至12时(26)
(7)南京	早、中稻(13)	上午8时以后 (20)	上午10时至11时 (27)
(7)南京	晚稻(14)	上午9时以后 (21)	中午前后 (28)
(8)北京	银坊(15)	上午10时至下午6时 (22)	下午2时至3时 (29)

1. Place 2. Variety 3. Blossoming time 4. Peak period
5. Canton, Kwangtung 6. Lien-t'ang, Kiangsi
7. Nanking 8. Peiping 9. early hsien 10. late hsien
11. early variety 12. late variety 13. early and medium
14. late variety 15. Yin-fang 16. 6:30 A.M to 4:30 P.M.
17. 9 A.M. to 2 P.M. 18. 7 A.M. to 3 P.M.
19. 10 A.M. to 3 P.M. 20. After 8 A.M. 21. After 9 A.M.
22. 10 A.M. to 6 P.M. 23. 10:30 A.M. to 11:30 A.M.
24. 11 A.M. to 12 A.M. 25. 9 A.M. to 11 A.M.
26. 10 A.M. to 12 A.M. 27. 10 A.M. to 11 A.M.
28. After the noon hour 29. 2 P.M. to 3 P.M.

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(2) Fertilization and Seed Formation

As soon as the anther breaks and the pollens are shed on a stigma, the pollen grain germinates. According to the observation of Yang Li-chiung (2799 4539 8713), the pollen tube grows down and enters the ovary four hours after the flower blosoms, and in another four hours the fertilization is completed. About 4 to 6 hours after the egg meets the first sperm nuclei, the first cell division occurs. In four to five days, the embryo begins to evolve. About 8 to 10 days after the flower blossoms, the various parts of the embryo become recognizable. Another sperm fuses with the two polar nuclei to form the endosperm nucleus, the continuous division of which fills the embryo sac with endosperm tissue. This is accomplished about four days after the flower blossoms, and the sac reaches its maximum size in about six to seven days after the flower blossoms. The formation of the endosperm tissue is faster for the early varieties and slower for the late varieties.

Ting Ying (0002 4481) and co-workers observed the growth of the grains of the early hsien variety No.305 and the late hsien variety Han-ha. They found that the fresh grain (pick a sample and take off the hull and measure it immediately) reaches its maximum size on the seventh to eighth day after the flower blossoms. The length of the dry grain of the early varieties reaches the maximum on the twelveth day and that of the late varieties on the sixth day. The width of the fresh grain of the early variety reaches the maximum on the seventh day, and that of the late varieties on the eleventh day. For dry grains, the maximum width is reached on the 14th and the 18th day respectively. Regarding the thickness of the fresh grains, the early varieties are on the 16thday, and the late varieties are on the 18th day when the maximum is reached. For dry grains of both the early and the late varieties, the maximum is reached on the 18th day after the flower blossoms. For the Yin-fang variety of Peking which is a keng subspecies, the maximum length is reached on the 8th to the 9th day, and the maximum width and thickness are reached on the 13th day. Therefore, generally speaking, the growth in length is the fastest, that of the width is the next, and that of the thickness is the slowest; while in all dimensions, the grain reaches its maximum growth on the 18th day after the flower blossoms.

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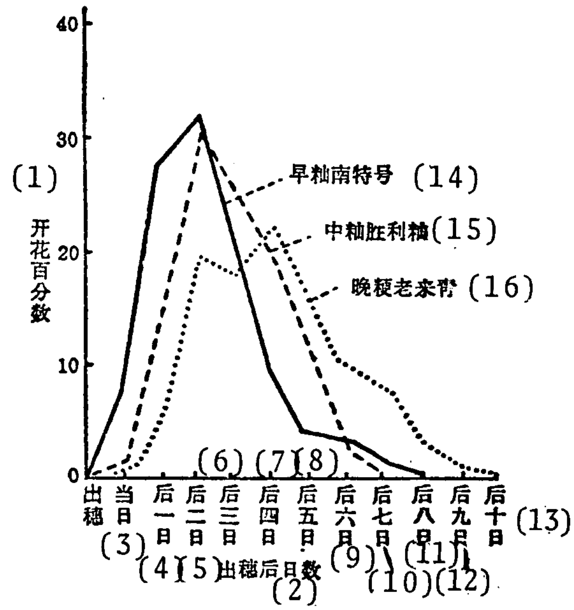

Diagram 4-15. Percentage of Blossoming Flowers in a Compound Inflorescence Every Day.

1. Percentage of blossoming flowers
2. Number of days after the inflorescence appears
3. The same day 4. one day later 5. two days later
6. three days later 7. four days later 8. five days later
9. six days later 10. seven days later 11. eight days later 12. nine days later 13. ten days later 14. Early hsien Nan-t'e-hao 15. medium hsien Sheng-li-hsien 16. Late keng Lao-lai-ch'ing

After Ting Ying (0002 4481) and co-workers had studied the weight of the dry substance, the contents, the external shape, and the outside hull, they began to understand the standards with which the development of the rice grain may be divided into the four stages of milk-ripe, wax-ripe, complete-ripe, and fully ripe. When starch begins to accumulate within the grain, there is white colored fluid, and the milk-ripe stage begins. This happens on the third day after the flower blossoms for the early varieties, and on the fifth day for the late varieties. Then, the white fluid gradually turns thick and pasty until the liquid disappears and the milky cells become hardened. At that time, the milk-ripe stage ends and the wax-ripe stage begins. The back of the grain is still green colored at this time, but the hull has begun to turn yellow. The shape of the grain is generally formed, but it is not yet transparent. The milk-ripe stage lasts seven days for the early varieties, and nine days for the late varieties.

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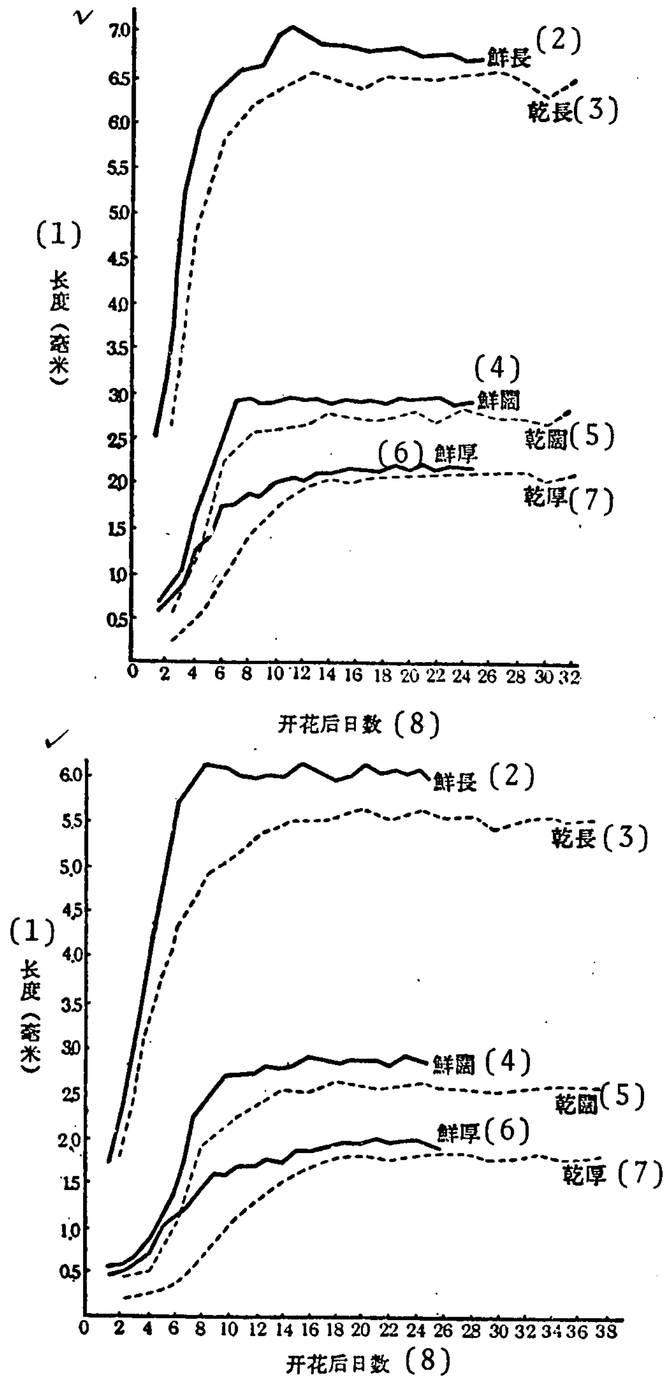

Diagram 4-16. The curves for the Length, Width and Thickness of the Fresh and the Dry Grain. Early hsien Hsien-chan No. 305 (above)
Late hsien Han-ha (below)

1. Length (mm)
2. Fresh length
3. dry length
4. fresh width
5. dry width
6. fresh thickness
7. dry thickness
8. number of days after the flower blossoms

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After the grain is hardened, the green color on its back gradually disappears. When at last the green color disappears from the back furrow, the wax-ripe stage ends, and the complete-ripe stage begins. The wax-ripe stage lasts seven days for the early varieties, and eight days for the late varieties.

When the complete-ripe stage begins, the hull has turned yellow, and the grain is turning white. It is hard and cannot be easily crushed. Then, the color of the hull begins to fade. The protective palea and the stem begin to wither. The top part of the stem may even be broken. The grain may have traces of crosswise lines. This is the fully-ripe, or the withering-ripe stage.

According to observations in the various rice growing areas, the ripening stages are shorter in the early varieties. The process lasts longer in the late varieties. The temperature requirements for these two types of rice plants during the ripening stages are different also. The quality of the grain of the early varieties is relatively inferior, and this is perhaps due to the fact that during the ripening stages, the temperature is higher, the temperature differential is small, and the ripening process is fast, therefore, a smaller amount of the carbohydrates is transformed into protein.

(3) The Effect of the Environmental Conditions on the Rate of Seed Formation

Environmental conditions affect fertilization a great deal. Measures must be taken to overcome the disadvantageous factors to increase the number and the weight of the seeds. The major environmental factors are temperature, daylight, rainfall, and the speed of the wind. The rate of empty hulls is low, when all the four factors are right. A great deal of research has been conducted in the various rice growing areas for preventing empty heads. The following are a few examples of the information we obtained through these research studies.

Low temperature has bad effects on fertilization for the early and the late varieties. Since when the flower of the late varieties blossoms and during the process of fertilization, the temperature is changing from high to low, therefore, the plants are easily damaged by low temperature, with a high rate of empty heads as the result.

For example, Hunan Provincial Weather Bureau reported that from the 15th to the 19th of September, 1957 was the period the rice inflorescence blossoms. The average temperature during the day was 22.9° to 25.4°C. The record highest temperature was 26.4° to 30.4°C, and the lowest was above 20°C. At that time, the rate of empty heads was below 17%. Then, from the 15th to the 30th of September, the average temperature suddenly dropped to below 20°C. The highest

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temperature was below 25°C and the lowest temperature was 14.7°C. The rate of empty heads was raised to 30%. Then, on the two days of the 29th and the 30th, the crop was further affected by the rainfall. The rate of empty heads reached above 50%.

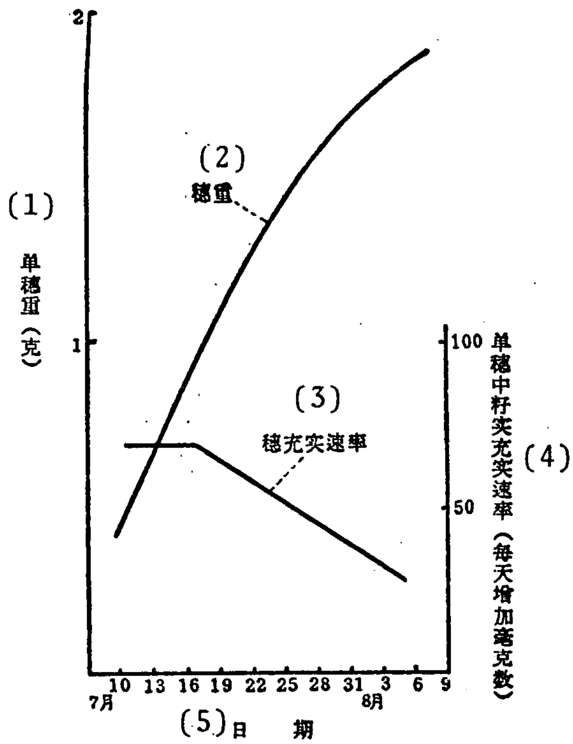

Diagram 4-17 The Rate of Weight Increase of the Grains of Bearded Keng Varieties

1. Weight of a single head (g) 2. Weight of the head 3. The rate at which the head is becoming full 4. The rate at which the seed within a single head is becoming full (the number of gm increased per day) 5. Date 6. July 7. August

It is difficult for the flower buds to blossom and pollinate if the average temperature is below 20°C and the highest temperature continuously stays below 23°. Under such temperature conditions, most of the flowers cannot be fertilized.

Daylight directly affects organic synthesis. If the daylight is weak during the time of inflorescence and fertilization, the number of empty heads increases, and the weight of a thousand grains drops.

When the late varieties of rice plants flower and fertilize, it is often the time for autumn rains in some regions. The rains at this time are bad for production. If the temperature does not drop markedly and the rainfall is less than 5 mm, the effect will not be very obvious. If the rainfall is from 5 to 10 mm, there will be some effect; if it is about 30 mm, the effect will be quite obvious; if it is more than 60 mm, the effect will be great.

As the farmers say "the rice is afraid of the noon winds;" most of the paddy rice varieties blossom from 9 A.M. to along noon, so strong winds at this hour are very damaging. According to observations in Hunan, on the 23rd of August the speed of the wind suddenly increased from 1 m per second to 6 m per second; the rate of empty heads increased from 29% to more than 40%.

2. PHYSIOLOGICAL AND BIOCHEMICAL CHANGES DURING HEADING AND FRUITING [p 99]

After the period of inflorescence and fertilization the starch is continuously being formed in the endosperm, and the weight of the dry substance rapidly increases. According to Ting Ying's (0002 4481) observation, for the early varieties, the weight of the dry substance increases at the highest speed between the fourth day and the 12th day after the flower blossoms. On the 16th day, more than 85% of the weight of the dry substance has been formed. For the late varieties of the continuous crops, the weight of the dry substance increases the fastest from the second day to the fourteenth day, and more than 75% of it is formed on the 14th day. (Diagram 4-17) Within a single stalk, the flowers which blossom early have fewer empty heads. On a single head, the lower part is slower to grow seeds. On a single stalk, the main stem grows faster and better heads than the tillers. The seeds become full in accordance with the same order as the blossoms are open. That is in the order of the first, the sixth, the fifth, the fourth, the third, and the second.

During the later part of the period of fertilization, the supply of the nutrients drops and the number of empty heads increases. Besides, if some buds are cut off near the period of inflorescence, there will be fewer empty hulls in the remaining ones. If the vascular bundles at the neck are cut to reduce the food supply, or a leaf at the top is cut off, the number of the empty hulls may increase. This explains that the supply of nutrients is closely related to the formation of the empty hulls.

Table 4-27 The Order in Which the Flowers of a Single Stalk Blossom, and Its Relationship to the Rate of Empty Hulls

品 (1) 种	(4) 空秕率										
	主(5)穗	一株中各分蘖穗的开花次序 (6)									
		1	2	3	4	5	6	7	8	9	10
(2) 矮架麻谷	6.2	5.8	6.1	8.4	11.8	16.5	21.5	28.8	32.9	41.0	36.9
(3) 三百棒	12.4	7.6	11.8	16.1	12.2	15.9	24.0	31.7	—	—	—

1. Name of variety 2. Ai-chia Ma-ku. 3. San-pai-pang
4. Rate of empty hulls 5. Main head 6. The order in which the flowers of the various heads of a single stalk begin to blossom.

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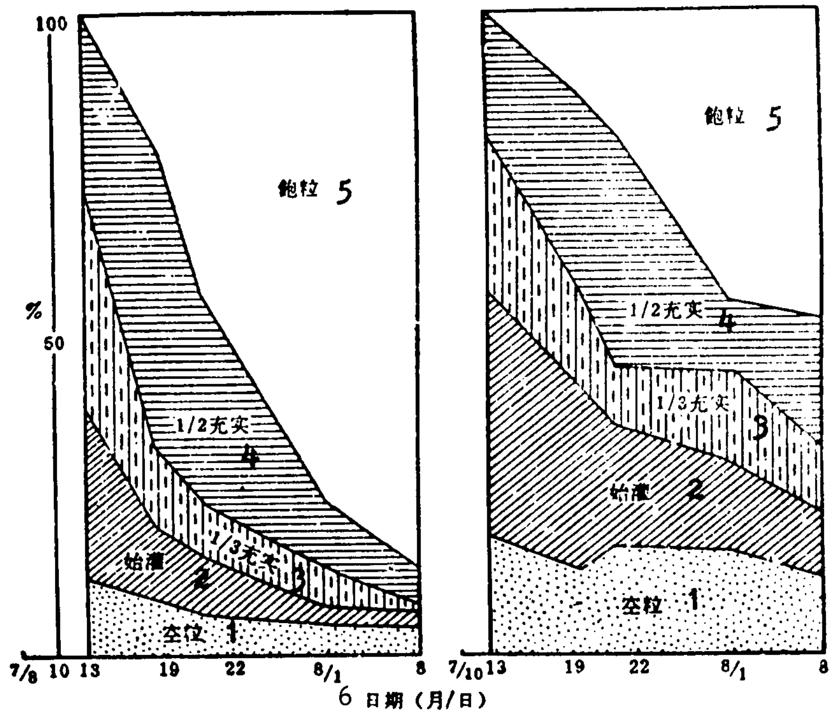
Diagram 4-18 The Growth Condition of the Grains of a Single Head of a Variety of Bearded Early Keng Rice Plant



1. Empty grains 2. Begin to be filled 3. 1/3 full 4. 1/2 full
5. Full grain 6. Date (Month/Day)

Tests prove that a great portion of the dry substance of the grain comes from photosynthesis after the head has appeared, and only a small portion is the result of transfer from earlier accumulations (2/3 to 3/4 versus 1/3 to 1/4). Tests with radioactive carbon dioxide prove that at the time when the head appears, the nutrients from the leaves are transferred largely to the stem, while after the flowers have blossomed, the nutrients go to the heads of the plant instead. During the blossoming and milk-ripe period, the nutrients assimilated by the leaves mainly go to supply the heads of the same stem, with a portion of them retained in the leaves themselves. Very little is sent to the other parts of the plant. Besides, since the leaf area begins to drop at that time, while the production from pure photosynthesis reaches its maximum during the milk-ripe stage, in order to maintain a full supply of organic matter, the plant must have a good nutritional foundation prior to that stage and a certain leaf area must be maintained. However, if the leaf area is too large, the large shade area may have adverse effect on

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yield. Moreover, a sufficient water supply during this stage is also important. When the water is drained too early from the rice paddy, some of the late ripening seeds may fail to grow full.

The process of blooming and ripening is accompanied by the activities of the carbohydrate synthesis enzymes and the hydrolytic enzymes. According to the reports of Yin Hung-chang (3009 1347 4545) and others, at first there is not much activity of the carbohydrate synthesis enzymes (the phosphate transfer enzymes) until about one to three weeks after the flowers have blossomed (the later part of the milk-ripe stage). The activity of these enzymes reaches the maximum during this stage, and tapers off after the wax-ripe stage. Almost none can be detected after the grain is ripe. This changing process corresponds exactly with the changing speed with which the carbohydrates of the grain accumulate. This fact indicates that there is a definite relationship between phosphate transfer enzymes and the formation of carbohydrates in rice. The activity of the hydrolytic enzymes (beta-carbohydrates) shows the same tendency, although the change is not as obvious. After the starch is dissolved to form maltose, the maltose is immediately digested or transferred into sucrose. Therefore, the existence of maltose is often not detected in the grain.

The transpiration function is also at its highest during the milk-ripe stage. It indicates that the metabolic level is high, and that the accumulation of carbohydrates and other substances is closely related to the entire metabolism. Hsiang-chien Ling-san [a Japanese scientist] also reported that the weight of the dry substance of the grain increases extremely fast after fertilization, and the maximum is reached in twenty days. The speed of this increase is the fastest from the 16th to the 20th day. The activity of the phosphate transfer enzymes is the strongest from the fifteenth to the twentieth day, and drops thereafter. At first there is a considerable amount of inorganic phosphorus. Then, as the amount is gradually reduced until about the 25th day after fertilization it disappears entirely. The activity of the phosphate transfer enzymes is at its highest when the temperature is about 30°C and the pH value is about 6.5.

In conclusion, we believe that in order to improve the fullness of the grains, the environmental conditions for the growth of the plant must be controlled so that the root system may be properly absorbent and a certain leaf area is maintained for efficient photosynthesis to supply the grains with the needed nutrients for proper ripening process. Besides, a proper relationship between the nourishing organs and the reproductive organs is also important. The former should not be allowed to overgrow the latter. Measures to improve the growth condition of the grains, to increase the ability of carbohydrate synthesis and the ability to absorb organic and inorganic nutrients are the proper methods for reducing empty hulls.

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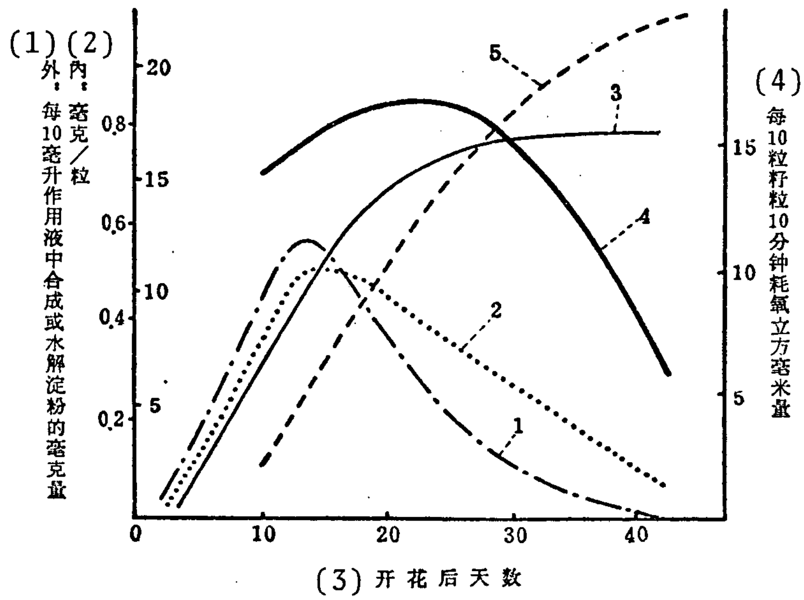
Diagram 4-19 Changes in the Activities of the Carbohydrate Synthesis Enzymes and the Hydrolytic Enzymes, the Content of Starch, and other dry substances, and of Transpiration (Ch'ang-ch'i T'ieh-kan-ch'ing, a late keng variety)



1. Outside: number of mg of hydrolyzed or synthesized starch per ml
2. Inside: mg/grain
3. Number of days after the flower blossoms
4. The amount of oxygen (cubic mm) transpired by 10 grains in 10 minutes

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SECTION 5. REGENERATION OF RICE [p 101]

After the rice has been cut and harvested, new tillers may be seen growing out of the old stumps. Under certain conditions, heads may eventually appear on these tillers and may become ripe. In the regions of warm winters, the rice stumps may survive the winter and become a perennial plant. The low fields around the lakes of Hunan and Hupei have good examples of the revived rice plants.

1. STATE OF THE LEAF BUDS ON THE NODES ON THE STEM BEFORE AND AFTER MATURITY [p 102]

A sprout grows on every leaf bud of the stem of the rice plant. If conditions are suitable, the sprouts near the base may grow into tillers. By the time the nodes appear and the heads begin to evolve, the plant usually stops having more tillers. The nodes usually have dormant sprouts. These sprouts are generally not alive, especially the lower ones which are generally no longer alive at the time the heads appear. Yang K'ai-ch'u (2799 7030 3255) reported that the number of live sprouts on the stalk drops as the grains are beginning to ripen. At the time the heads appear, each stem has an average of 3.5 live sprouts. When the grains are ripe, there are only 1.6 or 1.1 live sprouts for each stem, only about 52 to 68.7% of the live sprouts at the time the heads appear.

Table 4-28 The Number of Live Sprouts on the Stem from the Heading Time Onward

品 (1) 种		(6) 调查日期（月/日）					
		7/20 (出穗) (7)	7/27	8/3	8/10	8/17	8/24 (完熟) (8)
水白条 (2)	实数	3.4	3.3	3.3	2.9	2.1	1.6
	% (5)	100.0	98.0	96.5	85.1	62.3	48.0
小南粘 (3)	实数	3.5	3.3	3.2	2.9	1.9	1.1
	(5) %	100.0	93.1	90.1	82.0	53.3	31.3

(9)注：每期调查 450 稻秆的活芽平均数。

1. Name of variety 2. Shui-pai-t'iao 3. Hsiao-nan-chan 4. Actual number 5. Percentage (%) 6. Day of survey 7. Heading time 8. Ripening time 9. Note: The average number of live sprouts from the 450 rice plants surveyed each time.

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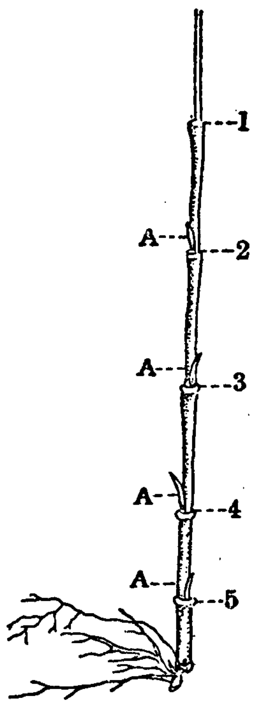

Diagram 4-20 The Sprouts on the Nodes at the Time of Harvest

The dormant sprouts near the base usually die first. Those of the upper nodes remain alive longer. Table 4-29 shows that the largest percentage of the live sprouts is found from the third node up.

When the grains are almost ripe, the sprouts quickly turn yellow and die, from the bottom to the top. The number of live sprouts remaining is closely related to the number of green leaves retained by the plant when the grains are ripe. Either due to the characteristics of the variety or due to the high level of nitro-fertilizer retained in the soil, some of the leaves fade slower. Or, in case the main stem is damaged prematurely, a greater number of live sprouts may be preserved. Therefore, if a suitable amount of fertilizer is applied just before the grains are ripe, more of the dormant sprouts may be kept alive for the purpose of cultivating a field of revived rice plants.

In the case of the keng varieties, the upper sprouts die before the base ones, exactly the opposite condition of the hsien varieties. Therefore, all revived plants of the keng varieties must be tillers of the sprouts near the base. The sprouts near the base are always larger and it is easier to be preserved through the winter if they are alive when the grains are ripe. Therefore, if we want to cultivate revived rice plants, it is better to use the keng varieties.

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Table 4-29 The Distribution of the Live Sprouts on the Various Nodes of the Rice Plant (%) (The Variety of Shui-pai-t'iao)

调查日期 (1) (月/日)	(4) 顶叶节	(5) 第2节	(6) 第3节	(7) 第4节	(8) 第5节	(9) 第6节	(10) 共计	实际总活苗数 (11)
7/20 (出穗)(2)	5.5	29.9	29.8	25.9	8.0	0.9	100.0	3.4
7/27	5.8	30.1	30.2	25.0	7.9	0.8	99.8	3.3
8/3	5.4	30.6	30.9	23.5	8.9	0.8	100.1	3.3
8/10	5.9	34.7	32.6	19.8	6.5	0.8	100.3	2.9
8/17	6.5	44.2	34.5	11.4	3.1	0.3	100.0	2.1
8/24 (完熟)(3)	8.7	39.6	35.7	12.7	3.1	0.1	99.9	1.6

1. Date of survey (month/day
2. (heading time)
3. (ripening time)
4. The top node
5. The second node
6. The third node
7. The fourth node
8. The fifth node
9. The sixth node
10. Total
11. Total actual number of sprouts

2. GROWTH AND DEVELOPMENT OF REGENERATIVE TILLER [p 103]

If the hsien varieties are used to cultivate revived rice plants, as many upper sprouts are preserved as possible, because the lower ones often die first. According to the experiment conducted by Yang K'ai-ch'u (2799 7030 3255) there is a relationship between the yield of the revived plants and the length of the stump left from the old crop. The taller is the stump, the earlier is the harvest of the revived plant, and the better is the yield.

When the late rice crop is harvested, there may be a great deal of live sprouts left on the stumps, but the temperature at that time is quite low and the revived tillers grow very slowly. If they come to a head at all, good yields seldom materialize. Therefore, late varieties are seldom used to cultivate revived crops. However, sometimes the late variety of a continuous crop may be preserved through the winter. Generally, these plants may react normally toward the local weather conditions next year. The condition of the live sprouts and the temperature during the time they are preserved are the key factors for the success of this method.

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Table 4-30 The Harvest Time of the First Crop, the Height of the Stumps, and the Yield of the Revived Rice Plants

Date of the harvest of the first rice crop (month/day)	8/24			3/29			9/4			9/9		
The yield of the first crop (chin/mou)	717			702.2			734.2			710.7		
The height of the stump	1/5	2/5	3/5	1/5	2/5	3/5	1/5	2/5	3/5	1/5	2/5	3/5
The yield of the revived plants (chin/mou)	18	109	152	16	109	125	17	40	123	11	25	103

Note: The plants come to a head on 25 July. The variety is Shui-pai-t'iao

In the Yangtze Valley, the harvest of the medium variety is in August, and the revived plants generally can come to a head in the middle or later part of September, when the temperature is still not too low yet, and the yield will not be seriously affected. Therefore, in areas of Hunan, Hupei, Szechwan, and Anhwei, the medium varieties are often used to cultivate a revived crop.

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CHAPTER 5. CLIMATIC CONDITIONS FOR CHINA'S PADDY RICE CROP

[p 109]

The growth, distribution, and planting techniques of paddy rice are closely related to climatic conditions. The special climatic conditions of China for rice culture include the following three aspects:

First, China has excellent climate for rice culture. The regions south of Nan-ling are suitable for growing rice almost all year long. The regions north of Nan-ling, and south of Huai-ho and Ch'in-ling have over 200 days a year of growing season, and two crops of rice may be grown every year. From the north of Ch'in-ling and Huai-ho to Mo-ho of Heilungkiang, the growth season is above 100 days, and a single crop of rice may be cultivated. The vast regions of the east and the south in our country are affected by the monsoons. The temperature is rather high during the rice growing season and the rainfall is plentiful. The daylight is short in the south but very intense. In the north, in the autumn during the rice growing season, the days are always clear and bright. All these are favorable conditions for the growth and maturity of the rice plants.

Second, within our vast boundaries, rice is distributed in the tropic, the subtropic, and the temperate zones. Rice fields are found in the highlands, the basins, the hills, the valleys, and the plains. When it is 40°C below zero in Heilungkiang, farmers are planting rice seedlings in Hai-nan-tao. In the summer, the temperature of such places as Ch'ang-sha and Nanking may reach above 43°C. It is really too hot for rice plants. However, at the same time in K'un-ming, the highest temperature is no more than 33°C.

In the Northeast, daylight stays over 14 hours and longer. In South China, the longest is no more than 14 hours.

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With respect to rainfall, during the rice growing season, it may reach 2,000 mm in Kwangtung and Taiwan, while in the regions of the Northwest it is not quite 100 mm. Through thousands of years of productive practice, our farmers created many cultivating methods and varieties of seedlings to suit the diverse climatic conditions of the various rice growing regions. The fruits of their labor are China's treasure in rice culture.

Third, due to the effect of monsoons, the major rice regions of China suffer from extreme climatic variations from year to year. In the same area, during the same season, it may be warm and clear one year, but rainy and cold the next. Since rice plants have strict requirements regarding heat and moisture, climatic variations bring adverse effects to their growth.

In this chapter, we shall discuss the general conditions of temperature, daylight, and rainfall in relation to rice culture, and the measures for utilization and improvement with regard to such unfavorable conditions as the frost and the typhoon.

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SECTION 1. GENERAL CLIMATIC CONDITIONS FOR CHINA'S PADDY RICE CROP [p 110]

1. CHINA'S GEOGRAPHIC ENVIRONMENT AND CLIMATIC CONDITIONS FOR RICE CROP [p 110]

(1) Latitude The Regions of high latitude have longer daylight amd colder temperature. The growth season is shorter, and there can be only one crop of early rice varieties. (such as the Northeast) The regions of low latitude have shorter daylight, higher temperature, and a long growth season. There may be two or three crops of rice, (such as South China). The climatic conditions may vary in regions of the same latitude, but the difference is not as obvious. Therefore, latitude more or less determines the varieties of rice plants and the method to be used for planting them in the various rice growing regions of our country.

(2) The Oceanic or Continental Positions

China forms an extension of the Eurasian Continent in the west and the north. In the south and the east, she faces the Pacific Ocean, and is only a short distance from the Indian Ocean across India and Burma. This geographical position makes the climate of China extremely affected by monsoons. During the rice growing season, the eastern half of the country becomes increasingly hotter due to the large angle of the sun. On the other hand, the oceanic monsoons bring humid air from the Pacific and the Indian Oceans, and often result in precipitation. This condition of high temperature and high humidity, with plenty of rainfall is particularly favorable for the growth of rice.

The climate of a region varies with the distance from the ocean. The coastal provinces of the Southeast have largely oceanic climate. The temperature and rainfall are more even. This is a favorable condition for rice plants. The climate of the west and the north is more continental. However, there is less fog; the daylight is long; and the temperature difference between the day and the night is greater. These are

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also favorable conditions for the rice plants.

(3) The Terrain

From Ta-hsing-an-ling to the southwest through T'ai-hsing-shan, Ch'ing-ling, and Ta-hsueh-shan, the various mountains form a straight line. The west of this line is high and mountainous, while the east of this line is a vast plain, with a few disarrayed hills and mountains in its southeastern part. This type of terrain makes it possible for the oceanic climate to spread to the entire eastern part of the country. The monsoons may travel along the narrow gorges of Heng-tuan Mountains to reach the highlands of Yunnan and Kweichow. Thus, these regions are also blessed with plenty of rainfall, and become very suitable for rice crops.

The regions to the west of the aforementioned line are not affected by the oceanic monsoons, and the rainfall is scanty, but the ice and snow of the high mountains may be gainfully utilized.

Moreover, due to the slow terrain of the eastern part of the country, when the cold current of Siberia moves southward, it may often reach the regions of South China. Therefore, during the early and the late stages of a rice crop, the various regions of the north and the south must all be watchful of the cold currents. The Szechwan basin is shielded by Min-shan of Ch'in-ling in the north and Kung-lai-shan in the west. There is less chance of being attacked by the cold currents. Therefore, compared with the other regions of the Yangtze Valley of the same latitude, spring comes to Szechwan Basin earlier, and the early rice plants may be planted earlier than the other areas.

2. RELATIONSHIP BETWEEN RICE CROP PRODUCTION AND AIR MASSES OVER CHINA [p 111]

Aside from the aforementioned geographical factors, the activities of the air masses within our country's boundaries also affect the climatic conditions. Such air masses as the polar continental, the tropical oceanic, the equatorial oceanic, the subtropical continental, and the warm air mass of the Southwest are very important for rice crops.

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The source of the polar continental air mass is Siberia. It enters our country from the north (in the winter it is called the continental monsoon), and is very cold and damaging to the growth of rice plants. However, as it moves southward its nature changes. It becomes warmer and more moist, and consequently more favorable for rice plants.

The tropical oceanic air mass originates in the tropic region of the Pacific Ocean. It is warm and humid, and very suitable for rice plants. In the summer half of the year, it moves from the southeast to the southern, central, and northern parts of our country. This is the southeast monsoon which has the greatest effect on the rice production of our major rice growing regions.

The equitorial oceanic air mass originates in the Indian Ocean. It is the warmest and contains the most moisture. During the summer half of the year, it moves from the south or the southwest to the southern and central parts and the highlands of Yunnan and Kweichow. This is the southwest moseon, which is also favorable to rice production. The farmers of Kiangsu call the southwest wind the gold wind, because it often comes just when the medium varieties are beginning to develop nodes and tillers and need its supply of heat and moisture.

The source of the subtropical continental air mass is still not determined at present. It is perhaps the Ch'ing-tsang Plateau and the southern part of Sinkiang. This air mass is arid and hot. In the summer, it brings clear, dry, and hot air to the regions of Shensi and Szechwan.

The warm current of the southwest moves from the high atmosphere of the equatorial region to our country in the winter half of the year. In the spring, it frequents Yunnan and the west part of Szechwan. Due to the prevailing west wind at that time, this dry current often causes spring drought in these regions. However, if irrigation is available, this air current and the subtropical continental air mass we just mentioned may be utilized for their heat and light energy and cause them to become favorable for rice plants.

The two contrasting air masses often come into contact, and along their interface, a cyclone wave may be created (low-pressure). Along the interface and the low-pressure areas, there soon is cloud formation and precipitation, which directly affect rice production.

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SECTION 2. TEMPERATURE CONDITIONS FOR CHINA'S RICE CROPS [p 112]

1. BEGINNING AND ENDING GROWTH STAGES OF PADDY RICE [p 112]

With regard to climate, the period which is suitable for the rice plants to grow from the beginning to the end is called the rice growing season. In our country, the length of the rice growing season is determined by temperature, because it is not correct to use the frostless concept to reflect the rice growing season. In the spring, even if there is no frost, if the temperature is not right, the rice plant cannot begin to grow. If the growth has begun, the young plant can often resist frost if it should come. In the fall, the end of the rice growing season for most regions is not determined by the coming of the frost either. It is mainly determined by the low temperature during the heading and the blossoming stages. Generally speaking, the average frostless season is longer than the rice growing season, while the absolutely frostless season is shorter than the latter. For example, in Shanghai, on the average the frost ends on the 20th of March, and begins on the 23rd of November, with an average frostless season of 243 days. However, the latest frostless day is 18th of April and the earliest frost day is 9th of November. Therefore, the absolute frostless season is only 204 days. The rice growing season in Shanghai is from the 25th of March to the 5th of November, a total of 220 days.

(1) The Beginning of the Rice Growing Season

When there are no temperature protective measures, the rice growing season begins when the young seedlings may safely begin their growth. When the average temperature rises to above 10°C the varieties of the keng subspecies may begin to sprout, and when it is above 12°C those of the hsien subspecies may begin to sprout. The constant temperature tests conducted in a Nanking Laboratory by the Central Weather Bureau and the former Hua-tung Institute of Agricultural Sciences indicate that the keng varieties sprout when the temperature is about 12°C; however, the sprouting is smoother in temperatures

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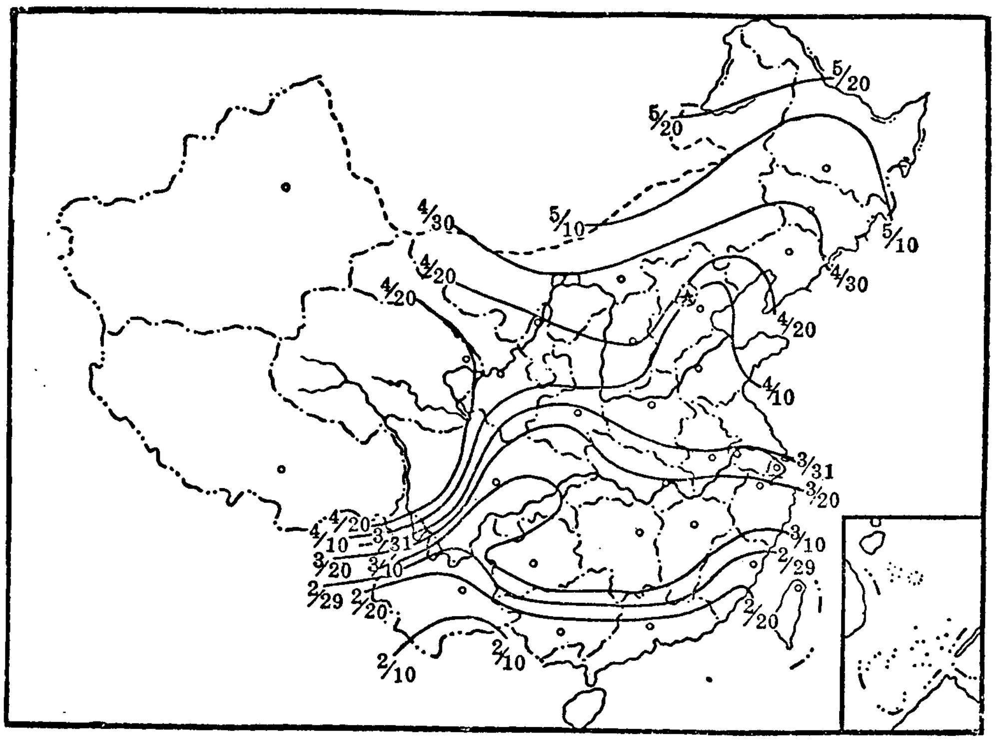
above 15°C. Judging from the year's average temperature, then, sprouts may be obtained in above 10°C temperature. This is due to the fact that if the average temperature is above 10°C, on a clear day at noon, the temperature may reach above 14° to 16°C, and may be as high as 16° to 20° on the seed beds. Due to the aforementioned reasons, we decided to use the time when the average temperature is stably above 10°C as the beginning of the rice growing season, and based upon this index, Map 5-1 was drawn.

Map 5-1 A Map of the Beginning of the Rice Growing Season in China (the Keng Varieties)

(On the basis of the map made by the former Shen-pao before the War of Resistance against Japan, we made revisions in accordance with information obtained since then. All of the maps used in this book are from the same source.)



Map 5-1 indicates the following characteristics of the distribution:

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(1) There is an obvious difference between the south and the north. The season begins as late as the latter part of May in the northern part of Heilungkiang, but in the provinces of Kwangtung, Kwangsi, Taiwan, and the southern part of Yunnan, the season lasts all year long.

(2) For the vast plain of North China, the season begins rather early, in the beginning of April, while in the loessic plateau, it is delayed until the middle or the latter part of April, although the latitude is the same. This is due to the fact that spring comes faster in the plains.

(3) The season begins earlier in the southern part of Shensi and in Han-chung than the valley of Huai-ho. It begins earlier in Szechwan Basin than the middle and the lower reaches of the Yangtze, although the latitude of the former and the latter is the same. This is due to the fact that Ch'ing-ling Mountains keep off the cold waves in the spring.

The season begins earlier in Fukien than the areas of Kiangsi of the same latitude, because Wu-i Mountains also keep off the cold front.

(4) In the provinces of Szechwan, Kweichow, Yunnan, and Fukien, altitude also is closely related to the opening of the rice growing season. The higher is the terrain, the later is the season. In Szechwan, the areas of different altitudes may have a variation of two months.

The concept of a rice planting time, and that of the beginning of the rice growing season are not the same. Aside from the temperature, the local weather condition, the special varieties of the rice plants, the crop rotation system, and the method of growing the seedlings, the two often correspond with each other. When the average temperature rises to above 10°C, it is usually time to plant. The early hsien varieties are normally planted 10 days later, that is when the average temperature is above 12°C. Therefore, Map 5-1 shows the general timing of the early keng varieties.

We must also point out that spring temperatures

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vary from year to year, and the planting may thus vary also. In our country, the spring weather of most regions is not stable. After each cold air mass, the temperature gradually turns warmer until another cold air attack. Normally, there are six to nine days between the cold spells. When the cyclone waves pass an area, the temperature does not change much, but the rain comes and goes. The farmers describe the changing spring weather as "the cold tail and the warm head." (That is to say as the cold wave passes, the weather begins to turn warmer.) Whenever there is a clear day, the farmers always hurry to plant. This is a very effective method for preventing the seedlings from becoming rotten.

A full utilization of the growing season of the spring is important for production increase. The following are the experiences in this respect:

(1) The various rice growing regions have adopted the types of varieties of seedlings which strongly resist cold temperature so that planting may be done earlier. For example, if the hisen varieties are changed to the keng varieties, planting may be made five days earlier.

(2) With improved techniques, such as damp seed beds, the seedlings grow better, and planting may be done earlier. If the seed beds may be kept warm, planting may be done still earlier.

(3) Early planting must be coordinated with early transplanting. Many tests have proved that early transplanting is even more significant than early seeding with regard to yield.

However, we must take into consideration the problem of possible low temperature at the end of spring and the beginning of summer when the heads begin to appear. In the valleys of Pearl River and the Yangtze, there may be cold currents in May. The early varieties, if planted early, may be damaged by them during the periods of heading and fertilization, and thus, there may be an increased rate of empty hulls. Therefore, before we decide upon the planting date for the early varieties, we must be certain that they may safely avoid the cold currents.

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(2) A Safe Heading Period and the Last Stage of Growth

The so-called a safe heading period implies that a rice plant must have all the heads before a certain time in the fall, so that there may be less chance for it to be damaged by cold currents during the stages of blossoming and fertilization. If the heading period comes later than this time, there is a possibility of more empty hulls, and thus, a high yield may not be guaranteed. Of course, the so-called safe period does not mean absolutely safe. Only through many years of experience, we come to realize that a certain time limit insures a better margin of safety. Therefore, we may not relax our preparation against cold currents, even though the crop is to complete the heading period before the safe period is over, and it is urgent to protect those plants which complete the heading period after that period.

During the heading period, the various varieties have different degrees of resistance against low temperature. For example, the late varieties can resist low temperature better than the early varieties. The varieties of highland origin can withstand low temperature better than those of plain origin. Thus, the safe heading period varies with the different varieties also. When new varieties are adopted by any particular region, the safe heading period of that region changes accordingly.

Through long years of productive practice, our farmers accumulated many experiences concerning the safe heading period for rice plants. In Kiangsu, the farmers say "If the heads are not there by Chiu-fen /a date on the lunar calendar/, cut them down to feed the cows." In Hunan, they say "If no sticky drops (the grain of the milk-ripe stage), when the dew comes, might as well feed the cows." They are all saying that if the heads are not all there before a certain time, there will be serious reduction in yield.

During the recent years, this problem has been studied in China from the agricultural meteorology viewpoint. The preliminary understanding is that during the period from the evolvement of the heads to the time when their growth is complete, the young heads may easily be damaged by low temperature currents of below 15° to 17°C. During the blossoming period, the fertilization rate may be seriously reduced

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if the average temperature stays below 20°C, or the highest temperature during the day remains below 23°C. The safe heading period in fact means that there should be no cold currents during this stage of growth.

Table 5-1 shows the safe heading period of some regions, obtained from surveys and research studies. For the keng varieties, the safe period corresponds with the time when the temperature is 23 to 24° on the average. It is slightly earlier for the hsien varieties. The index seems to be higher than the 20°C requirement for the blossoming period. This is due to the fact that temperature varies from year to year. According to weather information of 15 to 20 years in Kiangsu, and 7 to 10 years in Szechwan, before the period indicated in the table, temperature generally does not drop below 20°C.

For example, in 1957, autumn came especially early in the regions of South and Central China, and various degrees of damage were suffered by the rice plants which were within the safe heading period. On the highlands of Yunnan and Kweichow, the summers are cool, the average temperature seldom reaches above 20°C. The local rice plants come to a head when the temperature is between 20° to 21°C., while the average rate of empty hulls is only about 10%. This is an obvious indication of the extent of low temperature resistance of the highland varieties. This is an important feature worthy of the attention of those scientists who study the different varieties of rice plants.

Based upon an index of 23° to 24°C (20° to 21° for the highlands of Yunnan and Kweichow), we present a map (Map 5-2) showing the distribution of the safe heading periods. The safe heading periods for the hsien varieties should be about 5 days ealier than the day specified for any particular region on the map.

From the time the heads completely appear to the time when the grain is fully ripe, the varieties of the single crop regions of the north, and the late varieties of the central and the southern parts of China need about 45 days (the late varieties of South China need about 35 days). From the viewpoint of weather, the date about 45 days (35 days for

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South China) later than the safe heading period should be considered as the end of the rice growing season. Therefore, Map 5-2 may be said to also indicate the end of the rice growing season for most of the rice growing areas of China.

In the Northeast, the temperature drops suddenly in the fall, and frost comes especially early. The end of the rice growing season is mainly controlled by the time of the first frost.

Table 5-1 The Safe Heading Period and the Temperature Condition of the Rice Plants of the Various Areas

地 (1) 名	安全齐穗期 (9) (月/日)	常年该候平均温度 (12) (°C)	地 (13) 名	安全齐穗期 (21) (月/日)	常年该候平均温度 (°C) (24)
佳木斯 (2)	8/5—10 (粳)(10)	23.5	杭(14) 州[14]	9/15—20 (粳)(22)	23.0
延吉 (3)	8/5—10 (粳)(10)	23.4	武(15) 汉[1]	9/15—20 (籼)(23)	24.2
沈阳 (4)	8/15—20 (粳)(10)	23.8	成(16) 都[2]	9/5—10 (籼)(23)	23.4
天津 (5)	9/1— 5 (粳)(10)	23.4	长(17) 沙[14]	9/15—20 (籼)(23)	23.7
徐(6) 州[4]	9/5—10 (粳)(10)	23.0	毕(18) 节	9/1— 5 (粳)(22)	20.3
南(7) 京[23]	9/10—15 (粳)(10)	23.2	昆(19) 明	8/25—30 (粳)(22)	20.0
芜(8) 湖[1]	9/10—15 (籼)(11)	22.2	广(20) 州	10/10—15 (籼)(23)	24.0

1. Place name 2. Chia-mu-szu 3. Yen-chi 4. Ch'en-yang 5. Tientsin 6. Hsu-chou 7. Nanking 8. Wu-hu 9. Safe heading period (month/day) 10. Keng 11. Hsien 12. Average temperature for that time of the year (°C) 13. Place name 14. Hangchow 15. Wu-han 16. Ch'eng-tu 17. Ch'ang-sha 18. Pi-chieh 19. K'un-ming 20. Canton 21. Safe heading period (month/day) 22. Keng 23 Hsien 24. Average temperature for that time of the year (°C)

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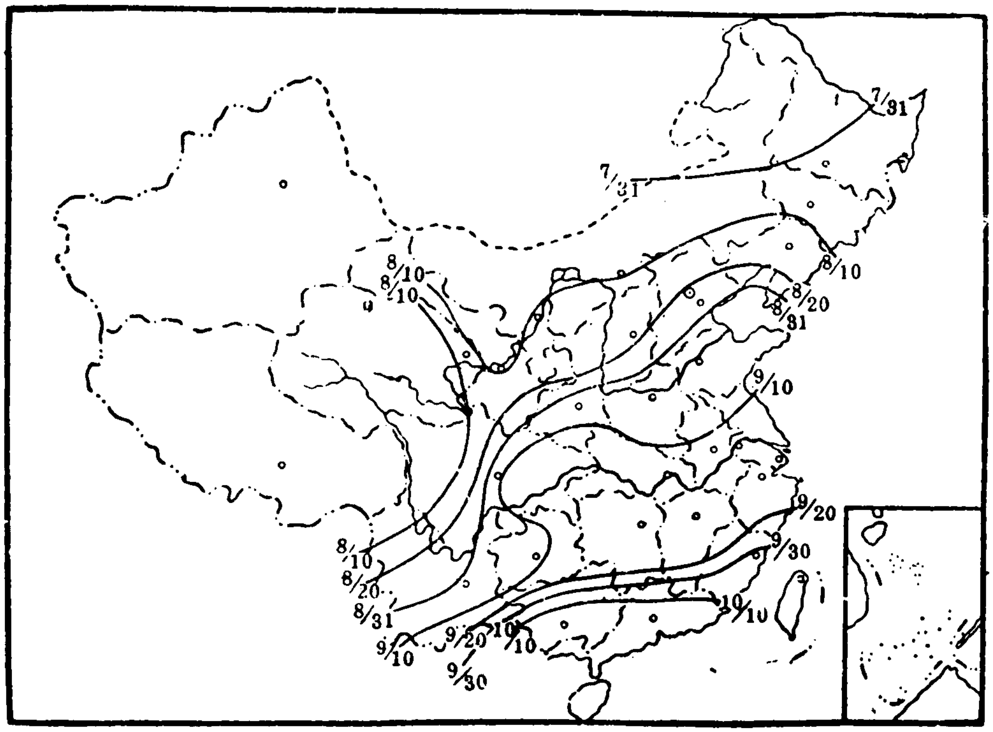
Map 5-2 A Map of the Distribution of the Safe Heading Periods for Rice Plants



Map 5-2 points out the following special characteristics of the distribution:

(1) From the north to the south, the difference is quite obvious. The safe period for the Northeast regions is from the later part of July to the early part of August; for the regions of North China, it is from the middle part of August to the early part of September; for the Yangtze Valley, it is from middle of August to the early and middle parts of September; for South China, it is from the later part of September to the middle of October. The cold currents of the later part of September in the Yangtze Valley and of the early part of October in South China have unfavorable effects on the blooming and fertilization of the late varieties.

(2) Comparing the regions of the same latitude, the safe period comes later in the east than the west. For example, it is the early part of September in Tientsin, and the middle of August in T'ai-yuan. This is due to the fact that the terrain

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is lower in the east, and adjusted by ocean currents, the temperature drops slower in the east. It is later in Fukien than it is in Kiangsi and Hunan, because Wu-i-shan keep out the cold currents from Fukien, which is further benefited by the ocean.

(3) The terrain of the Southwest is very complicated, as are the safe heading periods. It is earlier for the areas of higher altitudes.

In productive practice, the safe heading period is very important.

(1) When we consider a certain variety for a certain particular area, we must first consider whether it can come to a head before the safe heading period of that area. According to Yang K'ai-ch'u's (2799 7030 3255) studies, the safe heading period of Ya-an, Szechwan is in the early part of September. If the late varieties such as No.853 and No.10509 of Kiangsu and Chekiang are used as late crops of continuous rice crops in Ya-an, they will come to a head around the 20th of September. Therefore, only 40 to 60% of the grain may be harvested. Such medium varieties as Ch'uan-ta Keng, Yueh-chin No.1 and Kuei-hua-ch'iu may come to a head before the 10th of September, and the harvest should be more than 70%. It is, therefore, decided that the medium varieties should be used.

(2) When we decide the time for planting and transplanting certain variety in a certain location, we must also consider the local safe period. For example, the safe period for Hangchow is the 20th of September. According to the study of Chekiang Institute of Agricultural Sciences, the late crop of the continuous rice crops should be transplanted before the end of July in order to come to a head before the 20th of September. If the transplanting is delayed until the first part of August, the heading will not be completed until the later part of September. As a result, the rate of empty hulls may reach above 50%, and the yield will drop considerably.

(3) From Map 5-2, we may see that in many areas the rice plants actually come to a head before the local safe period. For example, the medium varieties of the Yangtze Valley generally come to a head in August, and the safe period for that region is generally in September. Therefore, after

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the medium rice is harvested there is still time to plant some short term crops or green fertilizers to raise the rate of land utilization.

Safe heading period is a direct and significant guide to production. However, Map 5-2 only shows a general tendency of the entire country. Each province and each area should conduct its own detailed surveys to determine more precisely its own safe heading period.

2. TEMPERATURE AND THE NUMBER OF DAYS IN THE GROWTH SEASON OF PADDY RICE [p 117]

(1) The Number of Days of the Growing Season and the Average Temperature

From the beginning of the growth of the rice plants to the end is the growing season for the rice plants, Map 5-3 shows the distribution of that season in our country. The distribution may be described by the following characteristics:

a. From the north to the south the difference is very obvious. It is 100 to 130 days in the northern part of the Northeast, 150 to 170 days in the southern part of the Northeast. In North China, it is 160 to 220 days. In the Yangtze Valley, it is 200 to 260 days. In South China, it is 260 days to the whole year round.

b. Aside from the latitude, the number of days in the growing season is also affected by other geographical conditions. It is shorter in the eastern mountain region of the Northeast than the Sung-liao Plain. It is longer in the North China Plain than the Loessic Plain. In the southwestern provinces, the growing season is shorter or longer in accordance with the altitude. For example, it is 260 to 270 days in the southern part of Kweichow, but it is less than 230 days in the northern mountainous area of that province. The river valleys and the plains of Yunnan have obviously a longer growing season than the mountain areas of that province. The coastal region of Kiangsu has a shorter growing

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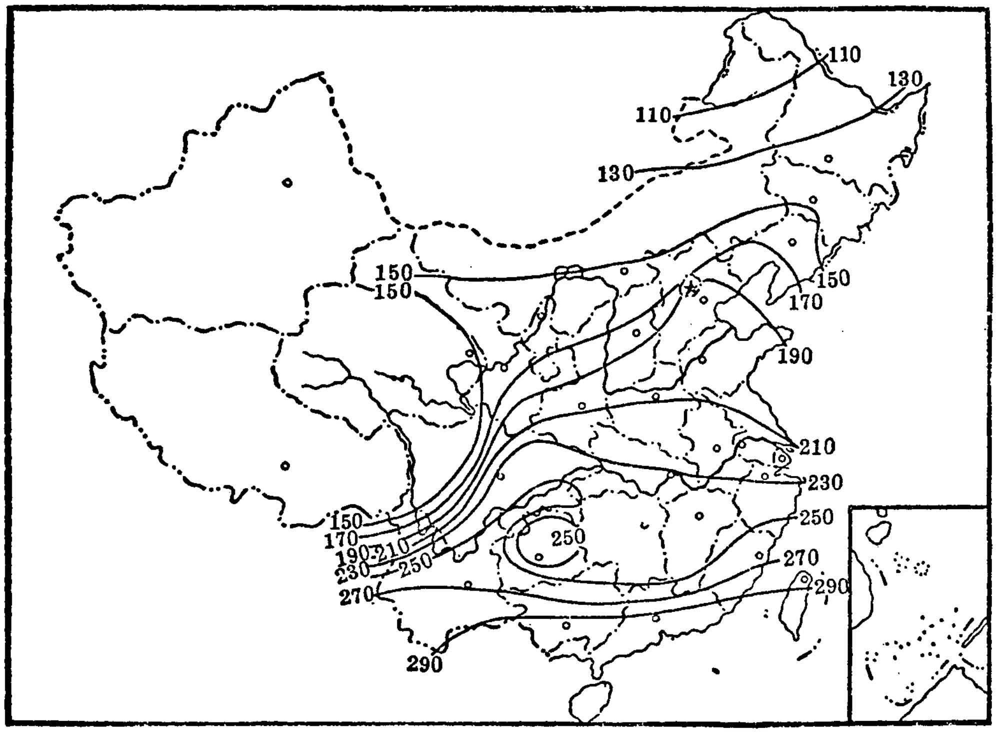
season than the interior of that province, because the spring is colder in the coastal region and thus the growing season starts later.

Map 5-3 The Distribution of the Rice Growing Season (the keng varieties)



Two areas may have the same number of days in the growing season, with a different average temperature. The difference is very significant in rice crops. Map 5-4 shows the average temperature of the rice growing season of the various areas of our country. When we compare Map 5-3 with Map 5-4, we may discover the following characteristics:

(1) For the regions of the Northeast and North China, the length of the growing season tends to correspond with the average temperature, i.e. the shorter is the growing season the lower is the average temperature during that season.

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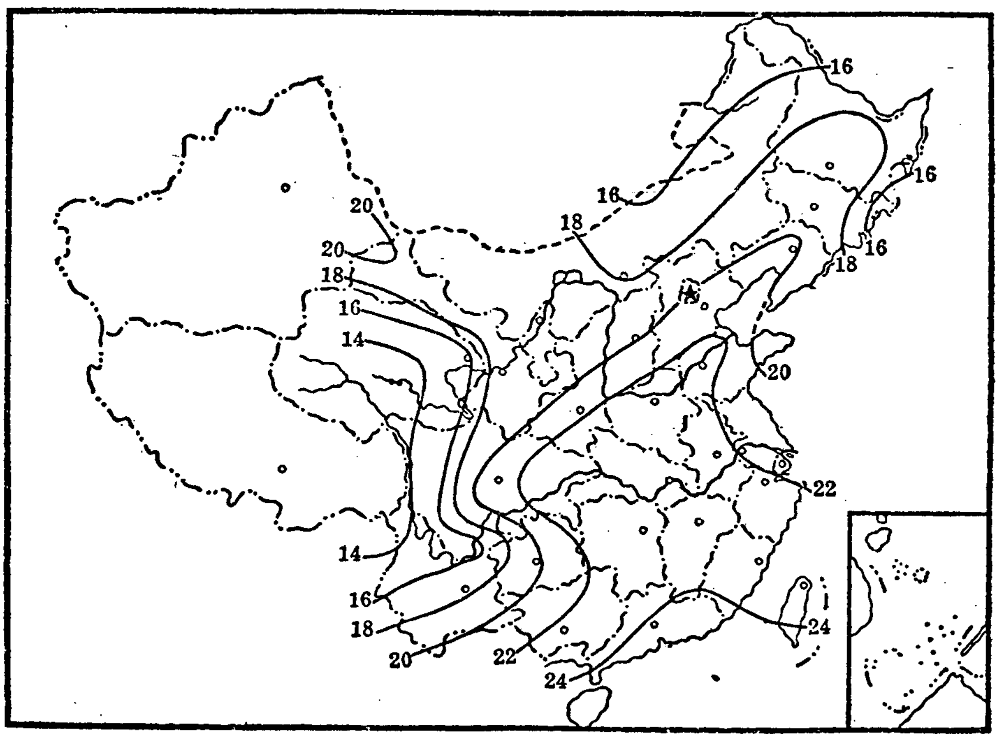
(2) In the provinces of Chinghai, Szechwan, Yunnan, Kweichow, Kwangsi, and Fukien, the average temperature is closely related to the terrain. The higher is the altitude the lower is the average temperature. The average temperature of the growing season in the highlands of Yunnan and Kweichow is below 20°C. The average temperature in July in these highlands is below 20°C. The entire growing season of the rice plants is cool like spring. This is a very special climatic condition of these highlands.

(3) The average temperature of the growing season in the coastal regions of Kiangsu and Shantung is lower than the interior areas of the same latitude. This is mainly due to the fact that the summers of the continental climate are hotter.

Map 5-4 The Average Temperature during The Rice Growing Season



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The number of days and the average temperature in the rice growing season are important factors when we consider whether certain varieties and certain cultivating methods are suitable for any particular place. The growing season in the Northeast is very short. The single season early varieties are most suitable. The growing season is longer in North China, and the single season late varieties are most suitable. The growing season is still longer in the Yangtze Valley. It is suitable for all the early, medium, and late varieties. The growing season is the longest in South China. It is suitable for those early and late varieties which take a longer time to grow.

With respect to the cultivating system, Maps 5-3 and 5-4 show that the provinces of Kwangtung, Kwangsi, and the southern part of Yunnan are all possible for the cultivation of winter grains or triple-seasoned rice. At present, in the regions south of the 220 days growing season line, double-seasoned rice crops are popular practice. As the cultivating techniques are bing improved, and more early ripening varieties are being selectively bred, the double-seasoned region will be extended further northward to the 210-day region and beyond.

Regarding the single season area, according to the successful experiment of rice culture in the Mo-ho region of Heilungkiang, we may safely say that there is no northern boundary of the single season rice culture in our country. In 1959, Nung-lin No.11 was planted in the Mo-ho region on the 22nd of May, and was ripe on the 1st of September. The plants grew 101 days. Aside from the very cold high altitude areas in China, the rice growing season of almost the entire country is over 100 days, with an average temperature of above 15°C in the growing season.

The temperature condition of the growing season is important in the work of introducing new varieties to any given area. Those varieties which react weakly toward the length of daylight are primarily affected by the local temperature conditions. For example, Chung-yuan-tzu No.2 of Table 5-2 takes more days to become ripe when introduced in Kung-tzu-ling of the Northeast (103 days) due to the lower average temperature of that locality. When it is introduced

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in the south, its growth period is shortened to 75 to 84 days, but due to a shortage of nutrients, the yield is not high. If suitable measures are taken to plant the seeds early, and the average temperature becomes lower during the heading period, and the plant may take more days to become ripe and thus the nutriment condition may be improved. Therefore, with early seeding and transplanting measures, it is definitely possible to introduce the north keng varieties to the south.

(2) The Temperature Difference Between the Night and the Day, During the Growing Season

Map 5-5 shows the temperature differential during the rice growing seaon of the various areas. From the map we may discover the following:

a. Generally speaking, the difference is more obvious in the north than the south. In the Northeast, it is a difference of 10 to 14°C; in North China 8 to 14°C; in the Northwest and Inner Mongolia 10 to 16°C; in the Yangtze Valley 8 to 10°C; in the South China 6 to 8°C; and in the Southwest 8 to 12°C.

b. The differential is larger from the lowland to the highland. If the latitude is the same, it is larger in the Northwest than the north; larger in Southwest than the areas south of the Yangtze. It is smaller in the Sung-liao plain of the Northeast than the mountain regions to its east and west. The temperature differential between night and day is larger in the high altitude regions, because more heat is received during the day, and more is dispersed during the night.

c. The temperature differential between night and day during the rice growing season is affected to a great extent by the ocean. The differential is small on the ocean, and in the coastal region.

d. Due to frequent fogs the temperature differential in Szechwan Basin and the basins of the two lakes is smaller than that of the regions surrounding the basins.

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Table 5-2 The Growth of Yuan-tzu No.2 in the Various Areas, and the Relationship between Growth and the Temperature Conditions

	(1) 地名	(9) 纬度	(10) 生长季平均温度 (°C)	(11) 最长日照时数	(12) 播种期 (月/日)	(13) 出穗期 (月/日)	(14) 播种到出穗天数	(15) 播种到出穗间平均温度 (°C)	(16) 株高 (厘米)	(17) 每穗粒数 (主穗)	(18) 备注
(2)	公主岭	44°N	19.0	15:31	5/10	8/21	103	21.2	92.7	119.8	1949—1955年东北所 (19)
(3)	南京	32°N	21.7	14:16	4/28	7/12	75	23.4	—	—	1955年华东所 (20)
(4)	南京	32°N	21.7	14:16	3/20	7/11	113	20.0	96.9	59.6	1958年华东所 (21)
(5)	杭州	30°N	22.2	14:05	4/13	7/6	84	22.5	91.6	49.9	1957年浙江省所 (22)
(6)	杭州	30°N	22.2	14:05	3/22	6/29	99	21.2	94.4	52.1	1957年浙江省所 (23)
(7)	成都	31°N	21.0	14:11	4/6	7/2	87	21.7	—	—	1955年四川省所 (24)
(8)	昆明	25°N	17.6	13:41	4/6	8/12	128	19.5	—	—	1955年云南省站 (25)

1. Place name 2. Kung-chu-ling 3. Nanking 4. Nanking 5. Hangchow 6. Hangchow 7. Ch'eng-tu 8. K'un-ming 9. latitude 10. Average temperature of the growing season 11. hours of the longest daylight 12. Planting date (month /day) 13. Heading date (month/day) 14. Number of days from planting to heading 15. Average temperature during the period from planting to heading 16. Height of the stalk (cm) 17. Number of grains per head (main head) 18. Note 19. Northeast Institute, 1949-1955 20. North China Institute, 1955 21. East China Institute, 1958 22. Chekiang Provincial Institute, 1957 23. Chekiang Provincial Institute, 1957 24. Szechwan Provincial Institute, 1955 25. Yunnan Provincial Institute, 1955

If the temperature at night does not drop below the margin of safety for rice plants, a large temperature differential between day and night is good for the rice plants. A high temperature during the day promotes stronger photosynthesis; and a low temperature at night weakens transpiration, so that the synthesis and the accumulation of sugar are more plentiful and the plant may grow more prosperously. The seeds are full and the yield is good. The farmers say: " With black night rains and clear daylight, so much harvest--no place to store the grain." They mean that a large temperature differential between night and day, and plenty of moisture supplied by night rains improve the harvest of grains.

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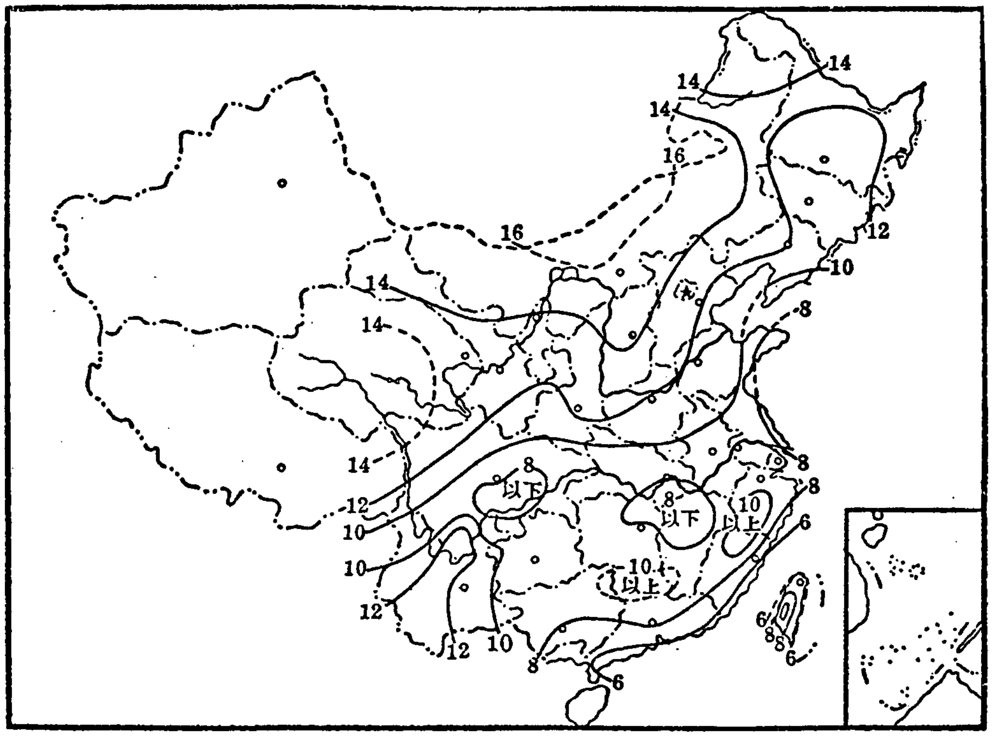
Map 5-5 The Average Temperature Differential Between Night and Day during the Rice Growing Season



A large temperature differential between night and day also improves the quality of the rice grain. Therefore, the northern part of our country and the highlands are good rice producing areas. However, in the regions with large temperature differences, certain irrigation measures should be adopted to protect the plants from being damaged by the low temperature at night. Irrigation is a good method for adjusting the temperature of the rice fields. Water preserves heat. When the temperature of the air drops, the temperature of the water drops considerably slower; and when the temperature of the air rises, that of the water rises slower also. Therefore, if the water level of the paddy is kept a little deeper, the large temperature differential

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between night and day may be made milder for the rice plants; while if the water level is kept shallow, the temperature differential between night and day may be accentuated.

The water should be kept deeper during the heading and the fertilization periods, because during these periods the plant is more sensitive to high and low temperatures. During the other periods, the water level should be kept shallow, or the fields should be sunned at a certain suitable time. It has been calculated that at night the damp field is 2^{o} to $4^{o}C$ cooler than the deep water paddy. During the day, the former is 2^{o} to $4^{o}C$ warmer than the latter. Therefore, the difference between night and day amounts to 4^{o} to $6^{o}C$. In the north, where the temperature is generally low, if conditions permit, irrigation should be applied with the system of draining during the day, and filling at night, so that the soil may be warmer either at night or during the day. In those fields where water seeps fast, filling should be done after the noon hour, so that the water level of the field may be guaranteed to be shallow during the day, and deep at night. This is very beneficial for the growth of the rice plants.

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SECTION 3. SUNLIGHT CONDITIONS FOR CHINA'S PADDY RICE [p 121]

1. RICE CROP AND THE NUMBER OF HOURS OF SUNLIGHT [p 121]

The various varieties of rice plants require different types of daylight conditions. For example, many early varieties can grow through the daylight stage smoothly in either the short daylight and the long daylight conditions. They are not sensitive to light exposures. The late varieties of the Yangtze Valley or South China are more strict in their daylight requirements. Their growth is delayed or they may fail to develop into the reproductive stage of life, if they are submitted to long hours of daylight (more than 14 hours, for example). Therefore, the local variation of the daylight hours is one of the important factors of environmental conditions.

The daylight hours (meaning the hours during which the sun shines) of the various areas vary strictly according to latitude. This factor is affected only very slightly by the factors of terrain and others. Table 5-3 shows the daylight hours of the various rice growing regions of our country, caused by the variation of the latitudes.

The table explains the following facts:

(1) At the time of Ch'un-fen (21 March) and Ch'iu-fen (23 September), the sun shines directly above the equator, therefore, the daylight hours for the southern and the northern parts of our country are almost the same 12 hours. The day and the night are equal in length at these times.

(2) At the time of Hsia-chih (21 June), the sun shines directly above the tropic of Cancer, i.e. 23°27' north latitude. In the northern hemisphere, daylight is the longest on that day. The higher is the latitude of an area, the longer is the daylight on that day.

(3) Among the rice growing regions of our country, the daylight hours are longer for the north and shorter for the south. The difference is very obvious.

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For example, in the northern part of the Northeast, the daylight hours are above 14 hours during the rice growing season, while in the south, the hours are all less than 14.

Table 5-3 Variations in Daylight Hours of the 1st, the 13th, and the 25th of Every Month (hours:minutes) during the Rice Growing Season between 20° and 50° North Latitude

纬度 (1)	代表性地点 (2)	月份 日期 (9)	(10) 3 月	(11) 4 月	(12) 5 月	(13) 6 月	(14) 7 月	(15) 8 月	(16) 9 月	(17) 10 月
50°	黑(3)河	1	10:58	12:53	14:41	16:04	16:18	15:14	13:31	11:39
		13	11:42	13:38	15:19	16:20	16:01	14:37	12:47	10:56
		25	12:28	14:21	15:50	16:21	15:34	13:55	12:02	10:12
40°	北(4)京	1	11:18	12:39	13:54	14:49	14:58	14:16	13:05	11:47
		13	11:50	13:10	14:19	15:00	14:47	13:51	12:34	11:16
		25	12:21	13:40	14:40	15:01	14:29	13:22	12:03	10:46
35°	开(5)封	1	11:26	12:34	13:35	14:21	14:29	13:54	12:55	11:50
		13	11:52	13:00	13:57	14:30	14:19	13:33	12:29	11:24
		25	12:19	13:24	14:14	14:31	14:05	13:09	12:03	11:0[illegible]
30°	绍(6)兴	1	11:33	12:29	13:20	13:57	14:03	13:34	12:46	11:53
		13	11:54	12:50	13:37	14:04	13:55	13:17	12:25	11:32
		25	12:16	13:10	13:50	14:05	13:43	12:58	12:03	11:11
25°	昆(7)明	1	11:39	12:24	13:05	13:35	13:40	13:18	12:38	11:55
		13	11:56	12:42	13:19	13:40	13:35	13:04	12:22	11:38
		25	12:14	12:58	13:30	13:41	13:25	12:48	12:04	11:22
20°	海(8)口	1	11:45	12:20	12:52	13:16	13:19	13:02	12:32	11:57
		13	11:59	12:34	13:03	13:20	13:15	12:51	12:18	11:44
		25	12:12	12:46	13:12	13:21	13:07	12:38	12:05	11:32

(18)注：表中日照时数是从太阳的上部边缘自东边地平线出现，以至没入西边地平线为止的时间，如早晚将"常用薄明"(相当于天空一等星还能看见的亮度)的时间计算在内，大約要增加一小时(20)。

1. latitude 2. Representative area 3. Hei-ho 4. Peking
5. K'ai-feng 6. Shao-hsing 7. K'un-ming 8. Hai-k'ou-shih
9. month/day 10. March 11. April 12. May 13. June
14. July 15. August 16. September 17. October
18. Note: The daylight hours listed in this table are calculated from the time the upper edge of the sun appears on the eastern horizon to the time the sun disappears from the western horizon. If we add the dusk and the dawn (when the stars are not seen), then another hour of daylight should be added to the figure in the table.

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The number of hours of daylight and the number of days in the rice growing season are important factors for selecting the varieties that are suitable for any particular area. In North China and the Northeast, the growing season is short but the daylight is long. This condition makes these areas suitable only for those varieties which have weak reactions to light exposure. Compared with the varieties suitable for the areas of North China, the Northeast varieties are even less sensitive to light exposure.

The growing season is longer in Central and South China. From spring to autumn, in the long growing season, the daylight hours change from short to long and again to short, therefore, these regions are suitable for the early and medium varieties which are not sensitive to light exposure and are also suitable for the late varieties which are very strict in their light exposure requirements. Compared with the varieties suitable for Central China, the South China varieties are even more sensitive to daylight.

Table 5-4 The Growth of the Variety No. 10509 in the Various Areas with Different Daylight Conditions

地名 (1)	纬度 (9)	最长日照时数 (时：分) (10)	播种期 (月/日) (11)	出穗期 (月/日) (12)	播种到出穗天数 (13)	播种到出穗间平均温度 (14)	株高 (厘米) (15)	每穗粒数 (16)	备注 (17)
南(2)京	32°N	14:16	5/10	9/15	128	25.7	155.5	63.7	1958年华东所 (18)
武(3)昌	30°N	14:05	5/17	9/15	121	26.8	140.0	63.9	1957年华中所 (19)
杭(4)州	30°N	14:05	5/15	9/6	114	26.4	149.6	64.1	1958年浙江省所 (20)
南(5)昌	28°N	13:56	5/14	8/29	107	27.1	129.0	62.2	1957年江西省所 (21)
长(6)沙	28°N	13:56	5/16	9/1	108	27.2	—	51.0	1957年湖南省所 (22)
新(7)会	22°N	13:29	3/11	6/1	81	22.2	100.6	41.8	1958年新会良种场 (23)
新(8)会	22°N	13:29	7/20	9/20	62	28.1	—	—	1958年华南所 (24)

1. Place name 2. Nanking 3. Wu-ch'ang 4. Hangchow 5. Nan-ch'ang 6. Ch'ang-sha 7. Hsin-hui 8. Hsin-hui 9. Latitude 10. The longest hours of daylight (hours:minutes) 11. Planting time (month/day) 12. Heading time (month/day) 13. Number of days from planting to heading 14. Average temperature during the period between planting and heading 15. Height of the stalk (cm) 16. Number of grains in each head 17. Note 18. Hua-tung Institute, 1958 19. Hua-chung Institute, 1957 20. Chekiang Provincial Institute, 1958 21. Kiangsi Provincial Institute, 1957 22. Hunan Provincial Institute, 1957 23. Hsin-hui Liang-chung Farm, 1958 24. Hua-nan Institute, 1958

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The growth of a certain variety is closely related to its reaction to the local daylight conditions. When the introduction of a new variety to a certain area is attempted, special consideration must be given to the difference in the daylight conditions of the source origin of the particular variety and where it is to be introduced. For the single and double-seasoned varieties of the south which are strict in their daylight requirements, they often do well if they are introduced to areas of the same latitude as that of their origin. For example, the variety No. 10509 is originally produced in Hangchow, and grows very well in Wu-ch'ang which is of the same latitude as Hangchow. When it is introduced to the areas north of the Yangtze, due to the lengthened daylight hours, its growth is delayed and cannot become ripe. When it is introduced to South China, in such areas as Yuan-kiang of the southern part of Yunnan, its growth season becomes very short and it is, therefore, a success as an early ripening variety.

When the late varieties are introduced from the south to the north or vice versa, they are affected by the two factors of temperature and daylight, and the effect of daylight is the more obvious of the two. For example, when No. 10509 of Table 5-4 is planted in its original area of Hangchow on the 15th of May, the head appears on the 6th of September. During this period of 114 days, the average temperature is 26.4°C. When it is introduced to Hsin-hui, Kwangtung, it is planted on the 11th of March, and the head comes on the 1st of June. The average temperature is only 22.2 during this period, but its growth is accelerated to 81 days. This is due to the fact that the effect of the shorter periods of daylight exceeds the adverse effect of the lower temperature. When it is planted later in the growing season in points of South China, the conditions of temperature and daylight are both favorable; its growth period is further shortened as a result.

2. RICE CROP AND INTENSITY OF SUNLIGHT [p 124]

Solar radiation is the source of energy for photosynthesis of the rice plants, and its intensity is closely related to the function of the latter.

Within a certain temperature limit (15° to 33°C), photosynthesis is stronger as the light intensity increases. It is generally believed that if the temperature condition is suitable, the photosynthesis of the leaves of rice plants reaches its maximum when the intensity of the solar radiation is 0.6 cal/cm^2. It does not become stronger when the solar radiation exceeds this intensity limit. (See Note)
(Note) In meteorology, the intensity of solar radiation (unit measurement is cal/cm^2.minute) indicates the energy of the sun light, while hours of daylight and percentage of light exposure are used to indicate the duration of solar exposure.

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The intensity of the solar radiation is determined mainly by the two factors of the angle of the sun and the transparency of the atmosphere. The factors which affect the angle of the sun are latitude, season, and the hours of the day. The factors which affect the transparency of the atmosphere are vapor and dust, and the most important of all, the extent of cloudiness.

Table 5-5 lists the intensity of the solar radiation during the most important month (July) of the life of the rice plants in four of the representative areas of our country. The records of the year 1958 are used.

Table 5-5 The Intensity of Solar Radiation During the Rice Growing Period (July) (cal/cm^2.minute)

地 (1) 名	晴阴 (6) 时分 (7) 纬度 (8)	(9) 晴天					阴 (13) 天				
		上午 6:32 (10)	上午 9:33 (10)	中午 12:33 (11)	下午 3:33 (12)	下午 6:31 (12)	上午 6:32 (10)	上午 9:33 (10)	中午 12:33 (11)	下午 3:33 (12)	下午 6:31 (12)
沈 (2) 阳	42°N	0.22	0.73	0.91	0.63	0.11	0.20	0.73	0.35	0.12	0.04
北 (3) 京	40°N	0.29	1.05	1.30	0.85	0.02	0.22	0.20	0.19	0.21	0.22
武 (4) 汉	31°N	0.25	1.06	1.30	0.86	0.06	0.08	0.61	0.57	0.70	0.03
广 (5) 州	27°N	0.09	1.10	1.37	0.87	0.02	0.19	0.22	0.24	0.17	—

1. Place name
2. Ch'en-yang
3. Peking
4. Wu-han
5. Canton
6. Clear or cloudy
7. Time
8. Latitude
9. A clear day
10. A.M.
11. Noon
12. P.M.
13. A cloudy day

In the first place, Table 5-5 explains the following:

(1) On the same day, the intensity of solar radiation at noon varies with the latitude. It is stronger when the latitude is lower. In Ch'en-yang, at noon, on a clear day in the summer, the intensity is 0.91 cal/cm^2.minute. This is above the maximum for photosynthesis (0.6 cal/cm^2.minute). It is obvious that in the various areas of our country, south and north, on clear days, the intensity of the solar radiation is sufficient for the rice plants. This is a favorable climatic resource for the rice production of our country. Besides, the leaves of the rice plants change their color to adjust to the different degrees of intensity of the solar radiation of the various regions. The varieties of the keng subspecies have darker colored leaves particularly suitable for the weaker sunlight of the north. The varieties of the

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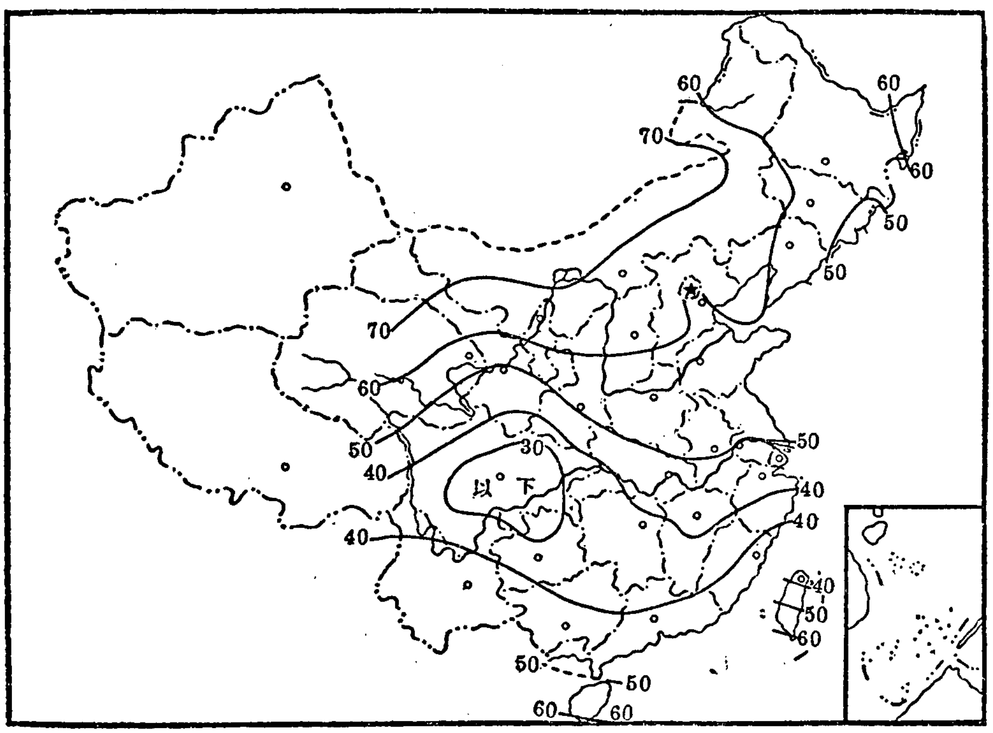
hsien subspecies, which are more suitable for the south, have lighter colored leaves for the more intense sunlight of the south.

(2) On a clear day, the intensity of solar radiation increases with the hour after sunrise, and it reaches the maximum for the photosynthesis of the rice plants after 9 A.M. and maintains that level until 3 or 4 P.M. The photosynthesis of the rice plants, therefore, is the strongest during these hours.

Secondly, Table 5-5 explains that the intensity of solar radiation on a cloudy day is considerably less than that of a clear day. Even in the south, at noon on a cloudy day in the summer, the intensity of the solar radiation is less than 0.6 cal/cm^2.minute. In order to understand the average intensity of the solar radiation during the entire rice growing season of the various areas, we must study the percentage of sunlight in these places. The so-called daylight percentage is the percentage of the daylight hours that is not covered by clouds. This percentage reflects the probability of a clear day in the various places. Map 5-6 shows the daylight percentage distribution during the rice growing season. The percentage is obviously higher in the north than the south. It is above 50% in the north. The percentage is the highest in the Northwest, more than 60 to 70%. This is the area with the best daylight conditions. In the south, the daylight conditions vary from year to year. They are particularly good during the drought years.

Map 5-6 The Distribution of Daylight Percentage during the Rice Growing Season



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Sunlight is the basic source of energy for rice production. Under the present cultivating conditions, only 1% of the sunlight shining on a field is utilized by the rice plants of that field. Therefore, there is a great potential in rice production if the rate of utilization can be raised. The low rate of utilization is the result of the fact that part of the light falls onto the ground surface instead of the leaves and another part is reflected by the leaf surface. Even that part of the sunlight which is absorbed by the chlorophyll is not fully utilized to manufacture organic matter.

Proper dense planting may increase the leaf area for full absorption of sunlight for the purpose of increased production. Reasonable density is the effective measure for the improvement of the daylight utilization condition of the rice fields. According to the calculation of Tientsin Station of the Agricultural Meteorology Laboratory of China Academy of Agricultural Sciences, for better light exposure conditions, the rice plants should be planted from the east to the west, instead of from the south to the north, because light exposure on the base of the rice plants at 2 P.M. is 28% better for the east-west rows than the south-north rows.

In the summer, the sun proceeds in the east-west direction. If the rice plants are in east-west rows, the light can easily fall between the rows. In the case of the south-north rows, the base of the plants are shaded from the sunlight by the stems of the plants. Therefore, under the condition of similar density, the light exposure condition of the field may be improved considerably if the direction of the rows is changed. However, the direction of the rows is also related to the direction of the prevailing wind, and to the flow of the water. Further studies of this subject must be conducted by each locality according to its own concrete conditions.

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SECTION 4. CONDITIONS OF RAIN FOR CHINA'S RICE CROP [p 126]

1. RAIN AND EVAPORATION DURING THE GROWTH SEASON OF CHINA'S PADDY RICE [p 126]

The water needs of the rice paddies include the two factors of seepage and evaporation (the amount of evaporation between the groups of rice plants and the amount transpired by the plants). The amount of seepage is determined mainly by the soil condition, while the amount of evaporation is mainly determined by the climatic conditions. We have more information concerning the climatic conditions of the various rice growing areas than the actual measurement of evaporation in the rice paddies. However, it is possible to use the climatic conditions to reflect the variations of evaporation in the rice fields. Of course, aside from the climatic conditions, the varieties and the cultivating techniques used may also affect the actual amount of evaporation in the fields.

Since the liberation, many irrigation stations have been studying the difference between the total amount of evaporation of the rice fields and the amount of evaporation in a small test vessel. Statistical results of experiments conducted in 25 areas indicate that the amount of evaporation in a rice paddy is about 1.23 times of that of the test vessel (the proportion varies with the variety and the cultivating technique). Based on this proportion and the information of many years supplied by the weather stations all over the country, we calculated the approximate value of transpiration of our country's rice fields. The distribution is shown in Map 5-7.

Map 5-7 indicates the following characteristics:

(1) The amount of evaporation in the rice paddies of Szechwan Basin and the area south of Yangtze and north of Nan-ling is lower than that of fields to the south and the north of this region. This region has more clouds and the relative humidity is higher, while the wind is not as strong.

(2) The rice fields of the region south of Nan-ling have higher amount of evaporation because the rice growing

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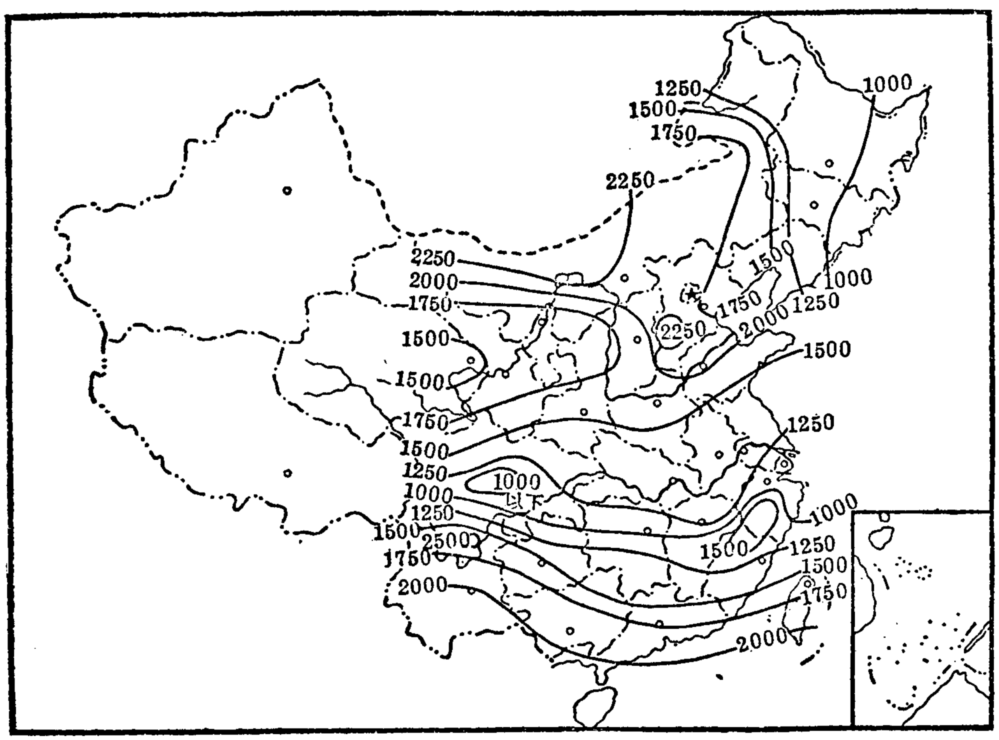
season is longer and its proximity to the ocean causes the winds to be stronger.

(3) Evaporation of the rice fields in the region north of the Yangtze increases as the latitude is higher, because the air is drier, there is less cloud cover, and the wind is increasingly stronger.

(4) In the Northeast, the evaporation of the rice fields varies with the areas. It is smaller in the east and larger in the west, because there is less cloud cover in the west less precipitation, and the air is drier.

Map 5-7 The Amount of Evaporation and Transpiration in the Rice Fields



The amount of rainfall is closely related to rice production. In China, in the south and in the north, rains are mostly concentrated in the summer. Therefore, there is

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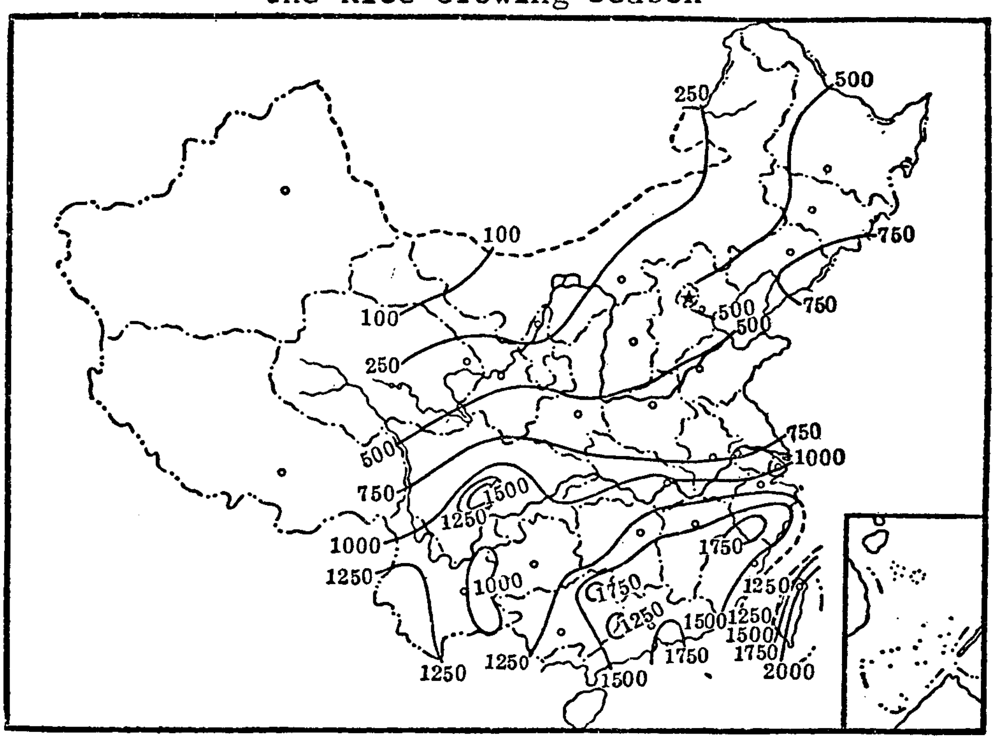
less difference in the various regions with regard to the amount of rainfall during the rice growing season as the difference is in the amount of average rainfall throughout the year. As natural precipitation is not distributed evenly at the various times and in the different areas, water conservation structures are needed for irrigation and drainage.

Map 5-8 shows the condition of rainfall during the rice growing season. It explain that :

(1) During the rice growing season, rainfall varies from the southeast to the northwest. It is more than 2,000 mm in Taiwan and generally less than 150 mm in the regions of the Northwest.

(2) There is not much of a difference in rainfall among the various areas of the Yangtze Valley. However, in North China, there is more rainfall in the east than the west. The terrain of the western part of North China is high, and the oceanic monsoons are obstructed to a certain extent.

Map 5-8 The Distribution of Rainfall during the Rice Growing Season



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(3) The rainfall condition during the rice growing season is quite good in the southern part of the Northeast, the Liao-tung Penisula and its vicinity. It is mostly above 600 mm. This is a very beneficial condition of this region for rice production.

(4) Although the terrain is high in the highlands of Yunnan and Kweichow, the latitude is low. Under the effect of the tropic monsoons, rainfall is abundant. It is usually above 1,000 mm, and most of it is in the two seasons of summer and autumn.

(5) Due to the fact that the main source of precipitation during the rice growing season is the vapor brought over by the monsoons, there is an obvious difference between the windward slopes and the leeward slopes. The windward slopes have more rainfall.

Some areas have scanty rainfall during the rice growing season, and the evaporation of the rice fields of these areas may be very high. Then, climatically speaking, the moisture supply condition of these areas is rather difficult with respect to rice production. The following is a formula to reflect the "extent of dryness of the rice fields."

$$\text{The extent of dryness of the rice fields} = \frac{\text{The evaporation in the rice field during the season}}{\text{The rainfall during the season}}$$

(Note) This formula does not include the factor of seepage of the rice paddies, because this is mainly a soil factor not a climatic factor. Moreover, if irrigation equipment is good, water leaked through the paddy is usually used over again for irrigation. Of course, many complicated natural conditions affect the moisture supply of the rice paddies; it is not our attempt to reflect them all in this formula.

If, by using this formula, the extent of dryness equals 1, then, the precipitation of this area is just enough to supply the moisture need by the rice fields of the same area. If it is less than 1, then there is surplus moisture. If it is larger than 1, then the rainfall is not sufficient. In this case, the rainfall of a larger area must be gathered to supply rice paddies of a smaller area.

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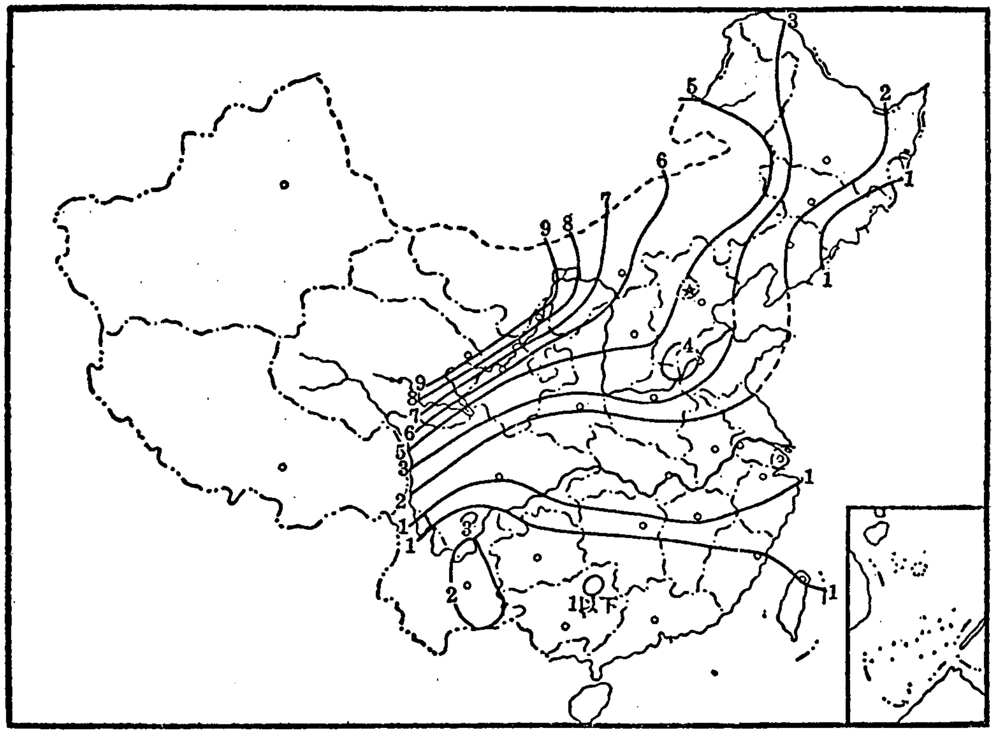
Map 5-9 The Extent of Dryness of the Rice Fields



Map 5-9 explains the following:

(1) The vast areas south of Huai-ho has a dryness around 1; therefore, inspite of the large areas of rice paddies, water conservation structures should be sufficient to overcome any uneven natural distribution of precipitation. The moisture supply for the rice paddies should be sufficient for this vast region.

(2) The eastern and the southern parts of our Northeast also have a dryness of around 1. This is to say that this region has rich moisture resources for the development of rice production.

(3) The extent of dryness rises quickly in the areas north of Huai-ho; this fact is apparently due to the reduced rainfall and increased evaporation. North China has a dryness of 2 to 6, and it is above 6 in the region to the west of

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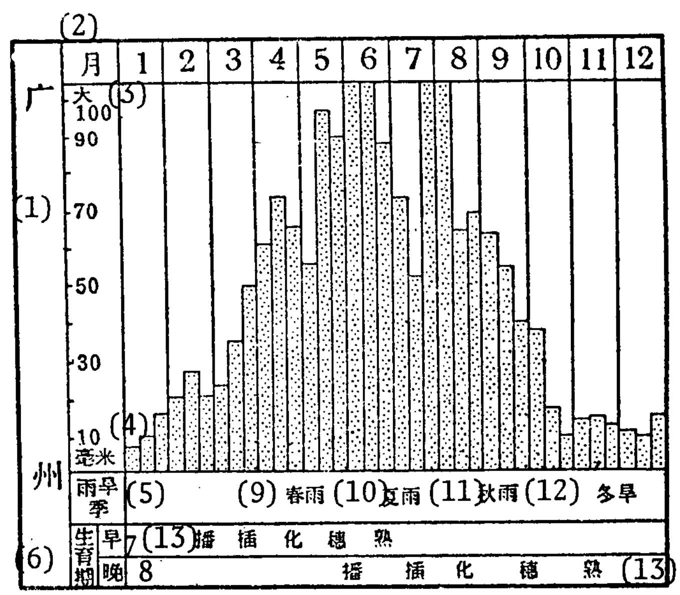
Kansu. In these areas, the precipitation of the rice acreage itself is apparently not enough to supply its needs.

2. RAINY AND DRY SEASONS FOR CHINA'S RICE CROPS [p 130]

The distribution of the dry and the rainy seasons of a particular locality is closely related to its system and technique of rice culture. The distribution of the dry and the rainy seasons in our country may be divided into four categories: The rainy season is in the summer in the areas to the north of Huai-ho. In the middle and the lower reaches of the Yangtze, it is in the spring and summer. In the Southwest, it is in the summer and autumn. In South China, it is in the spring, summer, and autumn. Of course, within each category, there are some local **variations of time** and duration with regard to the beginning of the rainy season.

Table 5-6 Distribution of Precipitation in Canton



注：图中"播，插，化，穗，熟"代表"播种，插秧，稻穗分化，出穗，成熟"，下同。(14)

1. Canton 2. Month 3. Heavy 4. mm 5. Rainy or dry season 6. Growth stage 7. Early varieties 8. Late varieties 9. Spring rain 10. Summer rain 11. Autumn rain 12. Dry winter 13. plant, transplant, evolvement, heading, ripe 14. Note: Representing the five growth stages of

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planting the seeds, transplanting the seedlings, the evolvement of the head, coming to a head, and ripening of the grain.

(1) The category of three rainy seasons

The region to the south of Nan-ling, Fukien, Kwangtung, Kwangsi, Taiwan, and that part of Kweichow which is to the east of Kuei-yang basically belong to this category. Although rain is distributed more evenly in these areas, there is still more of it in the summer, with the spring second, autumn third, and very little in the winter. For example, in Canton, the rainfall in the summer amounts to about 46% of that of the entire year, with 31% in the spring, 14% in the autumn, and 9% in the winter. (Table 5-6)

In the spring, the polar air mass coming from the north is quite weak when it reaches here, while the oceanic warm air mass is always active. The cyclone waves created by by a clash of these two air masses continuously pass this region, and bring clouds and rains all through the spring. The frequent rains make it difficult to work in the seed beds; however, there is plenty of water for transplanting. Due to the fact that the oceanic air mass comes from the east, spring rain starts earler in the eastern part of this region. In some years, it comes very late in the western part, and spring drought is,therefore, also possible. In the past, there were large areas of winter paddies which stored water to be used in the spring.

In the summer, this region is controlled mainly by hot and humid equatorial ocean air mass, and the weather is very unstable. Local heat storms are very frequent. If there is cool air present, the storm may spread to a large area. The frequent rains in the summer guarantee the supply of the tremendous need of water for the early and the late varieties of rice plants to grow in this hot climate. However, the storm may cause flood in the low areas. After the beginning of autumn, the warm and the cold air masses still clash in this region and the rains are still plentiful. The rainy and warm autumn is an excellent climatic resource of this region.

According to the special characteristics of the distribution of the rainy and the dry seasons, with regard to rice culture of this region we must pay attention to the

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following:

a. In order to make full use of the advantageous conditions of long growing season and relatively even distribution of rainfall, we must increase the acreage for repeated crops.

b. While planting the early varieties earler, we must also improve our technique of protecting the seedlings from decomposition as a struggle against the spring rains.

c. Dams and reservoirs should be built for the hilly areas of this region where spring drought can easily occur. Thus, we may gradually reduce the acreage of the winter paddies for water storage so as to increase the acreage for repeated rice crops.

d. The low areas should be equipped with drainage to prevent summer floods.

(2) The Category of Spring-summer Rainy Season

The areas north of Nan-ling and south of Ch'in-ling and Huai-ho, which include the middle and the lower reaches of the Yangtze, belong to this category. The rains are frequent in the spring and summer, while most of them come in the summer, and very little in the fall. However, there can also be dry years. In Nanking, the rains in the spring amount to 25% of the year's rainfall, with 45% for the summer, and 17% for the autumn. (Table 5-7)

In the spring, air masses move from the west to the east, one after another and bring frequent rains to this region. This condition makes it difficult to manage the seed beds; however, for the seedsbeds of the medium varieties, it is an advantage. At the end of spring and beginning of summer, the oceanic air mass reaches this region and crashes with the polar air mass to form a slow moving interface, with the result of sustained rains over a large area. These are the so-called "mei-yu." The "mei-yu" zone stays in the southeast hills and the mountainous areas of Nan-ling from Li-hsia (the early part of May) to Mang-chung (the early part of June); then, it moves gradually northward. Between Mang-chung and Hsiao-shu (the early part of July) it stays in the middle and lower reaches of the Yangtze. The fact that this region is

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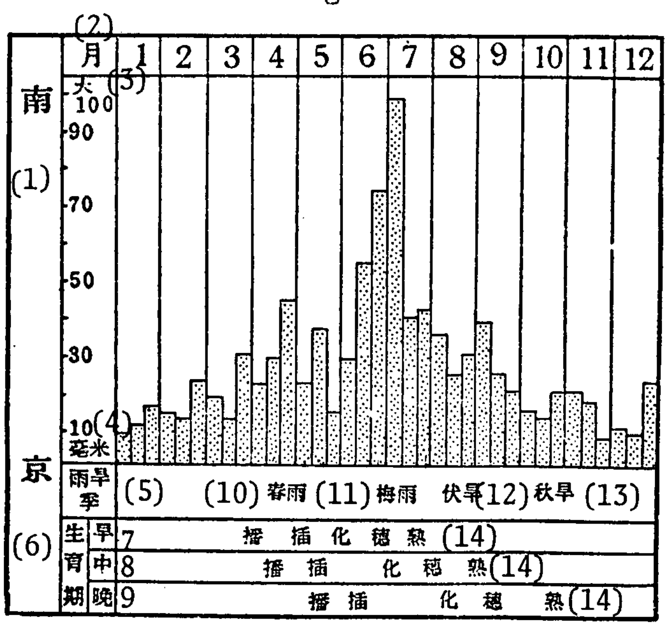
our country's most important rice growing region is inseparable from these "mei-yu." They come just on time to supply water for transplanting the medium and late varieties.

After "mei-yu," this region is controlled by the oceanic air mass alone. Due to the heat of the ground surface or the effect of the earth's uplifting motion, local storms often occur. Sometimes, flood may result. In some areas, after "mei-yu," a summer drought may occur, just when the heads of the medium and late varieties are beginning to evolve. This drought may present a threat to rice production. In some years, there are some autumn rains toward the end of summer and the beginning of autumn. Contrary to "mei-yu," the autumn rains move from the north to the south. However, in most years, it seldom rains in the autumn. This condition is good for the ripening and harvesting of the medium varieties, but, the late varieties may sometimes be damaged by a drought. The hilly areas of this region are frequently threatened by summer and autumn drought. Therefore, in the past, generally only one crop of early or medium variety was cultivated, or, as in the area of Chin-hua, Chekiang, an early crop of paddy rice is rotated with a second crop of upland produce.

Table 5-7 Distribution of Precipitation in Nanking



1. Nanking 2. Month 3. Heavy 4. mm 5. Dry and rainy season 6. Growth stages 7. Early varieties 8. Medium varieties 9. Late varieties 10. Spring rains 11. Mei-yu 12. Summer drought 13. Fall drought 14. Planting, transplanting, evolvement, heading, ripe

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According to the special characteristics of rainfall distribution, we must pay attention to the following factors with regard to rice culture:

a. The rice growing season of this region is also relatively long; therefore, it is entirely possible to plant double-seasoned rice crops, or a single-seasoned late varieties with a long growing season. This has not been the practice in the past, primarily due to the fact that a drought may occur toward the later part of the growing season.

b. A good drainage system is needed in the low areas of this region to prevent floods.

c. Since rains are very frequent in this region during the spring and the summer, and in most cases, there is a winter crop, rice transplanting is always on a tight schedule. There is a practical difficulty for such work produres as turning the soil of the paddies. Measures should be taken to complete the soil turning and sunning procedure in fall before the winter crop is planted so as to improve soil fertility.

(3) The Category of Summer and Autumn Rains

The Szechwan Basin of the upper reaches of the Yangtze and the Yunnan and Kweichow Plateau (the highlands to the west of Kuei-yang, Kweichow) belong to this category. The winter and spring of these areas are dry, and the rains come in the summer and autumn, with more in the summer. For example, in Ch'eng-tu, the rains of the winter and spring amount to only 17% of the year's rainfall, with 64% in the summer and 19% in the fall. (Table 5-8)

In the winter and spring, this region is controlled by the southwest warm currents. This air mass is warm and dry, and is quite stable. As the polar air mass moves down southward, it is not easily obstructed by the Ch'ing-ling, however, it is generally low and cannot easily reach these

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highlands. Therefore, there is less chance of an interface. The drought of the winter and spring continues through May and June. In Yunnan, all four seasons are like spring, and it is not easy to divide the seasons according to temperature. Based on rainfall, From November to the April of the next year is a dry season, and from May to October is a rainy season. The winters are dry. The yield of a winter crop was never very high in the past. The practice was to have large acreage of ponds and paddies to store water during the winter for the use of spring. Mei-yu comes to the Szechwan Basin about the end of spring and the beginning of summer. It lasts roughly from the later part of June to the middle of July. It is the source of water supply for the vast rice paddies. Immediately after the Mei-yu season, drought often occurs in Szechwan. This summer drought comes just when the medium varieties are evolving heads and the late varieties of the double crops are being transplanted. It presents a threat to the highland rice paddies. The threat is not as serious in Ch'eng-tu Plain, because our ancient laboring masses built Tu-chiang Dike which lessens the effect of the drought.

At the beginning of fall, the oceanic air masses tarry in Szechwan Basin after the northern polar masses have finally come down. Rains are therefore more frequent in the fall. This condition brings inconvenience to the harvest of the medium varieties; however, it also presents a possibility of increasing the acreage of late varieties. Although the rainy season begins in May in Yunnan, the rains are more concentrated in the period from July to September. The southwest monsoons bring the equatorial air mass across Heng-tuan Mountains to reach the highlands. The air is therefore hot and humid and very unstable. If a different type of air mass from the northeast or southeast is present, a great deal of rainfall may result. These rains may be used to supply water for the summer rice crops.

According to the special characteristics of the rainfall distribution of this region, the following factors are to be emphasized with regard to rice culture:

a. The spring drought of this region is a great obstacle to rice culture. Winter water storage fields are important for drought relief in the spring. However, this method reduces the acreage for repeated crops. The rice growing season is long in this region, and warm weather comes

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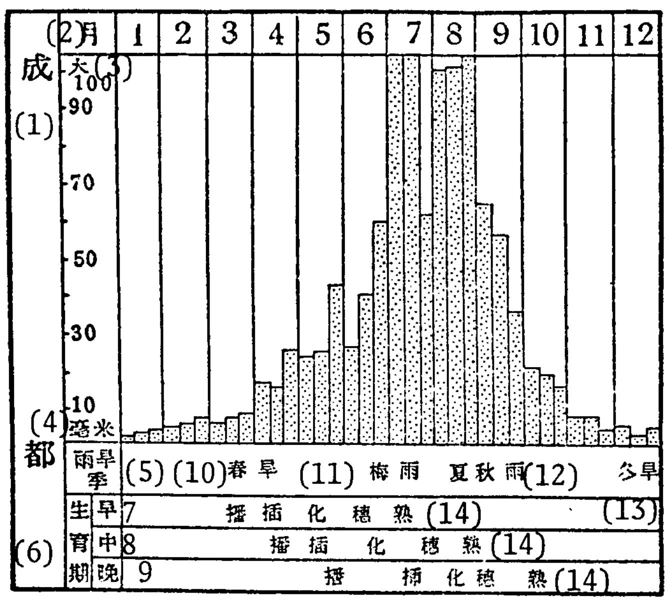
early in the spring. It is possible to develop double-seasoned rice crops if measures are taken to solve the irrigation problems.

b. Dams and reservoirs should be built in the hilly regions of Szechwan to store the surplus rain water of the Mei-yu season for the relief of the summer drought. The high temperature and intense sunlight of this area are good for rice plants if the water supply for summer rice fields can be guaranteed.

c. The paddies should be turned and sunned in the spring to take advantage of the many clear days in that season so as to raise soil fertility.

Table 5-8 Rainfall Distribution in Ch'eng-tu



1. Ch'eng-tu 2. Month 3. Heavy 4. mm 5. Dry and rainy seasons 6. Growth stages 7. Early varieties 8. Medium varieties 9. Late varieties 10. Spring drought 11. Mei-yu 12. Summer and autumn rains 13. Dry winter 14. Planting, transplanting, evolvement, heading, ripening

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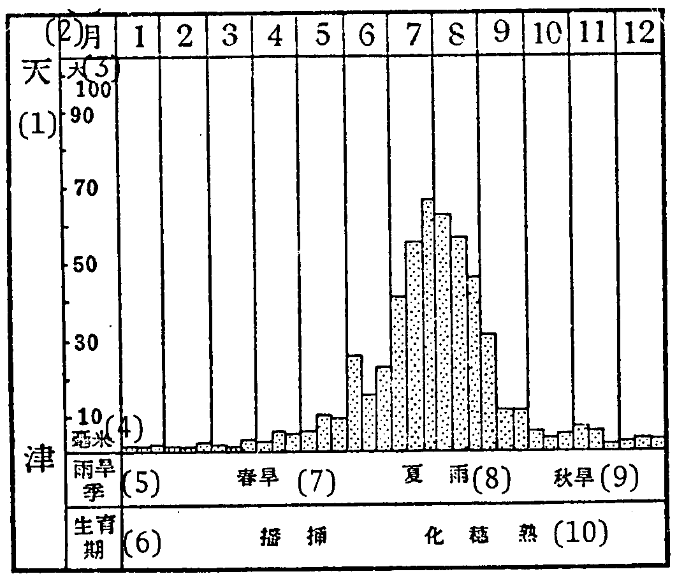
(4) The Category of Summer Rains

The areas north of the Ch'ing-ling and Huai-ho, North China, the Northeast, and the Northwest belong to this category. (Table 5-9) In these areas, the rains are concentrated in the summer, with very little in the other seasons. For example, in Tientsin, the summer rains amount to 72% of the year's rainfall, with 12% in the spring, 14% in the autumn, and 2% in the winter. Of course, there are local variations within this vast region. The similarity is the fact that rains are concentrated in the summer. However, as indicated in Table 5-9, even in the summer, the rains are not plentiful.

Table 5-9. Rainfall Distribution in Tientsin



1. Tientsin 2. Month 3. Heavy 4. mm 5. Dry and rainy seasons 6. Growth stages 7. Spring drought 8. Summer rains 9. Autumn drought 10. Planting seeds, transplanting seedlings, evolvement, heading, ripening

In the spring this region is controlled by the polar air mass alone. The air is dry and stable, and the oceanic air masses cannot reach this region. There is very little opportunity of cloud formation and rain. As the summer begins, the polar air mass retreats northward while the Mei-yu

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zone of the Yangtze Valley is moving northward. The northeastern monsoons come to the Northeast and the southeastern monsoons come to North China and the areas east of Lan-chou. The oceanic air masses bring a breat deal of vapor while the cold air mass is still active in the region. This condition brings summer rains. The rainy season usually begins in the later part of June or the early part of July and ends in the m ddle of September. The rainy season varies somewhat among the various areas of this region. Each time, the precipitation does not last long but the amount of rainfall is huge. In this manner, the rains do not reduce or weaken the sunlight excessively while providing water for the rice paddies. Toward the autumn, the polar air mass quickly renews its vigor and the oceanic air masses rapidly receed toward the ocean. The rains are suddenly reduced. The many clear days of autumn are beneficial for the rice plants during the stage of ripening. However, in the Northeast, there are more autumn rains which present some difficulty to rice harvest. The rice growing season here is mainly in the summer, and the concentrated summer rains are very beneficial. The major shortcoming of this region is the spring drought which affects the transplanting of rice seedlings. This is the main reason why rice acreage has not been too great in the past.

According to the special conditions of the distribution of the rainy and the dry season in this region, the masses have accumulated many precious experiences with regard to rice culture. The most important ones are as follows:

a. Efforts were exerted to build reservoirs and to control the lakes so as to construct irrigation channels and to store the rain water of the summer, to be used for spring planting next year.

b. In the Northeast, the farmers have had many years of experience in direct dry planting. The wet growing of dry seedlings method is currently being popularized in the area of Tientsin. With this method the seeds are planted in dry fields in order to save water. When the rainy season comes, the fields are then flooded to become paddies for the seedlings which have sprouted when the fields are dry.

c. There is a vast acreage of lowlands in this region. In the past, zerophyte crop plants planted in these lowlands often failed due to summer floods. During the recent

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years, there has been a great movement of planting paddy rice in these areas. If measures can be taken to overcome the rain shortage of the first and the second months of spring, the summer rains may be put to good use for the development of rice culture.

SECTION 5. UNFAVORABLE WEATHER CONDITIONS FOR CHINA'S RICE CROPS [p 135]

1. FROST AND RICE CROP [p 135]

To prevent frost damage to rice plants during their heading and blossoming stages, the selection of suitable varieties is the primary method. The varieties selected must complete the two stages before the safe heading period of a particular locality. This factor has been discussed in the section concerning the temperature conditions. Here, we shall emphasize frost damage during the sprouting stage and the ripening stage.

Table 5-10 lists the chances of final frost during the sprouting time. The time interval is figured by days after the seeds have sprouted. The figures in the table show the number of years in a ten-year period a final frost may occur during each of particular interval. (The figures were the result of calculations of years of actual records.) For example, rice plants begin their growth in Peking on the 1st to the 5th of April. One to five days later means from the 6th to the 10th of April. During this interval, there is a one and one-half chance in ten that there will be a final frost. In the records of the past 20 years, there were three such years.

The table explains that:

(1) In every rice growing area of our country, the possibility of a final frost during the sprouting stage exists. However, in South China, this rarely happens.

(2) Such chances are most frequent in the Northeast, about 5 to 7 years in every 10. The situation is worse in the north (K'o-shan) than the south (Kung-chu-ling). This is due to the fact that the latitude is high, so there is more chance of attacks by cold currents in the spring.

(3) The young seedlings also have good chances of encountering final frost in the Huang-huai Plain (Peking, Hsu-chou), about four years in every 10. This is due to the fact that warm temperature

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comes here early in the spring, and the growing season for rice plants is early too, but, the cold currents still have chances of a comeback.

(4) The western part of our country, i.e. the upper reaches of Huang-ho and Yangtze is shielded by Ch'i-lien and Ch'ing-ling Mountains; therefore, there is less chance of an attack of spring cold currents.

(5) The chances are rather great for Yunnan and Kweichow Plateau (K'un-ming). This fact is closely related to the great temperature difference between night and day in these highlands.

(6) The chance of a final frost within the first twenty days after sprouting time is much greater than any other time thenceforth.

Table 5-10 Chances of a Final Frost During the Sprouting Time (Number of times every ten years)

时 (1) 间 (水稻生长开始期)	(10) 克山 5月5—10日	公主岭 4月25—30日 (11)	北京 4月1—5日 (12)	兰州 4月10—15日 (13)	徐州 4月1—5日 (14)	昆明 2月5—10日 (15)	上海 3月25—30日 (16)	广州全年 (17)
(2) 后1—5天	3.0	1.5	1.5	0.5	1.5	1.5	1.0	(开始后仅1955年有一次) (25)
(3) 后6—10天	1.0	2.0	0.5	0	1.5	1.0	1.5	
(4) 后11—15天	2.5	1.0	1.0	1.0	0	0.5	0.5	
(5) 后16—20天	0	0	1.0	0.5	1.0	0.5	0	
(6) 后21—25天	0	1.0	0	0	0	0	0.2	
十年中有终霜年数 (7)	6.5	5.5	4.0	2.0	4.0	3.5	3.2	
(8) 最晚终霜期	5月16日	5月25日	4月26日	5月7日	4月22日	4月14日	4月23日	—
(9) 气象记录年数	(18) 13	(19) 13	(20) 20	(21) 20	(22) 14	(23) 12	(24) 14	13

1. Time (the beginning of growth for rice plants) 2. 1-5 days later 3. 6-10 days later 4. 11-15 days later 5. 16-20 days later 6. 21-25 days later 7. Number of years in ten when there was a final frost during that stage of growth 8. The latest final frost 9. Number of weather records available 10. K'o-shan 5-10 May 11. Kung-chu-ling 25-30 April 12. Peking 1st-5th April 13. Lanchow 10th-15th April 14. Hsu-chow 1st-5th April 15. K'un-ming 5th-10th February 16. Shanghai 25th-30th March 17. Canton the whole year 18. 16th March 19. 25th May 20. 26th April 21. 7th May 22. 22nd April 23. 14th April 24. 23rd April 25. Only once in 1955.

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Before the liberation, there was no weather prediction for the service of agriculture. The farmers regularly kept deep water in the seed beds to protect the seedlings from possible frost. However, deep water is not a favorable condition for the growth of the seedlings. They may easily fall or float. During recent years, the farmers have been forewarned against frost which is predicted on the basis of the cold currents. The seedlings are now planted in damp fields, and before a frost is to come, ashes or a temporary flood of the seed bed suffices to protect the young seedlings. When the frost has passed, the seed beds are drained again, and a small amount of fertilizer is added to further protect the seedlings.

Aside from frost, the areas of Central and South China must also protect the seedlings from decomposition caused by the spring rain and low temperature.

In the last two years, the early varieties of Szechwan, Hunan, and Kiangsi were damaged by low temperature when the heads were evolving. From 21st to the 23rd of May, 1959, Hunan was attacked by cold currents. The temperature dropped as low as 12°C. According to a survey of 21 points of 14 hsien of that province, the bearded early keng came to a head before the 13th of June, and the rate of empty hulls was as much as 73 to 100%. The yield was less than 200 chin per mou. In some fields, there was no yield at all.

According to past experience, cold currents are possible in the later part of May in the Yangtze Valley and in the later part of April in South China. This is just the time when the early varieties are evolving a head. Therefore, proper selection of varieties and suitable planting time are necessary to insure that the early rice crop come to a head after a certain time limit. This is an important technical measure for the stable yield of the early crop. Based on a preliminary summation of the experience of Ch'eng-tu, Ch'ang-sha, Nanking, and Canton, we believe that in the Yangtze Valley, the early varieties should come to a head after the 15th of June; in the southern part of Canton, it should be after 10th of May. The various varieties vary in their resistance to low temperature. Ch'ing-sen No.5 is stronger than bearded early keng and Yin-fang. This is a subject we have pay attention to in the future.

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At present, we do not have enough knowledge of the principles of low temperature damage during the head evolving stage of growth. Further studies are needed by the various rice growing regions.

The early frosts in the autumn also have great effect on the rice plants which are not yet ripe. Preliminary observations indicate that when the temperature drops to below 2°C, the leaves of the hsien varieties quickly turn white, then the stalk dies with the grain still not full. The keng varieties can endure down to 0°C. Table 5-11 lists the chances of low temperature of 0°C between the safe heading period and the end of the growth period. The figures in the table show the number of occurrences in 10 years. The time interval is figured within the 20 days after the completion of the heading period, with every five days as an interval. For example, in Peking, the safe heading period is the 25th to the 30th of August; then, 21 to 25 days later means the 21th to the 25th of September.

Table 5-11 indicates that the chances of low temperature damage during the ripening stage in the various areas correspond with the chances of frost damage during the sprouting stage. The situation is the worst in the Northeast, with five years in ten in the north (K'o-shan) and two years in ten in the south (Kung-chu-ling). The difference is very obvious. In the Huang-huai Plain, it is two years in ten, while it is almost none in the western parts, such as Lan-chou and Ch'eng-tu. The chances are not great in the middle and lower reaches of the Yangtze, but are greater in Yunnan and Kweichow. In the south (Canton), damage is possible in some years but not likely. In a word, the damage from low temperature during the ripening stage is not as frequent an occurrence as the damage during the sprouting stage. For example, in Kung-chu-ling the chance of the first type damage is two in ten, while the chance of the second type of damage is five and a half in ten.

A low temperature threat during the ripening stage is not as serious for the keng varieties, which are more resistant to low temperature during their later stage of growth. It is important to cultivate those varieties that are fast in becoming ripe, i.e. for these varieties there are fewer days from the time of heading to complete ripening.

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Table 5-11 Chances of Low Temperature (below $0^{o}C$) during the Ripening Stage which may Cause Death of the Plants

时 (1) 间	克山 (13)	公主岭 (14)	北京 (15)	兰州 (16)	徐州 (17)	成都 (18)	昆明 (19)	上海 (20)	广州 (21)
安全齐穗期 (2)	8月1—5日 (22	8月5—10日 (23	8月25—30日 (24	8月5—10日 (25	9月5—10日 (26	9月15—20日 (27	9月15—20日 (28	9月15—20日 (29	10月20—25日 (30
后21—25天 (3)	0	0	0	0	0	0	0	0	0
后26—30天 (4)	0	0	0	0	0	0	0	0	0
后31—35天 (5)	0	0	0	0	0.5	0	0	0	0
后36—40天 (6)	1.0	0	0	0	0	0	1.0	0	0
后41—45天 (7)	3.0	0	1.0	0	0.5	0	0	0	0.5
后46—50天 (8)	1.0	2.0	1.0	0	0.5	0	1.0	0.5	0
(9)十年中有低温年数	5.0	2.0	2.0	0	1.5	0	2.0	0.5	0.5
(10)最早 0°C 期	31 7月13日	33 9月28日	35 10月10日	37 10月2日	39 10月8日	41 12月2日	43 10月21日	45 11月9日	47 12月8日
(11)水稻生长终止期	9月15—20日 32	9月20—25日 34	10月10—15日 36	9月20—25日 38	10月15—20日 40	10月20—25日 42	11月1—5日 44	11月1—5日 46	12月8日 48
(12)气象记录年数	11	9	29	19	11	22	12	40	18

1. Time 2. Safe heading period 3. 21-25 days later 4. 26-30 days later 5. 31-35 days later 6. 36-40 days later 7. 41-45 days later 8. 46-50 days later 9. Number of years of low temperature occurrence in 10 years 10. The earliest occurrence of $0^{o}C$ temperature 11. The end of the growth of rice 12. Years of weather records available 13. K'o-shan 14. Kung-chu-ling 15. Peking 16. Lan-chow 17. Hsu-chow 18. Ch'eng-tu 19. K'un-ming 20. Shanghai 21. Canton 22. 1-5 August 23. 5-10 August 24. 25-30 August 25. 5-10 August 26. 5-10 September 27. 15-20 September 28. 15-20 September 29. 15-20 September 30. 20-25 October 31. 13 July 32. 15-20 September 33. 28 September 34. 20-25 September 35. 10 October 36. 10-15 October 37. 2 October 38. 20-25 September 39. 8 October 40. 15-20 October 41. 2 December 42. 20-25 October 43. 21 October 44. 1-5 November 45. 9 November 46. 1-5 November 47. 8 December 48. 8 December

2. TYPHOON AND RICE CROP [p 137]

Typhoon and thunder storms are not good for rice plants during any stage of growth, especially during the early part of the ripening stage. It is important to understand the principles of the storms so as to arrange the rice culture reasonably and to use various techniques to overcome the storms.

For our country, the typhoons are usually storms which have their beginning in the oceans east of the Philippines. Table 5-12 shows the number of times the various areas of our country are attacked by typhoons. On the average they come to our country three times a year, but there may be as many as eight times and in a few years there may be none at all.

Table 5-12 The Number of Times Typhoon Comes Ashore During the Rice Growing Season

地 点 (1)	5月 (9)	6月 (10)	7月 (11)	8月 (12)	9月 (13)	10月 (14)	11月 (15)	总计 (16)	各地登陆 %(17)
(2) 山东半島——上海	—	—	—	3	—	—	—	3	2
(3) 上海——溫州	—	—	17	20	6	—	—	43	22
(4) 溫州——汕头	—	3	17	26	14	1	—	61	31
(5) 汕头——广州湾	1	2	11	1	4	1	1	21	11
(6) 广州湾——海南島	2	5	19	17	17	6	—	66	34
(7) 总计	3	10	64	67	41	8	1	194	—
(8) 各月份总次数的%	2	5	33	35	21	4	1	—	—

(18) 注：表中包括一部分掠过舟山群島而未登陆的台风。

1. Place 2. Shantung Peninsula - Shanghai 3. Shanghai - Wen-chou 4. Wen-chou - Shan-t'ou 5. Shan-t'ou - Kuang-chou-wan 6. Kuang-chou-wan - Hai-nan-tao 7. Total 8. Percentage for each month 9. May 10. June 11. July 12. August 13. September 14. October 15. November 16. Total 17. Coming ashore on the various places % 18. Note: Including the times a typhoon may touch Chou-shan Islands, but does not really come ashore.

The major typhoon season is from June to October, and it occurs most frequently between July and September. On the average, typhoons come ashore once every five years in the area south of Shan-t'ou. It affects South China most, especially Hai-nan-tao. The two provinces of Kiangsu and Chekiang, to the south of Shanghai, are attacked once or twice every year, on the average.

August is the worst month for typhoons. It usually comes ashore and moves northward, and may reach as far north as Shantung. The eastern coast of our country, all the way north to the Northeast may be attacked, once or twice a year on the average. In September, chances of typhoon attacks are less. On the average, it comes ashore once a year in the areas south of Shan-t'ou; however, it may still affect the coastal areas of Kiangsu and Chekiang. There is seldom any typhoon in October.

Although the effects of typhoon are serious, if its rules are mastered, we may adopt effective measures of protection:

(1) In South China, typhoons start in June. The masses of Hai-nan-tao created, out of experience, a method of planting the seeds before January. Harvest thus comes in the middle of May, and typhoon damage may thus completely be avoided.

(2) In the provinces of Chekiang and Fukien, early varieties are ripe in July, and this is the time these areas are liable to be attacked by typhoons. If earlier varieties are used, and planting and transplanting are done still earlier, the early crop may be ripe before the typhoon comes.

(3) In the province of Kiangsu, typhoons frequently come in August. This is the time the medium varieties come to a head and begin to blossom. Therefore, the medium varieties suffer more from typhoons in this province than the early and late varieties. If we increase the acreage of the early and the late varieties or that of the double-seasoned crops, then, the damage from typhoons may be successfully reduced.

(4) Along the coast, short-stalked varieties should be selected. They are better for resisting the wind. This is an important measure for fighting the typhoon.

(5) A zone of protective forests along the coast can be very effective wind protection as well as for stabilizing the dikes.

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CHAPTER 6. SOIL ENVIRONMENT FOR CHINA'S RICE CROPS

[p 141]

The soil of the rice fields is called paddy rice soil, which is formed from natural soil or upland soil by the cultivation of paddy rice as the major crop. Through the alternated dry and wet cultivation, the soil becomes apparently different from ordinary dry soil in its physical, chemical, and biological characteristics. Paddy rice soil is closely related to the moisture layer. Water is not only a soil element of the paddy soil, it also affects the changes in its physical, chemical, and biological nature.

Although paddy soil may be developed from different types of natural soils, although the climate, parent material, terrain, and cultivating system may vary from place to place, the rules of development of its fertility remain the same. The scientific principle for improving the fertility of the paddy soil is applicable everywhere. In their prolonged productive practice, especially since the liberation, the farmers of our country have accumulated a wealth of experience nurturing the fertility of the paddy soil, accelerating its maturity, and changing low yield to high yield. Meanwhile, many important achievements have been made as a result of soil surveys and other related experimental research. The following is a discussion of the three aspects of the general conditions of the paddy soil, the nature of the paddy soil, and the concrete measures for the improvement of the fertility of the paddy soil.

SECTION 1. NATURE OF PADDY RICE SOIL [p 141]

In the process of agricultural production primarily

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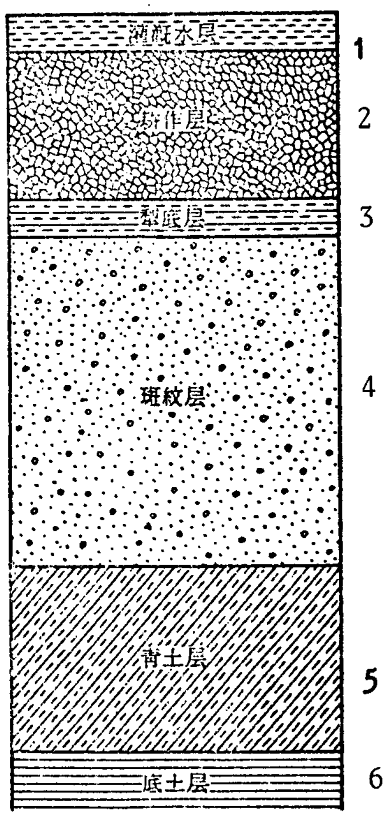
for the cultivation of paddy rice, the development of the paddy rice soil is the result of the various agricultural techniques applied. It has its particular charactieristics. The transfers and changes in the paddy soil proceed in such a special form that it reflects in its soil profile some special characteristics different from the profile of the dry soil. At the same time certain special biological activities develop and in turn affect the formation of the soil and its special fertility. The following is an explanatinn of the various aspects of the special nature of paddy soil.

Figure 6-1 A Profile of Paddy Rice Soil



1. Irrigated wet layer
2. Plowing layer
3. Plow sole
4. Mottled layer
5. Blue soil
6. Subsoil

1. CROSS SECTION CHARACTERISTICS OF PADDY RICE SOIL [p 141]

Under the condition of seasonal alternation of

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dry and wet farming, years of tillage and fertilizer application, and various other cultivation measures, a special soil profile is formed. Generally the layers of the profile are the plowing layer, the plow sole, the mottled layer, the blue soil layer, and the subsoil, as pictured in Figure 6-1.

(1) The plowing layer

This is also called the mature or the surface soil. It is formed and developed under the direct effect of plowing and fertilizer application, and is most closely related to the growth of the crop plants. When we talk about the "fat soil", the "oily soil" and so forth, we are describing the nature of this layer, because to a large extent, it represents the soil fertility of a special field. Its thickness is determined by the depth of plowing, generally between 15 and 25 cm. During the rice growing period, only the few mm-surface of this layer is in an oxidized stage; due to direct contact with the air or the fresh irrigation water containing plenty of air, and certain biological activity, the iron content of the soil has turned into high valence iron and become yellowish brown in color. Below this several mm-surface, aside from the areas in the vicinity of the root system of the rice plants, the iron content of the remaining soil is in reduced state, and due to the formation of ferrous compounds, the color is bluish gray.

After the harvest of rice, a winter crop is planted. As the moisture is reduced, the oxidation state returns. Therefore rust marks may be seen on the lumps and cracks. The farmers of Kiangsu call these reddish marks, "shan-hsueh" /the blood of eels/; and those of Anhwei call them "hung-chin" /red veins/. This is a sign of strong iron oxidation reduction which is the result repeated application of organic fertilizer, and is a definite mark of soil fertility.

Due to wet plowing and wet picking the plowing layer of soil is very soft and is separated into small granules, during the rice growing season. After the water is drained, and the field is kept dry for winter crops, the soil is again plowed dry to beome lumps or broken lump structure. However, if organic matter is lacking or if the soil contains heavy clay, then, it may be too loose when wet and too hard and shrunk when dry. This condition makes it hard for the plow, and bad for the crop plants.

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(2) The Plow Sole

This is also called the subsurface soil. It has been pressed by the mechanical action of the plow and the downward motion of the soil particles. The soil of this layer is very tight and has no structure. The existence of this layer serves to protect the surface soil for the preservation of moisture and fertility, especially if the layer below consists of highly permeable sandy or stony soils. However, if this layer is too tight, the tightness may affect proper drainage and the renewal of the nutritional environment of the rice plants. The recent adoption of the deep plowing measures has increased the thickness of the plowing layer, and the position of the plow sole has been moved downward. It is now about 10 cm thick. In case of heavy clay soil, the deep plowing method is alternated with shallow plowing method so as to prevent the plow sole from becoming too tight.

(3) The Mottled layer

This is also called the heart soil. It is located below the plow sole and above the ground water table. Due to the fact that the rust streaks are most obvious in the soil of this layer, it is called the mottled layer. During most of the rice growing season, the plowing layer is constantly soaked with water, which seeps through the plow sole and the mottled layer to reach the ground water. At this time, the ground water level is high. Although the structural spaces of this layer are thus filled with water, the entire layer of soil is not saturated. The small pores of the soil still contain air. This situation is beneficial for the downward motion of water as well as for the growth of the root system of the rice plants.

When the paddy is drained, the ground water retreats, and the air content of this layer increases. It is thus in an oxidized state. Meanwhile, the soil shrinks when it dries. Many vertical cracks are thus created. There is a settling of many oxides of iron and manganese in the form of yellow, rust, brown, and black spots. Nodules are gradually forming. This condition is more obvious in the paddies with better drainage conditions, and does not exist in those paddies which are soggy all year long. The farmers of the T'ai-hu region of Kiangsu call this the "yellow mud bottom",

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and look upon it as a mark of a fertile rice paddy.

(4) The Blue Soil

This layer is formed by the prolonged saturation of the ground water. The soil is in a reducing state all year long. The reduction products of the iron and manganese oxides are bluish gray and grayish blue colored. If due to reduction, the iron and manganese are lost, the soil appears to be white. This layer generally does not have structure. If it is located high in the soil profile, it is a sign of faulty drainage. It may easily cause the soil to be "cold", and it makes the rice plants difficult to tiller. Then, the soil is not good for the growth of rice neither is it good for the winter crops.

(5) The Subsoil

The subsoil may also be called the layer of the parent material. Normally it means the weathered substance of the rocks, and to a certain extent, it reflects the original appearance of the paddy soil before its development. It makes us understand the process of soil maturity and the development of fertility. Whether a layer of subsoil exists at certain depth of the soil profile is related to the original soil type and the extent of development of the paddy soil. This is generally quite obvious in the paddy soil profile of the hilly and mountainous regions. In the plains, it is often hard to identify.

The aforementioned description of the nature, the thickness, and the arrangement of the layers in the paddy soil profile, not only reflects its form of development but also marks its condition of fertility. General speaking, in the paddv soil profile of a depth of 1 m, the best soil has a thick plowing layer, a properly tight plow sole, and a mottled layer with balanced moisture and air.

2. CONVERSION OF MATTER IN PADDY RICE SOIL [p 143]

The special principle of the transfer of materials in the paddy soil under the condition of alternated dry and wet farming is the most important characteristic of

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the paddy soil. A series of physical chemical and biochemical changes occurs when the soil is saturated with water. The most obvious changes include the following: the electric potential of oxidation reduction is lower, the pH value of the acid soil is higher, the reducibility of iron and manganese and the solubility of phosphorus and silicon are higher. These changes affect rice production to a great extent, and may be properly adjusted by various cultivation measures. The following is an explanation of some important processes of change.

(1) The Condition of Oxidation Reduction

After the paddy is flooded, aside from the several mm-surface which is in contact with fresh irrigation water and is affected by the growth of moss and,therefore, is in an oxidized state, and aside from the small areas in the vicinity of the root system, which also remains in oxidized state, the remaining portion of the plowing layer reverses into a reduction state. The electric potential of oxidation reduction is generally below 250 mv. The layers from the plow sole to the ground water table remain in an oxidized state, and the electric potential stays above 300 mv. The oxidized state of the plowing layer is recovered only after the rice harvest and during the winter crop.

The change of the soil's electric potential is an effect of many complicated factors; however, it is primarily related to poor ventilation and the dissolution of organic matter. Proper ventilation may bring back electric potential to its normal level. This is the purpose of draining and sunning the paddies and soaking them with good fresh water. However, the dissolution of organic matter consumes a great deal of oxygen from the soil moisture, and thus reduces the electric potential. The dissolution of the reduction products of iron and manganese has a certain effect on the nutritional condition of the rice plants, and is also obviously related to the lowering of the electric potential, because the two changes constantly correspond with each other.

Although the root system of the rice plants releases a certain amount of oxygen, it may sometimes not be sufficient to offset the reduction functions. Such reduction products as hydrogen sulfide may poison the root system and

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obstruct its transpiration and nutrient absorption. Sometimes they even cause the root system to become black, decomposed, and to die. Therefore, it is important to adjust the oxidation reduction function of the paddies, especially when a large amount of fertilizer is applied.

(2) In the paddy soil, the process of dissolution of the organic matter is carried out under the saturation condition; therefore, the process is relatively slow. The products of this process are also more complicated than the corresponding products of the dry fields. The latter are mainly carbon dioxide, nitrate, and sulfate; while the former products are carbon dioxide, methane (marsh gas), hydrogen, ammonia, and hydrogen sulfide. The problem of nitrogen transfer is very significant in the study of nutritional physiology of rice plants. The nitro-ammonium which the rice plants absorb is a negative ion, and is therefore easier to be absorbed and preserved by the sticky substance of the soil which carries a negative charge. When the paddy is filled with water, there is actually very little nitrate in the soil. It may either be changed into nitro-ammonium or may turn into gas and be lost. The latter is the often talked about problem of denitration of soil.

Table 6-1 The State of Nitro-ammonium and Nitrates in the Soil After Flooding

地 (1) 点 (江苏练湖)	深 (4) 度 (厘米)	銨态氮含量 (微克/克土)(5)		(8) 硝态氮含量 (微克/克土)	
		灌(6)水 前	(7)灌水后 4 天	灌(9)水 前	灌水后 4 天(10)
(2) 农場3号水田	0—5	10	67.5	6	痕 迹 (11)
	5—15	30	90.0	5	痕 迹 (11)
(3) 农場1号水田	0—5	15	52.5	3	痕 迹 (11)
	5—15	20	67.5	—	痕 迹 (11)

1. Place (Lien-hu) 2. Paddy of Farm No.3 3. Paddy of Farm No.1
4. Depth (cm) 5. Nitro-ammonium content (0.001 mg/g of soil)
6. Before flooding 7. Four days after flooding
8. Nitrate content (0.001 mg/g of soil) 9. Before flooding
10. Four days after flooding 11. trace

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Due to the fact that nitrate is easier to be lost in the paddies, when chemical fertilizers are used, we usually use nitro-ammonium instead. Immediately after the secondary application of fertilizer, a thorough mixing is usually done, so that the fertilizer will not be lost in a rain, and at the same time, if the fertilizer stays on the surface, it may easily oxidize and cause denitration.

The products of dissolution of the organic matter, if in small amounts, do not have great effect on the rice plants. Regular draining and sunning of the paddies may prevent their accumulation.

With regard to the problem of the proportion of carbon and nitrate in organic fertilizer, it is not as important as in the case of dry fields. When the organic matter dissolves under an ill ventilated condition in the paddies, the soil microorganisms require little nitrogen; therefore, fresh and undecomposed stubble may be applied to the paddies as fertilizer. In China, in the areas of double rice crops, the farmers are very experienced in utilizing the stubble of the early crop for fertilizer. In some areas, fresh grass is also used when the temperature is very high. It is found to be highly effective.

Draining and sunning of the paddies are very effective, because when the paddy is rich in organic matter, the soil may not drain well. Once it is drained, sunned, and flooded again, the transfer of the organic matter is strengthened, and the amount of nitro-ammonium increases very quickly. When the soil is highly acid, draining and sunning may improve its alkali content. Since a neutral or slightly alkali reaction is required for mineralization of the organic matter to produce nitro-ammonium, the effect of the draining and sunning process should be very obvious. Lime is also very helpful. According to the studies of the Kiangsu Branch of China Academy of Agricultural Sciences, if phosphorus and potassium fertilizer is applied when the paddy is being dry plowed and sunned, the effectiveness of this process may be further improved. (Table 6-2)

(3) Changes in Acidity and Alkalinity

The fact that the pH value rises when the paddy is flooded has been confirmed by many studies. The study of

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the Kiangsu Branch of China Academy of Agricultural Sciences explains that this change is related to the pH value of the soil before flooding. The change is most obvious in the soil that is highly acid before flooding. In this case the pH value obviously rises. In the paddies of alkali soil, the pH value has a tendency of dropping until it finally becomes neutral. (Table 6-2)

Table 6-2 The Relationship between Phosphorus and Potassium Fertilizer and the Effectiveness of Soil Drying (Paddy soil developed from marsh soil)

处 (1) 理		(8) 不施磷、钾肥		(11) 施磷、钾肥	
		(9) 干耕晒垡	不 (10) 干	干耕晒垡 (12)	不 (13) 干
(2) 植株高度(厘米)		122.30	112.00	128.00	114.60
(3) 总分蘖数(个/盆)		29.00	17.00	33.00	13.50
(4) 穗数(个/盆)		22.50	14.00	25.50	13.00
(5) 单穗平均重(克)		1.86	1.64	1.79	1.62
(6) 茎秆产量	(克/盆)	32.93	17.98	39.86	15.73
	(%)	183.20	100.00	254.29	100.00
(7) 籽实产量	(克/盆)	39.91	21.15	46.94	20.01
	(%)	188.69	100.00	234.58	100.00

1. Treatment 2. The height of the stalk
3. Total number of tillers (number/vase)
4. Number of heads (number/vase)
5. Average weight of a single head (g)
6. Amount of stalk produced (g/vase) (%)
7. Amount of grain produced (g/vase) (%)
8. Without the use of phosphorus and potassium fertilizer
9. Dry plowed and sunned 10. Not drained
11. With the application of phosphorus and potassium fertilizer 12. Dry plowed and sunned 13. Not drained

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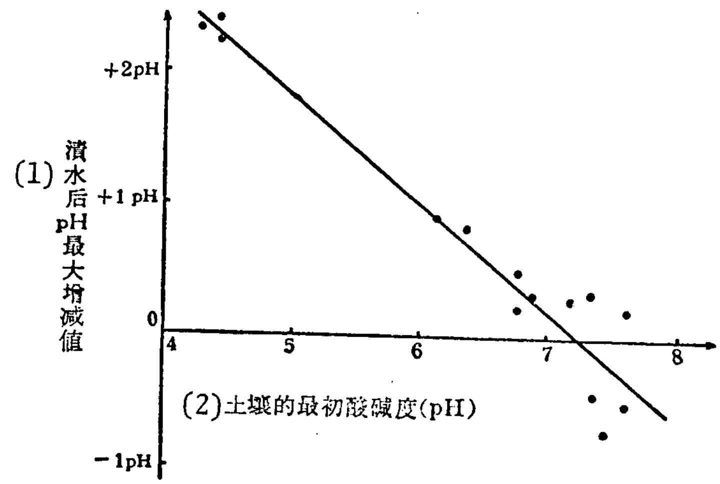
Figure 6-2 The Change of pH values after Flooding and its Relationship to the Original pH value of the Soil



1. The greatest change in pH value after flooding
2. The original pH value of the soil

This adjustment in the pH value of the soil is beneficial to the growth of the rice plants, because too much acid impedes the activities of certain microorganisms and weakens many bio chemical functions. This may be harmful for the rice plants.

(4) The Changes in the Phosphates and Silicates

When the paddy is flooded, the condition induces the reduction of iron phosphate and is beneficial to the supply of phosphorus for the rice plants. The result of the study conducted by the Institute of Pedology, Academia Sinica is shown in Table 6-3.

An analysis of the drainage water shows that the solubility of silicon is increased (Table 6-8). This is

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possibly due to the rise of the pH value of the soil and the reduction of the iron silicate compounds. This condition helps to build strong stalks to resist falling and at the same time improve the resistance of the rice plant against certain diseases.

(5) The Changes in Iron and Manganese

The change in the iron oxide reduction recognized long ago, because it is clearly demonstrated in the soil profile. When the paddy is flooded, the reduction process is carried out quickly, and the ferrous products are quickly dissolved in the water. This process supplies the nutrient requirements of the rice plants, and the combination of the ferrous products and hydrogen sulfide results in the formation of iron sulfide, the settling of which reduces the harmful effect of the product of organic dissolution. However, too much ferrous product is also harmful to the rice plants; therefore, proper adjustments of the oxidation reduction condition remains an important measure in agricultural production.

(6) The Changes in Calcium

The calcium content varies a great deal among the various paddy soils. It corresponds with the pH value to a certain extent. In the north, the paddy lime soil may have a calcium content more than 5%; while in the south, the acid soil generally has less than 0.5%. The normal neutral soil contains about 0.8% of calcium. In the southern soils, calcium exists as an ion exchange; it is combined with other ions carrying negative electric charge which is present in the sticky matter of decomposed vegetation and minerals. The sticky matter, therefore, is very powerful in preserving soil fertility. Aside from a small amount of calcium supply from the water, the calcium requirements are generally furnished by organic fertilizer. The highly acid soil also needs lime. Since the irrigation water contains a great deal of carbon dioxide, calcium solution may easily become lost; therefore, it is important to supply the southern acid soils with sufficient calcium.

In a word, the series of chemical reactions brought about by the flooding of the paddies are sometimes beneficial and sometimes harmful. Therefore, proper drainage and sunning of the paddies are important measures to adjust the renewal of the nutritional environment of the paddy soils.

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According to the observations of the Institute of Pedology, prolonged flooding may improve the reduction function of the plowing layer, especially with the application of organic fertilizer. Draining and sunning produce the opposite result. (Table 6-4). Therefore, irrigation and drainage not only supply the physiological needs of the rice plant, they also produce a series of reactions related to the nutrition of the plant. This is the significance of the combination of water, fertilizer, and soil in the technical measures of agriculture. Moreover, the increased density has a tendency of increasing the electric potential of the soil. Deep plowing has a more complicated effect on the reduction state of the soil. It increases the thickness of the plowing layer, and with the application of organic fertilizer, the electric potential may thus drop; however, deep plowing also improves permeability, and raises electric potential.

Table 6-3 The Solubility of Phosphates under Various Conditions of Oxidation Reduction

1 处理	氧化还原电位（毫伏）(月/日) 4			0.5N醋酸提取P_2O_5毫克/百克土 (月/日) 5		
	9/28	10/12	10/26	9/28	10/12	10/26
2 湿润	357	505	528	0.509	0.93	1.74
3 淹水	139	41	38	0.825	2.53	2.68

6 注：南京石灰性水稻土。

1. Treatment 2. Damp field 3. Flooding
4. Electric potential of oxidation reduction (mv) (month/day)
5. 0.5 N acid produces P_2O_5 (mg/100 g of soil) (month/day)
6. Note: the lime paddy soil of Nanking

The changes in the oxidation reduction state of the paddy soil present an important as well as complicated problem. When cultivating techniques are applied, we must consider all the related factors so that we may create for the rice plants a better nutritional environment in the soil.

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Table 6-4 The Effect of the Oxidation Reduction State on the Transpiration of Rice Plants

处理 1	氧化还原电位(毫伏) 4	总根数 5	白根 6		黑根 8		黄根 10		呼吸强度 12	
			根数 7	%	根数 9	%	根数 11	%	微升/1克鲜重/小时 13	%
晒田后 (8月18日) (回水一天) 2	90	97.0	8.1	8.4	8.3	8.6	80.6	83.1	23.95	114.6
不晒田 3	50	93.8	2.0	2.1	33.5	36.3	58.3	61.5	20.89	100

14 注：江苏常熟晚稻。

1. Treatment 2. After sunning the paddy (18th August), the paddy is flooded again for one day 3. Sunning the paddy 4. Electric potential of oxidation reduction (mv) 5. Total number of roots 6. White roots 7. Number of 8. Black roots 9. Number of 10. Yellow roots 11. Number of 12. Transpiration 13. (ml) 1 g of fresh weight/hour 14. Note: A late variety of Ch'ang-shu, Kiangsu.

Table 6-5 Effect of Cultivating Measures on the Oxidation Reduction State of the Paddy Soil

层次 (厘米) 1	灌排 (江苏常熟晚稻) 2						施肥 (中稻分蘖期) 11		密植 (早稻拔节期) 6/4 16		
	晒田 8/14 3			对照 8/13 7			施基肥 12	对照 14	2万穴/亩 17	4万穴/亩 19	6万穴/亩 20
	氧化还原电位 (毫伏) 4	亚铁 (毫克/100克) 5	亚锰 (毫克/100克) 6	氧化还原电位 (毫伏) 8	亚铁 (毫克/100克) 9	亚锰 (毫克/100克) 10	氧化还原电位 (毫伏) 13	氧化还原电位 (毫伏) 15	氧化还原电位 (毫伏) 18	氧化还原电位 (毫伏) 18	氧化还原电位 (毫伏) 18
3—10	300	—	—	50	303	16.6	75	165	45	60	139
13—15	270	31.2	12.6	150	244	17.0	135	205	—	—	—
20—25	415	0.34	0.21	405	—	—	410	359	—	—	—
40—45	425	0.32	1.13	440	—	—	365	455	—	—	—

1. Layer (cm) 2. Flooding and draining (a late variety of Ch'ang-shu, Kiangsu) 3. Sunning (14th August) 4. Electric potential of oxidation reduction (mv) 5. Ferrous (mg/100 g) 6. Manganese (mg/100 g) 7. Control group (13th August) 8. Electric potential of oxidation reduction (mv) 9. Ferrous (mg/100 g) 10. Manganese (mg/100 g) 11. Fertilizer application (the tillering stage of the medium variety) 12. the application of initial fertilizer 13. electric potential of oxidation reduction (mv) 14. Control group 15. electric potential of oxidation reduction (mv) 16. Dense planting (the stage of node growth of the early variety) 17. 20,000 groups/mou 18. electric potential of oxidation reduction (mv) 19. 40,000 groups/mou 20. 60,000 groups/mou.

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3. BIOLOGICAL ACTIVITY IN PADDY RICE SOIL [p 149]

Numerous groups of microorganisms dwell in the paddy soils, and they improve soil fertility and adjust the various nutrients. The following is a description of these groups of microorganisms.

(1) Putrefactive Bacteria

Bacteria of the paddy soil dwell mainly in the plowing layer. Their number drops quickly below the plow sole, and very few may be found in the mottled layer. (Table 6-6)

Table 6-6 The Distribution of Microorganisms in a Paddy Soil Profile

1 采土地点	8 土壤	15 土壤母质	22 土壤层次	26 细菌(万/1克干土)	27 放线菌(万/1克干土)	28 真菌(千/1克干土)
江苏新海连市 2	老稻田 9	滨海盐土 16	表23土	1,250.0	229.0	25.0
			犁底层 24	639.0	70.0	8.7
江苏无锡 3	黄泥土 10	湖积物 17	表23土	299.0	68.0	12.9
			犁底层 24	228 0	39.0	4.2
			心25土	29.0	12.0	0.2
江苏南京市 4	马肝土 11	长江冲积物 18	表23土	1,410.0	114.0	123.3
			犁底层 24	636.0	110.0	5.7
			心25土	45.0	24.0	12.1
江苏南京市 5	青马肝 12	下蜀系 19	表23土	1,909.0	307.0	39.2
			犁底层 24	446.0	76.0	19.5
			心25土	42.0	12.0	4.6
江西资溪 6	白沙土 13	花岗岩 20	表23土	191.0	37.6	12.0
			犁底层 24	51.6	12.8	0.6
			心25土	17.3	4.4	0.3
江西进贤 7	青格田 14	第四纪红色粘土 21	表23土	1,134.0	132.0	46.1
			犁底层 24	140.0	64.0	8.8

1. Place from which the soil sample is taken 2. Hsin-hai-lien Shih, Kiangsu 3. Wu-hsi, Kiangsu 4. Nanking, Kiangsu 5. Nanking, Kiangsu 6. Tzu-ch'i, Kiangsi 7. Chin-hsien 8. Soil 9. Lao-tao-t'ien 10. Huang-ni-t'u 11. Ma-kan-t'u 12. Ch'ing-ma-kan 13. Pai-sha-t'u 14. Ch'ing-ko-t'ien 15. Parent material 16. Coastal saline soil 17. Lake deposit 18. Yangtze sediments 19. The lower Shu series 20. Granite 21. Quaternary red clay 22. Soil horizon 23. Surface soil 24. Plow sole 25. mottled layer 26. Bacteria (10,000/1 g of dry soil) 27. Actinomyces (10,000/1 g of dry soil) 28. Fungi (1,000/1 g of dry soil).

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During the entire rice growing season, these soil bacteria are affected by such cultivating measures as irrigation, drainage, and fertilizer application; their number and make-up undergo various changes (Table 6-7).

Table 6-7 Aerobes and Anaerobes in Paddy Soils (1,000/1 g of dry soil)

日期（月/日）(1957) 1	土壤情况 2	好气性细菌 10	嫌气性细菌 11	比例 12
5/24	灌水前 3	21,874	2,200	0.10
6/5	灌水后12天 4	7,069	3,100	0.43
7/5	分蘖（蓄水） 5	6,994	3,260	0.52
7/25	圆秆拔节,小穗分化(晒田),施硫酸铵氮素5斤/亩 6	6,554	3,490	0.51
8/8	孕穗（蓄水） 7	3,377	6,400	1.90
8/23	出穗—乳熟（蓄水） 8	3,449	1,500	4.33
9/23	成熟（排水） 9	11,620	1,016	0.87

1. Date (month/day) 2. Soil condition 3. Before flooding
4. 12 days after flooding 5. Tillering (with water)
6. Nodes are growing on the stem, small heads evolving (paddy is dried and sunned), with an application of ammonium sulphate nitro-fertilizer, 5 chin/mou. 7. Evolvement of heads (with water) 8. Heading--milk-ripe (with water) 9. Ripe (drained) 10. Aerobic bacteria
11. Anaerobic bacteria 13. Proportion

Bacteria of the paddy soil include those which form spores and those which do not. Among them, Bacillus megatherium, Bacillus mycoides, Bacillus subtilis, Bacillus putrificus, and Pseudomonas fluorescens are the most numerous, and they play an important part in the nutritional environment of the rice plants. Through ammoniumification, they turn complicated organic nitrates into simple ammonium nitrate which is an essential nutrient for the rice plants. Besides, these bacteria also participate in the mineralization of organic phosphates which is also important for the rice plants.

(2) Nitrifying and Denitrifying Bacteria

The ammonium nitrate of the soil may be further converted into nitrites. This conversion is performed by the nitrifying bacteria, which are strictly aerobic and autotrophic. They require neutral and alkali reactions. Therefore, the flooding and draining of the paddy greatly affect their activity. After flooding, their number drops, and the nitrite content of the soil drops also. Both of these conditions improve when the paddy is exposed to sun after draining.

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Then, there is also denitrification action in the paddy soil. This is accomplished by the denitrifying bacteria. They reduce nitrites to ammonia or to nitrogen. The latter function may bring the loss of nitric content of the soil. When the paddy is flooded, the putrefactive bacteria are very numerous, and all of them may convert nitrates to nitrites and ammonia. There are not many denitrifying bacteria. However, steps must still be taken to improve ventilation of the soil in order to discourage the activities of the denitrifying bacteria.

(3) Nitrogen-fixing Bacteria

These symbiotic bacteria are usually found in roots of the various leguminous plants, and are able to fix atmospheric nitrogen to make it available to host plants. Therefore, planting such winter green fertilizers as Astragalus sinicus, Pisum sativum, and clover may improve the nitrate content of the soil.

There are also autotrophic nitrogen-fixing bacteria. They include the non-spore formers of Azotobacter and Azotomonas, the Anaerobic Clostricium pasteurianum, and others.

The most popular nitrogen-fixing bacteria of the paddy soil are the Azotobacter Chrococum. They may be found in any paddy soil except the highly acid paddy soils of the south. Each gram of soil may contain several hundred to several thousand of them. In some paddies which are rich in organic matter, neutral reaction, and moist, their population may reach ten to thirty thousand. Under suitable conditions, one gram of carbon source (such as glucose) is enough for them to fix ten to fifteen mg of nitrates. At present, they are being added to the soil as a bacteria fertilizer. Experiments of the Institute of Pedology , Academia Sinica in Nanking in 1959 brought excellent results. The bacteria fertilizer may increase the yield of paddy rice more than 10%.

Clostricium Pasteuriaum is a anaerobic bacillus. It does not have as strict environmental requirements as Azotobacter, and is widely distributed in the soil. Their nitrogen fixing ability is lower. From each gram of glucose, they may produce 1.3 mg of nitrates. Their activity in the acid soils of the south is, nevertheless, very important.

(4) Cellulose Decomposing Bacteria

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There are many non-nitrate compounds in the soil, and they are decomposed and converted by various bacteria. However, only a few types of bacteria are able to decompose cellulose. When the paddy is flooded, the function of cellulose decomposition depends mainly on the anaerobic bacteria. The extent of their activity is important for the decomposition of green fertilizers.

(5) Fungi, Actinomyces, and Blue-green Algae

In the paddy soil, there are also various types of fungi and Actinomyces. Just like bacteria, they are concentrated in the plowing layer. The number of fungi in each gram of soil is about seventy to one hundred twenty thousand. The number of actinomyces is about two hundred thousand to two million. The fungi and the actinomyces participate in the mineralization process of organic matter, and certain hard-to-decompose organic matter. They are positively useful in the nitrogen and carbon cycles of the soil.

Besides, the paddy soil also has various types of blue and green algae. Some are able to fix nitrogen. The Institute of Hydrobiology, Academia Sinica discovered that a certain No.686 nitrogen-fixing algae (a blue algae), under bacteria free condition, is able to live four days in a nitrogen free broth, and fix 1.01 mg nitrates. Further tests in the fields proved that they obviously can improve rice production.

Microorganisms also play an important part in the conversion process of the potassium, sulfur, iron, and manganese content of the paddy soils. In a word, microorganisms are numerous in the paddy soil. They do not live in isolation, and they are affected by evironmental conditions. Other forms of organisms (including plants) are closely related to these microorganisms.

4. PRODUCTIVE CHARACTERISTICS OF PADDY RICE SOIL [p 151]

The productivity of the paddy soil is a reflection of many physical and chemical functions which are directly related to the growth of the rice plants. The concept of soil productivity is based on the unified concept

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of crops, soil, and agricultural management. It is closely related to the growth of the rice plants and the cultivating measures adopted. Among the various special characteristics of soil productivity, there are the plowing, the moisture preserving, the fertilizer holding, the tillering, the starch forming, the cold, and the poisoning characteristics. The following is a description of all these.

(1) The Plowing Characteristic

This characteristic is mainly an indication of how easy or how difficult a particular soil is for cultivation. The factors affecting this characteristic of the soil are very complicated. It is not only related to the mechanical composition of the soil. It is also related to the organic and the inorganic composition, the positive ion exchange, the granulation, and the moisture content. The farmers sometimes describe a paddy as "like a knife when it is dry, like a mess when it is wet." Or,"if it is wet it is too early to plow; if it is dry it is too late to plow. Not too wet and not too dry makes it just the right time." They are explaining the relationship between the plowing characteristic and the moisture content.

This characteristic is first affected by the mechanical composition of the soil. Sandy soil is loose and therefore easy to plow; however, its granulation is not so good. If the soil contains too much powdered sand, it may easily become too tight. Too much clay may cause the soil to become hard when it is dry. Generally speaking, if the soil contains 40 to 60% of granules with a diameter of less than 0.01 mm, and 15 to 20% of granules with a diameter of less than 0.001 mm, it is very good for plowing.

The soil that is too loose to hold together may be improved by an increase of organic matter. At the same time other sticky substances may also affect this character.

If the soil lacks organic matter, flooding may cause the soil to lose all its sticky substance, and become extremely tight. In practice, the improvement of the plowing characteristic of paddy soil is done by the application of organic fertilizer.

(2) The Water Holding Characteristic

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When cultivation is carried out in the wet field, the space between the granules and the pores of the surface layer have a tendency of moving downward. This fact and the pressure of the plow often cause the formation of a very tight layer of plow sole. This layer helps to hold the water. Water holding characteristic is very desirable in rice paddies. How to make a new paddy to develop a water holding characteristic is, therefore, an important problem. However, if the plow sole is too tight, the drainage of the field may become very bad, and a problem of stale water may be created to the disadvantage of the rice plants. Much of the nutrient of the plant depends upon the oxygen content of the water. Although paddy rice may grow in stale water, a contantly renewed environment is important for high yield, especially when the plant colony is dense and the fertilizer application is plentiful.

If the water is draining too fast, the poisonous reduction products are thus removed, but, utilizable nutrients are lost also. This kind of contradiction is resolved by a thicker plowing layer, and a good mottled layer.

Aside from irrigation techniques, the water holding characteristic of paddy soil is also affected by the proportion beteen sand and clay, and the porosity of the lower layers. Some of the paddies which were originally dry fields must be plowed and picked repeatedly after being flooded so as to reduce the cracks and pores.

(3) Fertility Holding Characteristic

The application of green fertilizer, manure, and silts helps the soil to hold water as well as fertility. The characteristic of fertility preservation means the amount the nutrients the soil is able to preserve and store, the time it takes for a fertilizer application to become effective, and the length of time it is able to preserve the fertility.

The fertility holding characteristic of paddy soil is closely related to its content of organic matter, its consistency, its absorption capacity, and its saturation point. At the same time its conditions of moisture, air, and temperature also limit its fertility. If a field is low in water holding capacity, it is low in fertility holding capacity also. Sandy soil is not very good for preserving water or fertility.

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The organic matter is decomposed too fast, and the effectiveness of fertilizer does not last long. It is specially important to mix soils of a different region into the sandy soil while applying organic fertilizer. For those fields in which the water has a tendency to become stale, it is important to improve the drainage system and the cultivating system as well. When the water is stale, organic matter is slow in decomposing, and the nutrients are often preserved in the soil. The fertility is released, in this case, only when the soil has been drained and sunned. Therefore, it may be assumed that the paddies preserve fertility better than the dry fields. As the techniques of paddy rice culture improves, the fertility preserving factor of the paddy soils may be further developed.

(4) The Characteristic of Tillering

This is to indicate how fast and how strong the stem grows after the seedling has turned green again. The farmers emphasize the tillering characteristic of the soil. In fertile soils, the seedlings turn green quickly after the transplant, the tiller grows abundantly, and the stems are large and strong. The opposite is the case if the soil is thin

Many factors affect the tillering characteristic. They include the temperature, organic content, the consistency of the soil, and whether or not poisonous substance exists. If the plowing layer is in suitable consistency, and the nutritional environment is good for the young seedling, then the tillering characteristic is likely good.

(5) The Pasty Characteristic

This is to indicate that the soil has a tendency to turn pasty first after being cultivated and flooded; then, the paste soon begins to settle, and the granules hold tightly together to make a board-like surface. While transplanting in this type of soil, if the seedlings are pushed into the soil too hard, the roots are broken easily; if no effort is used to push them in, they soon float on the surface of the water. If the soil contains too much powdered sand, this situation can easily happen. In some cases when the soil granules have been badly washed away, this characteristic may also occur. Measure taken to improve the fertility of the soil will also correct this defect.

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On the contrary, in some other paddies, the paste may not settle at all. The soil stays in a thin and pasty state, and cannot hold the roots of the rice plants. This situation is usually due to prolonged flooding, with an excessive anaerobic decomposition which breaks the soil granules accompanied with poisonous substance. This characteristic of the soil should be duly corrected.

Table 6-8 An Analysis of the Water of a Paddy in Ch'ang-shu, Kiangsu

(Institute of Pedology, Academia Sinica) 1959

项 (1) 目	(7) 灌溉水	(8) 田面水	(9) 渗漏水
硅（毫克/升）(2)	3.0	—	5.0
磷（毫克/升）(3)	0.20	0.33	0.86
亚铁（毫克/升）(4)	0.0	0.0	2.72
亚锰（毫克/升）(5)	0.0	0.0	0.90
氧化还原电位(Eh)（毫伏）(6)	380	305	190

1. Items 2. Silicon (mg/l) 3. Phosphorus (mg/l) 4. Ferrous (mg/l) 5. Manganese (mg/l) 6. Electric potential of oxidation reduction (Eh) (mv) 7. Irrigation water 8. Water of the paddy surface 9. Drainage water

(6) The Characteristic of Being Cold and Poisonous

The growth of the rice plants is closely related to the temperature of the water and the soil. Generally speaking, the paddy with stale water or cold spring water is a low yield field. Therefore, it is important to drain the stale water and to raise the temperature of the soil.

The anaerobic decomposition of organic matter in the soil creates a great deal of poisonous substances. If the soil environment is not renewed properly, these substances may accumulate and eventually harm or kill the rice plants. This

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also a special problem of the rice paddies. Besides, there is also the so-called rusty water fields (it is called reddish paddies in Yunnan), which are caused by a high concentration of ferrous compounds, the occurrence of which indicates a lack of oxygen. The electric potential of oxidation reduction is low, and the acidity is high. This condition impedes the activities of the microorganisms and is bad for the rice plants. In some areas such as the coastal regions of Kwangtung, the soil contains salt and alkali, while the acid content is burried in the lower layers. This is also a bad condition for the rice plants and should be corrected.

5. CHARACTERISTICS OF THE FERTILITY OF HIGH YIELD PADDY RICE SOIL [p 154]

The improvement of the fertility of the paddy soil has the goal of improving the yield of all the crops of a rotation system. Measures are taken to suit the different natural conditions and soil characteristics of different areas so that the soil may continuously mature. The following is an explanation of the general characteristics of a high yield rice paddy.

It is essential that a high yield paddy should be high in its water holding capacity while there is also a good drainage system so that the water requirement of the plants may be renewed in time. The soil must contain a high percentage of organic matter and minerals, and it must have a large capacity of absorbing these substances for the use of the rice plants. It must also be able to release these substances in time for the needs of the plants. A paddy should have a thick plowing layer (surface soil) and also a plow sole (subsurface soil) with proper tightness. It must have a mottled layer for air adjustment. The soil must not remain pasty or settle too tight, and must be well granuled so as to be a good paddy as well as a good dry field. It must not contain too much clay or too much sand, and a minimum of labor is required to cultivate it.

The paddy must be well irrigated and drained so that the oxidation reduction state may improve in the process of alternated wet and dry farming. The acidity and alkalinity is close to neutral, and all physical and chemical reactions

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proceed in the proper direction. The so-called cold characteristic must not occur, and there must not be such harmful substances as salt, soda, rust water, and acids.

With the rich experience of our farmers, the aforementioned characteristics of the paddy soil have all proved to be capable of being cultivated or corrected with cultivation, fertilizer application, and other agricultural techniques. Aside from natural conditions and production demands, the conditions of fertility we just described represent the direction of soil improvement, and at the same time, the basic requirement of high yield soil.

Production experience and scientific research proved that the application of organic fertilizer is the basic measure of improvement for paddy soils. Therefore, planting green fertilizer, developing animal husbandry, and especially raising pigs are very significant measures in rice culture.

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SECTION 2. GENERAL SITUATION OF PADDY RICE SOILS THROUGHOUT CHINA [p 155]

Our country's boundaries are large. The rice growing areas include the tropic, the subtropic, the temperate, and the cold temperate zones, with with the various humid and arid climatic conditions. The system of cultivation and crop rotation is also different. The following is a description of a few representative paddy soils of the major rice growing areas.

1. PADDY RICE SOIL IN SOUTHERN CHINA [p 155]

South China includes the provinces of Taiwan, Fukien, Kwangtung, Kwangsi, and the southern part of Yunnan. In these areas, rice paddies cover the mountain slopes, the valleys, the river banks, and the coastal plains. Everywhere water is available paddy rice is planted. The paddy rice here is mostly formed through many years of cultivation from the zonal red soil and the alluvium.

The parent material of the hilly and mountainous regions is mostly the red soil (with a portion of yellow soil). There are many terraced fields. Due to the effect of the parent material and the natural environment, the soil is mostly acid. However, the acidity is reduced by the cultivation, fertilizer application, and irrigation, and in some places, it is almost neutral. There are many types of soils. Huang-ni-tien T'u, which is developed from the red and the yellow soils, has the largest distribution. (Concerning the characteristics of Huang-ni-tien-t'u, there will be an explanation in the section regarding the paddy soils of the Yangtze Valley.) Besides, there are also some rust-water paddies, cold paddies, pasty paddies, and dried out paddies. These are not very large, but improvement is urgently needed.

In the plains, rice paddies are distributed mainly in the deltas of Pearl River and Han-chiang, the lower reaches of Tung-chiang, Hsi-chiang, and Pei-chiang, and in the Province of Fukien, the lower reaches of Min-chiang and Chiu-chiang and the coastal regions. The soil here is thick and

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soft, and people generally call it mud-meat paddy. Most of these paddies are planted with double-seasoned rice. Besides, there are also some sandy paddies, board-like paddies, powdery paddies, and some alkali-acid paddies along the coast. All of these are low yield, and should be improved.

(1) The Ni-jou-tien T'u /The mud-meat paddy soil/

This soil is very thick, soft, and fertile. The name is given as an opposite to Ni-ku-tien /Mud-bone Paddy/. Ni-jou-tien soil is popularly distributed in South China, and may even be found in the hilly areas, although it is more widely distributed in the plains.

In the plains, this soil is mostly formed from river alluvium. The terrain is flat, the layer is thick, and the consistency is uniform. Its mineral content is complete, and its organic content is rich; therefore, its fertility is high. When it is used for double-seasoned rice crops, years of intensive cultivation and frequent application of fertilizer have made the soil that much more soft, damp but not sticky, and very easy to plow. When it is dry, it is not hard. At present, the mature layer is about 6 ts'un thick and is continuously deepening. Sometimes, organic content may reach 2 to 5%. The soil surface is black and shiny. Therefore, it is also called Hei-ni-tien or Yu-ni-tien /Black mud paddy or oily mud paddy/. It holds water and fertility well, and its nutrients may be released whenever the crop plants need them. Therefore, fertilizer application for the fields of this soil is very economical and brings obvious results.

The following is a description of a profile of Ni-jou-tien-t'u and its chemical analysis.

A profile of the Ni-jou-tien-t'u of Kao-ho-hsien, Kwangtung shows a layer of 0-18 cm of dark brown heavy soil, with a few rust streaks. There are numerous rice roots. The pH value is 5.2; organic matter 3.3%; whole nitrogen 0.0258%; utilizable phosphorus 0.56 chin; utilizable potassium 25 chin per mou. From 18 to 25 cm, there is a layer of yellowish gray heavy soil, with numerous rust streaks, and less rice roots. The pH value is 5.8; organic matter 2.81%; whole nitrogen 0.0215%; utilizable phosphorus 0.75 chin per mou; and utilizable potassium 30 chin per mou.

From 25 to 50 cm there is a layer of grayish white clay, with many rust streaks, and very few rice roots. From 50 to 100 cm there is sandy soil, with the upper part grayish white, and the lower part sediment. The chemical analysis of Ni-jou-tien-t'u of another area is as follows:

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Table 6-9 An Chemical Analysis of Ni-jou-tien of Several Areas

地 (1) 点	有机质 (%) (6)	(7) 氮 (%)	(8) 磷 (%)	(9) 鉀 (%)	酸碱度 (pH) (10)
(2) 广东省龙门县	3.28	0.190	0.060	2.04	6.8
(3) 广东省德封县	2.91	0.100	0.053	1.44	5.9
(4) 广东省广四县	1.91	0.073	0.042	2.72	5.0
(5) 广西僮族自治区容县	4.97	0.243		2.26	6.9

1. Place 2. Lung-men-hsien, Kwangtung 3. Te-feng-hsien, Kwangtung 4. Kwang-szu-hsien, Kwangtung 5. K'o-hsien, The Autonomous Region of the Chuang Nationality, Kwangsi 6. Organic matter (%) 7. Nitrogen (%) 8. Phosphorus (%) 9. Potassium (%) 10. pH value

(2) Sha-ni-tien-t'u [Sandy mud soil]

The fertile Sha-ni-tien-t'u contains a right amount of sand, with high organic content, good and loose structure. It is easy to plow, and holds fertility very well. The seedlings turn green soon after transplanting. They tiller early, and become ripe early. The grains are full and of good quality. A profile of it is shown in Table 6-10.

Table 6-10 A Profile of a Fertile Sha-ni-tien of T'ai-p'ing-hsiang, Liang-chung-Hsien, Hai-nan-tao

性(1)质 / 层(2)次	(8) 剖面性质	酸碱度 (14) (pH)	有机质 (15) (%)	有效磷 (16) (斤/亩)	有效鉀 (斤/亩) (17)
0— 16厘米 (3)	灰棕色砂壤土，稻根密布 (9)	6.1	3.12	0.90	1.5
16— 27厘米 (4)	棕色壤土，稍紧实，稻根中量 (10)	5.9	3.19	4.50	7.5
27— 36厘米 (5)	灰褐色砂壤土，紧实，稻根少 (11)	5.4	2.54	0.08	7.5
36— 53厘米 (6)	灰褐色砂壤土，不见稻根 (12)	6.0	0.58	3.00	1.2
53—150厘米 (7)	暗棕色中壤土，紧实 (13)	—	—	—	—

1. Characteristics 2. Layer 3. 0-16 cm 4. 16-27 cm 5. 27-36 cm 6. 36-53 cm 7. 53-150 cm 8. Characteristics of profile 9. Grayish brown sandy soil, with a tremendous amount of rice roots 10. Brown soil, slightly tight, with a medium amount of rice roots 11. Grayish red-brown sandy soil very tight, with a few rice roots 12. Grayish red-brown sandy soil; rice roots are not seen 13. Dark brown medium soil, very tight 14. pH value 15. Organic matter (%) 16. Utilizable phosphorus (chin/mou) 17. Utilizable potassium (chin/mou).

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Soils of the aforementioned profile have high organic content, which is distributed all the way to below 30 cm. It is rich with nitrogen but is low in utilizable phosphorus and potassium. This is a point to be emphasized when fertilizer is applied. These fertile soils all have been intensively cultivated, with frequent fertilizer application. They are the result of prolonged practice of rice culture.

There are Sha-ni-tien soils which are not as fertile. They contain less than 1% of organic matter, and are poor in the other elements also. The following is a profile of this type of Sha-ni-tien found in Yuan-ling, Hai-nan-tao.

Table 6-11 Profile of a Paddy of Sha-ni-tien Soil in Yuan-ling, Hai-nan-tao

土 层(厘米) (1)	剖 面 性 质 (3)	有 机 质 (7)(%)	全 氮 (8)(%)	有 效 磷 (斤/亩)(9)	有 效 鉀 (斤/亩)(10)	酸 碱 度 (pH)(11)
0—14	灰黄色砂壤土，松软(4)	0.67	0.07	2.3	1.3	6.2
14—36	黄棕色砂壤土，稍紧实(5)	0.22	—	3.0	1.3	6.8
36以下 (2)	紫灰色砂土，有锈斑(6)	0.23	—	1.2	1.3	6.8

1. Layers (cm) 2. Below 36 3. Profile characteristics
4. Grayish yellow sandy soil, loose and soft
5. Yellow brown sand soil, slightly tight
6. Purple gray sandy soil, with rust marks
7. Organic matter (%) 8. Whole nitrogen (%)
9. Utilizable phosphorus (chin/mou)
20. Utilizable potassium (chin/mou) 21. pH value

Hai-nan-tao is in the tropical region. The high temperature makes it possible to plant rice all year long. The continuous consumption of organic matter and minerals of the soil is supplemented by continuous fertilizer application, and the soil fertility is improved and developed in the process. In a tropical region, the formation and decomposition of organic matter is relatively fast, while the physical, chemical, and biological reactions of the soil are also very intense. Therefore, it is possible to use the correct technical measures to obtain an even higher yield.

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(3) Hsiu-shui-tien, Leng-chin-tien, and Lan-ni-tien [Rusty water paddy, cold paddy, and messy paddy]

Hsiu-shui-tien is formed by the excessive ferrous content of the ground water drained from the terraced paddy above. Leng-chin-tien is caused by stale water. The soil temperature is low, the reductive reactions are high, and the fertility cannot be utilized. Lan-ni-tien consists of very sticky soil. It is pasty when flooded. Since stale water stays in the paddy all year long, the soil utilization rate is very low. The main cause of these three types of soil is the high reduction reaction, and improvement is badly needed.

(4) Wang-t'ien-tien-t'u [Looking-up-to-the-sky soil]

The condition of this soil is the opposite of the ones described above. It is distributed on the higher sections of the hills, and there are no ponds, dams, or reservoirs to store the water for irrigation. It suffers easily from natural calamities. The fertility is low, and the soil remains in the nature of the red or the yellow soil. Organic matter is lacking. It is highly acid, with little mineral content. For this type of soil, irrigation problems should be solved first so that with proper cultivation the soil fertility may be improved. In some cases, irrigation is extremely difficult; then, we must adjust the mode of land utilization according to the general soil survey.

(5) Alkali, or Alkali-acid Soil

This type of soil is distributed mainly in the coastal regions of Kwangtung and Fukien. The alkali soils contain chlorides or sulfuric salts, about 0.03 to 0.05%, and in some cases, almost 1%. At the same time, below the layer of alluvium, there is a layer of highly acid marl which was formed by the decomposition of the mangrove forest which flourished along the coast in the past. The pH value of these soils remains constantly about 3. Improvement is urgently required.

2. PADDY RICE SOIL IN THE YANGTZE RIVER AREA [p 159]

This region includes the provinces of Kiangsu, Chekiang, Anhwei, Kiangsi, Hunan, Hupei, Szechwan, Kweichow, and the central and northern parts of Yunnan. This is our country's major region of the two crops of rice and wheat. The soils of this region are Hung-jang [Red soil], Huang-jang [Yellow soil], Lin-yu-ho-t'u [eroded brown soil], Huang-ho-t'u [Yellowish brown soil], Marsh soil, and meadow soil. The reaction of these soils is close to neutral. The lime content is mostly lost, but silicon nutrients are still plentiful. The paddy soils of the region are formed from the above natural soils.

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The hilly and mountainous areas of this region all have terraced fields. The paddies which are formed from Hung-jang and Huang-jang are called Huang-ni-tien-t'u. Those which are formed from Tzu-tsung-jang are called Tzu-she-ta-ni-tien-t'u. Those which are formed from Huang-ho-t'u are called Ma-kan-t'u and Pai-t'u. Huang-ni-tien-t'u and Ma-kan-t'u have the widest distribution. They are of ordinary fertility. Tzu-she-ta-ni-tien is distributed only in the hilly areas of Szechwan and Kweichow, and is quite fertile. The fertility of Pai-t'u is the lowest. Just like South China, there are some Hsiu-shui-tien, Leng-chin-tien, Lan-ni-tien, and Wang-t'ien-t'ien urgently in need of improvement.

The plains include the valleys of the Yangtzu and its tributaries, as well as the salt and soda soils of the coastal regions. The regions of T'ai-hu, P'o-yang-hu, and Ch'eng-tu are among the most famous rice producing areas of our country. There are double rice crops with green fertilizer, or two crops of rice and wheat. After many years of cultivation, the river alluvium has developed into paddy soils of Shan-hsueh-t'u, Ch'ing-ni-t'u, Ya-shih-t'u, and others.

(1) Huang-ni-tien-t'u

It is widely distributed in the hilly regions of the central and the southern parts of our country. All the paddies of this soil are contour terraced fields. Those of the upper section of the hills are smaller. The plowing layer is shallow, and the fertility low. Those of the intermontane basin and its edges have deeper plowing layer and higher fertility. The soil is often heavy with a high clay content. It is good in preserving water and fertility. The parent material is acid, and the acidity has been greatly reduced. The pH value is about 6. However, some of these paddies need lime. The organic content is less than the paddies of the plains, about 1.5%. The soil lacks calcium, magnesium, phosphorus, and potassium, and is in need of supplements. See Table 6-12, 13 for profile and analysis.

Since Huang-ni-tien-t'u is primarily acid, there are less activities of such microorganisms as the nitrogen-fixing bacteria, and not enough minerals. The plowing layer is naturally shallow on the terraced fields, and fertility is not as good as may be desired. At present, the practice of deep plowing is gradually being adopted; with the application of organic fertilizer, burnt soil, wood ashes, lime, and phosphorus fertilizer, Huang-ni-tien-t'u is gradually being improved and is developing into Huang-ni-jou-tien.

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Table 6-12 An Analysis of a Huang-ni-tien-t'u Paddy, in Lang-ch'i-hsien, Anhwei Province

(1) 土层深度(厘米)		0—16	16—42	42—55	55—85	85—130
(2) 采样深度(厘米)		0—16 (21)	16—30 (24)	42—55 (27)	55—75	(33) 95—115
颜 (3) 色		浅黄灰	浅黄灰	淡黄灰	棕 (30) 黄	浅棕黄
质 (4) 地		中 (22) 壤	重 (25) 壤	重 (28) 壤	粘 (31) 土	粘 (34) 土
新 (5) 生体		锈 (23) 纹	锈纹及结核 (26)	锈纹及灰色胶膜 (29)	锈纹及灰色胶膜 (32)	锈色及灰白色胶膜 (35)
(6) 酸碱度 (pH)	干土(水浸液) (7)	4.95	5.85	6.60	6.70	6.50
	湿土(水浸液) (8)	5.40	6.25	6.95	7.00	—
	干土(盐浸液) (9)	3.85	5.00	5.65	5.70	5.60
	湿土(盐浸液) (10)	4.15	5.65	5.80	5.95	5.40
(11) 有机质(%)		1.48	0.70	0.46	0.33	0.14
(12) 氮 (N) (%)		0.088	—	—	—	—
(13) 磷 (P_2O_5) (%)		0.058	0.055	0.072	0.055	0.031
(14) 速效磷(%)		0.002	0.003	0.003	0.002	0.001
(15) 鉀 (K_2O) (%)		1.26	1.22	1.33	1.17	1.18
(16) 速效鉀(%)		0.015	0.009	0.010	0.011	0.011
(17) 铁 (Fe_2O_3)(%)		2.88	5.70	4.210	4.100	3.650
(18) 锰 (MnO) (%)		0.13	0.11	0.04	0.03	0.13
(19) 钙 (CaO) (%)		0.24	0.02	0.28	0.25	0.25
(20) 镁 (MgO) (%)		0.58	0.24	0.63	0.48	0.33

1. Depth (cm) 2. Depth from which the sample is taken (cm) 3. Color 4. Consistency 5. Newly created substance 6. pH value 7. Dry soil (soaked in water) 8. Damp soil (soaked in water) 9. Dry soil (soaked in salt water) 10. Damp soil (soaked in salt water) 11. Organic matter (%) 12. Nitrogen (%) 13. Phosphorus (%) 14. Quickly utilizable phosphorus (%) 15. Potassium (%) 16. Quickly utilizable potassium (%) 17. Iron (%) 18. Manganese (%) 19. Calcium (%) 20. Magnesium (%) 21. Light yellowish gray 22. Medium 23. Rust streaks 24. Light yellowish gray 25. Heavy 26. Rust streaks and nodules 27. Light yellowish gray 28. Heavy 29. Rust streaks and grayish sticky membranes 30. Brownish yellow 31. Clay 32. Rust streaks and grayish sticky membranes 33. Light brownish yellow 34. Clay 35. Rust color and grayish white sticky membranes.

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Table 6-13 Soil Analysis of Huang-ni-tien-t'u of Certain Areas of Hunan and Kwangtung

地 (1) 点	有机质 (8)(%)	氮 (9) (%)	有效磷 (10)(斤/亩)	有效鉀 (11)(斤/亩)	酸碱度 (12)(pH)	资料来源 (13)
(2) 湖南邵东齐心社	2.17	0.257	1.56	45.3	6.15	湖南农业通讯，1958第8期 (14)
(3) 湖南望城群力社	1.41	0.159	9.69	41.6	5.80	
(4) 湖南衡南前进社	1.44	0.115	1.78	16.8	—	
(5) 广东博罗县	1.77	0.053	—	—	—	广东土壤志（初稿），1959 (15)
(6) 广东珠海县	1.68	0.070	0.90	45.0	6.00	
(7) 广东三水县	2.60	0.150	—	42.0	6.50	

1. Place 2. Ch'i-hsin-she, Shao-tung, Hunan
3. Chun-li-she, Wang-ch'eng, Hunan 4. Ch'ien-chin-she, Hunan
5. Po-lo-hsien, Kwangtung 6. Chu-hai-hsien, Kwangtung
7. San-yung-hsien, Kwangtung 8. Organic matter (%)
9. Nitrogen (%) 10. Utilizable phosphorus (chin/mou)
11. Utilizable potassium (chin/mou) 12. pH value
13. Source of information 14. Agricultural Bulletin, Hunan No. 8, 1958
15. Soil Survey of Kwangtung (draft), 1959

(2) Tzu-she-ta-ni-tien-t'u

It is distributed in the hills of Szechwan and Kweichow, and is highly fertile. "Ta-ni" is the term people use to call fertile soil. Its physical characteristics are similar to those of Huang-ni-tien-t'u, but it is less aged, and therefore, still preserves many of the minerals of the parent material. It holds water and fertility well. With intensive cultivation, high and stable yield is guaranteed.

(3) Shan-hsueh-t'u

This is the name of the soil of T'ai-hu region. It is also called "Hung-chin-t'u." This type of soil is widely distributed in the lake plains of the middle and lower reaches of Yangtze. Its special characteristic is the fact that there are many yellowish red or rust colored streaks in the plowing layer. The farmers call these streaks "shan-hsueh" [the blood of eels]. According to the studies of the Institute of Pedology, these streaks are a kind of ferrous organic compound, and are different from ordinary rust streaks. Contrary to the latter, they are good for the nutritional elements of the plants. Their formation is closely related to frequent application of organic fertilizer, and they are, therefore, the marks of fertility. It is often distributed next to Ch'ing-ni-t'u and Hsiao-fen-pai-t'u. Its drainage

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is quite good. Whenever the cultivation is intensive, silts and organic fertilizer are applied year after year, and the soil is thus highly mature, it is mostly "shan-hsueh-t'u." It contains more than 2% of organic matter, sometimes even exceeding 3%. Its structure is good. It is loose when dry; smooth and soft when wet. It is easy to plow. Water and nutrients are very well preserved. At present, it is used for a rotated crop of rice, wheat, oil cabbage, and green fertilizer. The following is one of its profile:

Table 6-14 A Profile of the Shan-hsueh-t'u of Wang-t'ing Experimental Station, Su-chou, Kiangsu (Kiangsu Branch of China Academy of Agricultural Sciences 1958)

深度(厘米)(1)	0—25	25—57	57—77	77—105
剖面性态 (2)	棕灰色，轻粘土多锈色斑纹及棕黑色斑点结构 (15)	青灰色重壤土同前 (16)	青灰色重壤土同前但数量较少 (17)	青灰色重壤土同前但数量较少 (18)
pH (水浸液) (3)	7.0	6.8	6.8	7.1
有机质 (%)(4)	1.97	0.86	0.5	0.47
氮 (%) (5)	0.126	0.059	0.043	0.037
磷 (P_2O_5) (%) (6)	0.154	0.180	0.086	0.055
速效磷 (%)(7)	0.004	0.011	0.004	0.002
钾 (K_2O) (%) (8)	1.820	0.170	1.530	1.36
速效钾 (%) (9)	0.012	0.006	0.008	0.006
钙 (CaO) (%) (10)	0.840	0.910	1.670	0.66
镁 (MgO) (%) (11)	1.080	1.080	0.950	0.66
碳氮比 (12)	9.000	8.500	7.400	7.40
代换性盐基总量(13) (毫克当量/100克)	23.90	22.80	19.30	14.90
(14) 机械组织 <0.005毫米	97.74	96.42	96.10	6.52
<0.01毫米	62.65	56.96	56.76	52.18
<0.001毫米	31.40	30.40	30.10	26.46

1. Depth (cm) 2. Profile 3. pH value 4. Organic matter (%) 5. Nitrogen (%) 6. Phosphorus (%) 7. Quick utilizable phosphorus (%) 8. Potassium (%) 9. Quickly utilizable potassium (%) 10. Calcium 11. Magnesium (%) 12. Carbon/nitrogen proportion 13. Total amount of exchangeable alkali (mg equivalent/100 g) 14. Mechanical composition ...mm 15. Brownish gray, considerable light clay, rust colored streaks, and brownish black mottles 16. Bluish gray heavy soil, same as the layer before 17. Bluish gray heavy soil, same as the layer before, but with fewer streaks 18. Bluish gray heavy soil, same as before, but with still fewer streaks.

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(4) Ch'ing-ni-t'u

Another type of soil distributed in the middle and low reaches of Yangtze Valley is the Ch'ing-ni-t'u. The area is usually lower, and the drainage conditions are not as good. The parent material is the sediments of the river and the lakes. Sometimes, before turning into paddies, the area was a meadow with marsh plants. Deep under the surface, a layer of black silts is buried, and under the effect of water, the silts have turned blue. The soil is relatively heavy. It is sticky when wet; hard when dry. Plowing is therefore rather difficult. It is not very permeable, and reductive activity is strong. Drying and sunning measures are, therefore, particularly effective here. The soil holds water and fertilizer very well. The organic content is medium. If the drainage condition can be improved with intensive cultivation, frequent application of fertilizer so as to loosen the soil, and a rotation of legumes, this type of soil may be made into very fertile paddies. The Wu-ni-t'u and Hung-chin-t'u of Anhwei, and the San-hsueh-t'u and Wu-shan-t'u of Kiangsu are really highly matured Ch'ing-ni-t'u. The following is one of its profiles.

Table 6-15 An Analysis of the Wu-ni-t'u of Hsin-yuan Commune, T'ai-p'ing Hsien, Anhwei

土 (1) 层 (厘米)	0—15	15—33	33—42	42—100
酸碱度 (pH) (水浸液) (2)	7.7	7.6	6.8	7.5
有 机 质 (%) (3)	1.77	1.90	1.64	0.95
氮 (%) (4)	0.125	0.155	0.072	—
磷 (P_2O_5) (%) (5)	0.038	0.084	0.047	—
代 换 性 盐 基 (毫克当量/100 克土) (6)	18.65	19.40	18.40	21.02

1. Soil layer (cm) 2. pH value (soaked in water) 3. Organic matter (%) 4. Nitrogen (%) 5. Phosphorus (%) 6. Exchangeable salts (mg equivalent/100 g of soil).

(5) Ya-shih-t'u

It is distributed in Hupei, Anhwei, Kiangsu, and Chekiang, with the largest acreage in Kiangsu. The paddies of this soil have been accumulating water year after year. The soil is pasty, with a thick surface of floating muck, sometimes more than one ch'ih. Plowing is very difficult. Generally speaking, the organic content is high, with plentiful nitrogen. Due to the high reduction activities, soil fertility is not easily utilized. In many areas, paddies of this soil are being converted into dry fields, with rotated crops of rice, wheat, oil cabbage, and legumes, so as to raise the utilization rate. A profile of this soil is shown in Table 6-16.

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Table 6-16 An Analysis of the Ya-shih-t'u
of Hsing-hua-hsien Farm, Kiangsu

土 层（厘米）(1)	0—10	10—38	38—88	88—150
剖 (2) 面 性 态	(12) 暗棕灰色中壤表土耕作层	(13) 灰棕色重壤过去浮泥层	(14) 黑色重壤埋藏黑土层	(15) 灰白色轻壤沼泽时期灰漂层
酸 碱 度 (pH)(水浸液) (3)	7.55	7.40	6.20	7.35
有机质 (%) (4)	2.19	2.73	4.70	0.37
磷 (P_2O_5) (%) (5)	0.118	0.113	0.066	0.118
鉀 (K_2O) (%) (6)	1.97	1.85	2.00	1.38
鈣 (CaO) (%) (7)	1.53	1.41	1.05	1.04
鎂 (MgO) (%) (8)	1.72	1.49	1.05	1.14
氮 (%) (9)	0.142	0.154	0.245	0.025
(10) 代换性盐基总量（毫克当量/100克）	20.50	20.90	27.70	9.80
(11) 机械组织 <0.01毫米	44.90	46.31	49.96	27.94
(11) 机械组织 <0.001毫米	23.16	25.44	24.96	15.38

1. Soil layer (cm) 2. Profile condition 3. pH value (soaked in water) 4. Organic matter (%) 5. Phosphorus (%) 6. Potassium (%) 7. Calcium (%) 8. Magnesium (%) 9. Nitrogen (%) 10. Exchangeable salts (mg equivalent/100 g) 11. Mechanical composition ...mm
12. Dark brownish gray medium soil, surface plowing layer
13. Grayish brown heavy soil, the floating mud layer of the past
14. Black heavy buried soil, the layer of black soil
15. Grayish white light soil of the marsh.

(6) Ma-kan-t'u

It is widely distributed in the hills of the Yangtze Valley. "Ma-ka-t'u" /horse-liver soil/ so-called because of the small, brownish black iron and manganese spots and nodules it contains. This soil is formed from the Huang-ho-t'u, the natural fertility of which is higher than the Hung-t'u and Huang-t'u of the hills. It is generally heavy, not easily plowed, but, its pH value is close to neutral, with plenty of exchangeable salts. It holds water and fertility well, and has a high mineral content. If cultivated intensively, with frequent application of organic fertilizer, it may turn into Hei-yu Ma-kan-t'u /Black-oil Horse-liver soil/, which is extremely fertile. The following is an example of its profile.

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Table 6-17 A Profile of Ma-kan-t'u in Hsiao-ling-wei, Nanking

		0—18	18—34	34—69	69—159
土壤深度(厘米)(1)		0—18	18—34	34—69	69—159
(2) 剖面性态		棕灰色重壤土疏松，植物根多，有锈色斑纹及棕黑色中型铁錳结核 (14)	灰棕色中壤土稍紧实，植物根较少，有锈色斑纹及小结核 (15)	黄棕色中壤土，较紧实，植物根少，有锈色斑纹及棕色小型铁錳结核 (16)	灰棕色中壤土，多锈色斑纹及棕黑色铁錳斑点及小结核 (17)
(3) 酸碱度(pH)	水浸液	7.35	7.70	7.35	7.75
	盐浸液	6.05	6.10	5.75	5.60
(4) 有机质(%)		1.22	0.40	0.26	0.29
氮(%) (5)		0.086	0.043	0.030	0.033
磷 (P_2O_5)(%) (6)		0.143	0.096	0.075	0.096
鉀 (K_2O)(%) (7)		1.70	1.73	1.73	1.76
速效性磷(%) (8)		0.008	0.005	0.003	0.005
速效性鉀(%) (9)		0.006	0.002	0.002	0.006
鈣 (CaO)(%) (10)		0.64	0.63	0.61	0.53
鎂 (MgO)(%) (11)		0.79	0.63	0.51	0.58
交換性盐基总量(毫克当量/100克) (12)		15.60	14.08	13.40	15.50
(13) 机械组织	<0.05毫米	94.96	92.56	39.24	43.58
	<0.01毫米	48.44	42.56	39.24	43.58
	<0.001毫米	20.58	19.54	17.96	21.82

1. Depth (cm) 2. Profile 3. pH value, soaked in water, soaked in salt water 4. Organic matter (%) 5. Nitrogen (%) 6. Phosphorus (%) 7. Potassium (%) 8. Quickly utilizable phosphorus (%) 9. Quickly utilizable potassium (%) 10. Calcium (%) 11. Magnesium (%) 12. Exchangeable salts (mg equivalent/100 g) 13. Mechanical composition ...mm 14. Brownish gray heavy soil, loose, with many plant roots, rusty colored mottles and brownish black medium sized iron and manganese nodules 15. Grayish brown medium soil, slightly tight, with fewer plant roots, and rusty colored mottles and small nodules 16. Yellowish brown medium soil, rather tight, with only a few plant roots. There are rusty colored mottles and brown colored small sized iron and manganese nodules 17. Grayish brown medium soil, with plenty of rust colored mottles and brownish black iron and manganese mottles and small nodules.

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(7) Pai-t'u

Pai-t'u may be divided into Hui-pai-t'u (Yu-pai-t'u), Huang-pai-t'u, Pai-t'u, Ch'en-pai (Ting-pai-t'u) and so forth. This is also a common paddy soil of the hills, and is often found next to Ma-kan-t'u. In some areas, it is also called "Pai-shan-t'u). Its parent material is the same as Ma-kan-t'u. Its plowing layer is white colored when it is dry. Lack of organic matter (about 1%) is the reason for its turning white. Its granules and mineral content have been largely washed away. The content of powdered sand increases as a result. It is generally low in fertility. The powdered sand content is very high (60-70%), with very few granules (less than 20%). After flooding, the soil quickly settles into a board-like surface, and this condition makes it very difficult to plant the seedlings. Although the saturation point is not low (about 80%), the amount of absorption is small (generally 14 mg equivalent in 100 g of soil). The fertility is low, and minerals such as iron and manganese are lacking. This type of soil is often located a distance from the villages, and cultivation has not been intensive for years. The plowing was shallow, and fertilizer application infrequent. The granules and minerals have been constantly washed away. For this type of soil, different cultivating systems bring different results. Even though the powdered sand content is high, with a large amount of organic fertilizer, the board-like surface may be made to disappear. Deep plowing may increase the depth of the plowing layer; with additional pond silts and rotated crops of green legumes, it is possible to improve the physical and chemical characteristics of the soil.

Besides, it is necessary to supplement the soil with minerals. Sometimes, mixing hulls and straw into the soil while wet plowing may bring good effects. The soil analysis of Pai-t'u is shown in Table 6-18.

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Table 6-18 An Analysis of P'ai-t'u in Anhwei Province

(1) 分析项目	(6) 有机质 (%)	(7) 氮 (%)	(8) 磷 (%)	(9) 有效鉀 (%)	(10) 有效磷 (%)	(11) 吸收容量 (毫升/100克土)	12 砂粒 (%)	13 粉砂 (%)	14 粘粒 (%)
(2) 灰白土	1.64	0.128	0.032	0.0128	0.0077	17.73	10.0	73.0	17.0
(3) 黄白土	1.07	0.107	0.026	0.0048	0.0010	13.59	12.0	79.0	9.0
(4) 白土	0.87	0.063	0.022	0.0024	0.0009	13.46	9.0	79.0	12.0
(5) 澄白土	0.68	0.068	0.002	0.0048	0.0029	8.64	13.0	79.0	8.0

1. Item 2. Hui-pai-t'u 3. Huang-pai-t'u 4. Pai-t'u 5. Ch'en-pai-t'u 6. Organic matter (%) 7. Nitrogen (%) 8. Phosphorus (%) 9. Utilizable potassium (%) 10. Utilizable phosphorus (%) 11. Absorption capacity (ml/100 g of soil) 12. Sand grains 13. powdered sand (%) 14. Sticky grains (%)

3. PADDY RICE SOIL IN NORTH CHINA, NORTHEAST AND NORTHWEST CHINA [p 164]

Dry farming was the prevailing system in the north. Paddy rice was planted in low areas with poor drainage. Therefore paddy soils of the north often contained salts and soda. Since the liberation, with the development of water conservation construction and irrigation, many new paddies have been created. At present, rice culture presents a new solution to the improvement of the salt and soda soils; with the adoption of a crop rotation system of paddy and dry farming, the total yield has been raised considerably.

The paddy soils of the north are mostly formed from chestnut earth, meadow soil, and soda and saline soils. The soils are generally high in mineral content. Phosphorus is usually present in the form of calcium phosphate and magnesium phosphate; while in the south it is usually in the form of

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ferric phosphate or aluminum phosphate. The former type of phosphate compounds are not only utilizable for rice plants, they are also easily absorbed by the dry crops. The sticky minerals of the soil have a large capacity for absorbing positive ions. This type of soil is high in nutrient preservation, and its moisture is easily adjusted to suit the needs of the rice plants. However, aside from those paddies of the Northeast with meadow soil as their origin, the others generally lack organic matter, often between 0.05 to 1%. The paddy soils of the south contain about 2% of organic matter, while the specially fertile paddy soils contain about 3%. Besides, the ground water is high in mineral content, especially in the regions of the salt and soda soils. Measures of cultivation, and fertilizer application should be adopted in coordination with a proper irrigation system so as to prevent fluctuations of the ground water table.

The following is an explanation of the paddy soils of the rice growing areas of the north:

(1) The Paddy Soil of the Northern Plains

It is distributed mainly in the northern plains. The development of water conservation has helped to enlarge its acreage. It is formed largely from alluvium and saline soils. The following is an analysis of the soil of several areas of the Huai-pei Plain.

Table 6-19 An Analysis of the Soil of the New Rice Growing Region of the Huai-pei Plain

(1)采集地点	土(10)壤	(19)酸碱度	(20)碳酸钙(%)	(21)有机质(%)	(22)全氮(%)	(23)水解性氮(%)
徐(2)州	黄河冲积土(11)	8.7	14.5	0.94	0.033	0.0010
邳(3)县	黄河冲积土(12)	8.3	8.3	1.28	0.088	0.0083
东(4)海	沂河冲积土(13)	7.6	0.11	1.09	0.060	0.0092
(5)新海连	盐(14)土	7.75	0.04	1.49	0.074	0.0089
淮(6)阴	淮河冲积土(15)	8.3	9.16	1.00	0.058	0.0099
淮(7)安	淮河冲积土(16)	8.2	3.89	1.25	0.087	0.0077
宿(8)迁	黄淮河冲积土(17)	8.0	1.60	1.06	0.060	0.0060
涟(9)水	花碱土(18)	8.6	7.96	0.64	0.236	0.0060

1. Place from which samples are taken 2. Hsu-chou 3. P'ei-hsien 4. Tung-hai 5. Hsin-hai-lien 6. Huai-yin 7. Huai-an 8. Su-ch'ien 9. Ta-shui 10. Soil 11. Huang-ho alluvium 12. Huang-ho alluvium 13. I-ho alluvium 14. Saline soil 15. Huai-ho alluvium 16. Huai-ho alluvium 17. Huang-ho and Huai-ho alluvium 18. Hua-yen soil 19. pH value 20. Calcium carbonate (%) 21. Organic matter (%) 22. Whole nitrogen (%) 23. Soluble nitrogen (%).

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(2) The Paddy Soil of the Arid North

It is distributed mainly in Chang-chia-k'ou, north of Ta-t'ung to Hu-ho-hao-t'e and Pao-t'ou, and the area eastward to Wu-lan-hao-t'e and the upper reaches of the Hsi-liao-ho. This is a region of dry meadow chestnut soil. There is a small acreage of paddy rice. The paddy soil is formed from the saline soils within the irrigation zone of the Huang-ho. The ground water table is 1 to 3 m, with a mineralization of 25 to 50 g/l, mostly oxidized sodium and magnésium, and heavy carbonate salts. After the water of Huang-ho and Hei-shui is drawn to dredge the salts, rice may be planted. However, the drainage system must be improved so as to prevent the saline content from coming back.

(3) The Paddy Soils of the Northeast

They are distributed mainly in Liaoning, Kirin, and Heilungkiang. They are formed from the meadow soil and saline soils of the three provinces. They are quite suitable for rice culture. Therefore, at present, there is a tendency of enlarged rice acreage in this region.

The paddy soil which is formed from the meadow soil contains a thick layer of humus and the fertility is high. The following is a description of a profile of this type of soil in Heilungkiang and another in Kirin, and the result of physical and chemical analyses.

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Table 6-20 A Profile and An Analysis of the Paddy Soil of Hsing-huo Commune, Heilungkiang (Institute of Pedology, Academia Sinica, 1959)

(1) 剖面层次（厘米）		0—20	20—35	35—55	55—67	67—97	97—117
(2) 采样深度（厘米）		0—10	25—35	—	55—65	—	107—114
(3) 剖面性态		灰色中壤有锈斑，软糊根多 (8)	灰棕色重壤，有小型铁子，粘韧，根少 (9)	灰棕色重壤，有锈斑及小铁子，粘韧，根少 (10)	灰棕色重壤，有锈斑，干时结构表面显白色硅酸粉末 (11)	灰棕色重壤，结构表面有暗棕色斑块及白色硅酸粉末 (12)	灰棕色轻壤，冲积层次明显 (13)
(4) 腐植质（%）		3.38	1.08	—	0.68	—	—
(5) 酸碱度(pH)	冰浸	6.22	6.28	—	6.31	—	6.75
	盐浸	5.00	4.70	—	4.66	—	4.76
(6) 代换性阳离子（百克土中毫克当量）	鈣	11.48	13.00	—	12.73	—	8.09
	鎂	3.77	8.48	—	9.96	—	6.16
	氢	0.024	0.031	—	0.04	—	0.007
(7) 机械组织	<0.01毫米	43.0	50.00	—	54.0	—	26.0
	<0.001毫米	14.0	26.00	—	30.0	—	18.0

1. Layers (cm) 2. Depth from which sample is taken (cm) 3. Profile description 4. Humus (%) 5. pH value (soaked in ice; soaked in salt) 6. Exchangeable positive ions (100 g of soil/mg equivalent)- Calcium; Magnesium; hydrogen 7. Mechanical composition ... mm
8. Gray medium soil, with rust spots; soft, with numerous roots 9. Grayish brown heavy soil, with rust spots and small iron nodules; sticky, with few roots 10. Grayish brown heavy soil, with rust spots and small iron nodules; sticky with few roots 11. Grayish brown heavy soil, with rust spots. White silicate powder is seen on the surface of the soil structure when it is dry. 13. Grayish brown light soil, with obvious layer of alluvium

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Table 6-21 A Profile and An Analysis of the Paddy Soil Formed from Saline Soil in Kirin

(1) 土壤层次 (厘米)	部面性态 (2)	腐植质 (%) (9)	石灰性 (10)	酸碱度 (pH) (17)	蒸发残渣(%) (18)	(19) 水溶盐分（百克土中毫克当量）						
						$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+
0—5	暗灰色砂壤土，表面1—2厘米层状，下部显柱状，有小壳 (3)	3.25	中 (11)	10.2	0.707	0.13	4.14	—	0.35	0.19	0.32	4.61
5—11	暗灰色中壤土，碎块结构，紧实 (4)	2.50	中 (12)	10.2	0.606	0.17	4.53	—	0.34	0.35	0.27	4.43
11—27	暗灰色轻壤土，块状结构，坚实，有锈纹与小贝壳 (5)	0.82	强 (13)	8.1	0.076	—	0.87	0.16	0.52	0.36	0.31	0.83
27—65	灰色棕壤土，碎块结构坚实，有锈纹 (6)	1.78	中 (14)	9.4	0.221	0.04	1.76	0.12	0.16	0.17	0.31	0.58
65—91	灰棕色轻壤土，紧实，锈斑增多 (7)	0.47	无 (15)	8.1	0.067	—	0.75	0.14	0.17	0.30	0.34	0.42
91—115	黄棕色轻壤土，锈斑多 (8)	0.37	无 (16)	8.0	0.040	痕迹	0.76	0.15	0.22	0.36	0.36	0.41

1. Layer (cm) 2. Profile description 3. Dark gray sandy soil; granuled from 1 to 2 cm; the remaining portion is pillar shaped, with small shells 4. Dark gray medium soil, in broken lump structure, very tight 5. Dark gray light soil, in lump structure, tight with rust streaks and small sea shells 6. Grayish brown soil, with broken lump structure; tight, with rust streaks 7. Grayish brown light soil, tight, with more rust spots 8. Yellowish brown light soil, with numerous rust spots 9. Humus 10. Lime 11. Medium 12. Medium 13. Heavy 14. Medium 15. None 16. None 17. pH value 18. Residue 19. Soluble salts equivalent/100 g of soil 20. Trace

(4) The Rice Paddy Soil of the Northwest

It is distributed in Yin-ch'uan Plain and Ho-t'ao Plain. This region is historically famous as the "Chiang-nan of the frontiers." The low areas of this region are turned into rice paddies. After flooding, the soil becomes blue, therefore, it is called paddy blue soil. The soil of most of the paddies here contains about 0.03 to 1% salt. It is rich in nitrogen, potassium, and phosphorus. The nitrogen and phosphorus content is about 0.015%, and the potassium content is more than 1.5%. The soil is alkali in reaction, the pH value is about 8.5. The soil contains salts, therefore, irrigation and drainage arrangements are very important. Currently, the farmers of Yin-ch'uan are already very experienced in the technique of planting rice in saline soils.

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SECTION 3. STRENGTHENING OF THE FERTILITY OF PADDY RICE SOIL [p 167]

The goal of the effort of raising the fertility level of paddy soil is to obtain high yield from all the crops in a rotation system with rice as the primary crop. The measures are devised for the special natural environment and soil characteristics of each area. The following is a description of the rules of fertility development, the means to improve it, and the methods of improving the low yield paddy soils.

1. PATTERNS OF CHANGE IN FERTILITY OF PADDY RICE SOIL [p 167]

The process of maturity and fertility development in paddy soils directly controlled by means of cultivation. After many years of fertilizer application and cultivation, a highly fertile rice paddy may be obtained, regardless of the fertility of the parent material. The process of development is from juvenile soil to mature soil, from mature soil to fertile soil and oily soil. As the soil fertility is improving, the soil characteristics are also changing for the better. The preservation and drainage of water become better adjusted; the soil is more capable to hold fertility and to supply the nutrients to the crops as they are needed. The soil becomes better granulated and is easier to plow. Besides, the cold and poisonous characteristics of some soils also gradually disappear.

The rice culture of our country covers a vast region. The natural conditions and productive methods vary considerably. Although the development process is generally as we just have described, local individual characteristics also exist. In the double-seasoned rice crop region of South China, the standard fertile paddy soil is the Ni-jou-t'u, which is the direction of development of all paddy soils. The paddy

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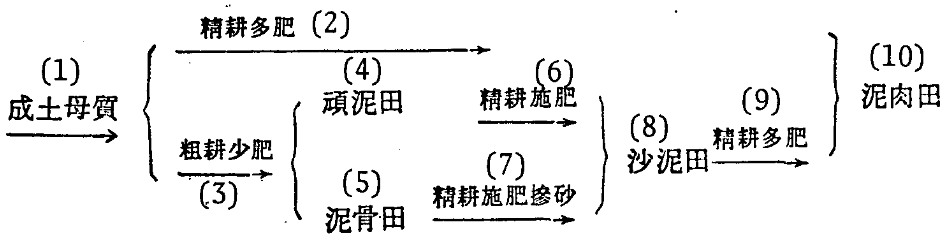
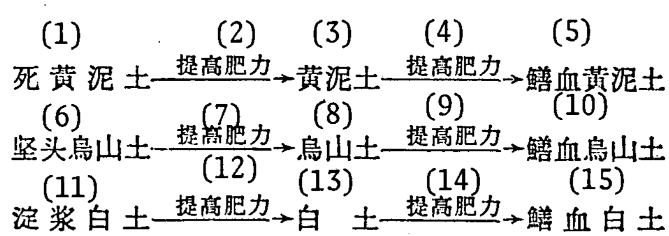
Soils of the alluvial plains as well as the hills may be turned into Ni-jou-t'u with human efforts and reform measures. The process of change and development is as follows:



1. Parent material 2. Intensive cultivation and frequent fertilizer application 3. Rough plowing and infrequent fertilizer application 4. Wan-ni-tien [Stubborn mud paddy] 5. Ni-ku-tien [Mud bone paddy] 6. Intensive cultivation and fertilizer application 7. Intensive cultivation, with application of fertilizer and sand 8. Sha-ni-tien [Sandy mud paddy] 9. Intensive cultivation and frequent fertilizer application 10. Ni-jou-tien [Mud meat paddy]

The special characteristics of Ni-jou-tien are deep, soft, and fertile, i.e. the plowing layer is thick, the soil is soft, and the nutrients are rich.

In the Yangtze Valley, the soil of the dual crops of rice and wheat in the areas such as T'ai-hu, is developing in the direction of "shan-hsueh-t'u," which is the standard fertile soil of this region. The process of development is as follows:



1. Szu-huang-ni-t'u 2. Raising soil fertility 3. Huang-ni-t'u 4. Raising soil fertility 5. Shan-hsueh Huang-ni-t'u 6. Chien-t'ou Wu-shan-t'u 7. Raising soil fertility 8. Wu-shan-t'u 9. Raising soil fertility 10. Shan-hsueh Wu-shan-t'u 11. Ting-chiang Pai-t'u 12. Raising soil fertility 13. Pai-t'u 14. Raising soil fertility 15. Shan-hsueh Pai-t'u

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Table 6-22 The Changes in Fertility of the Paddy Soils of Kiangsu

	死黄泥 (4)	黄泥土 (5)	鳝血黄泥土 (6)	坚头乌山土 (7)	乌山土 (8)	鳝血乌山土 (9)	板浆白土 (10)	白土 (11)	鳝血白土 (12)
耕层深度(寸)(1)	3	4—5	6—8	3—4	5—6	6—8	3	4—5	6—8
有机质(%)(2)	1.54	1.75	2.34	0.68	2.17	2.14	0.89	1.54	2.05
全氮(%)(3)	0.056	0.079	0.136	0.046	0.09	0.11	0.061	0.107	0.114

1. The thickness of the plowing layer (ts'un) 2. Organic matter (%)
3. Whole nitrogen (%) 4. Szu-huang-ni-t'u 5. Huang-ni-t'u
6. Shan-hsueh Huang-ni-t'u 7. Chien-t'ou Wu-shan-t'u 8. Wu-shan-t'u
9. Shan-hsueh Wu-shan-t'u 10. Pan-chiang Pai-t'u 11. Pai-t'u
12. Shan-hsueh Pai-t'u

In the hilly region of the middle reaches of the Yangtze Valley, the development process of the paddy soils is as follows:

(1) 死馬肝土 ⟶ (2) 黄馬肝土 ⟶ (3) 黑馬肝土 ⟶ (4) 油馬肝土

(5) 死黄土 ⟶ (6) 黄白鳝土 ⟶ (7) 白鳝土 ⟶ (8) 油白鳝土

1. Szu-ma-kan-t'u 2. Huang-ma-kan-t'u 3. Hei-ma-kan-t'u
4. Yu-ma-kan-t'u 5. Szu-huang-t'u 6. Huang-pai-shan-t'u
7. Pai-shan-t'u 8. Yu-pai-shan-t'u

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Table 6-23 Fertility Development of the Paddy Soils of the Hills of Middle Reaches of the Yangtze

土壤名称 (1)	酸碱度 (7)(pH)	有机质 (8)(%)	全氮 (9)(%)	有效磷 (10)(斤/亩)	有效钾 (11)(斤/亩)	水稻产量 (12)(斤/亩)	小麦产量 (斤/亩)(13)
(2) 死黄土	6.4	0.85	—	1.20	2.00	110	83
(3) 黄白鳝土	6.8	1.06	0.12	2.5	3.2	200	—
(4) 白鳝土	6.8	1.88	0.19	5.1	15.0	520	225
(5) 油白鳝土	7.4	2.28	0.28	24.0	55.5	600	270
(6) 澄白鳝土	5.6	1.72	0.17	1.92	6.60	425	110

1. Name of soil 2. Szu-huang-t'u 3. Huang-pai-shan-t'u 4. Pai-shan-t'u 5. Yu-pai-shan-t'u 6. Ch'en-pai-shan-t'u 7. pH value 8. Organic matter (%) 9. Whole nitrogen (%) 10. Utilizable phosphorus (chin/mou) 11. Utilizable potassium (chin/mou) 12. Yield (chin/mou) (rice) 13. Yield (wheat) (chin/mou)

Although the process of fertility development may vary from place to place due to different natural conditions and cultivation systems, with human efforts and measures of improvement, the fertility of any soil may be raised continuously.

2. HASTEN MATURITY OF THE SOIL TO RAISE FERTILITY [p 169]

The method of accelerating soil maturity and improving soil fertility should be selected in accordance with the characteristics of the soil using the high yield soil of the same locality as a reference. Judging from the surveys of the various regions, the high yield soils may be described mainly as follows:

The land is level, with a matured plowing layer of about 5 to 7 ts'un. The plow sole is properly tight, with a good water holding capacity and drainage. The soil does not contain too much sand or too much clay. The farmers believe that 3% sand and 7% clay, or 4% sand and 6% of clay make a good combination. The soil should be well granulated, and easy to plow whether dry or wet. The soil should not be in a big lump when it is dry, but should be easily crushed with a pick. After flooding, the soil should not settle into a board-like surface.

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It should be soft, yet not pasty. The surface should not crack when the water is drained off, so that it may easily be flooded again. The organic content should be more than 2%, with near neutral reaction (pH value 6.0-7.5), and its absorbing capacity should be no less than 15 mg equivalent/100 g of soil. It should hold the nutrients well and should release them well. Its fertility should be stable and long lasting. The sprouting is never delayed, and the soil will not fail toward the fall.

Based upon the aforementioned characteristics, the basic measures for improving soil fertility should be as follows:

(1) Deep Plowing to Improve Maturity

When there is a thick, soft, and mature layer of surface soil, the roots of the rice plants have a good and nourishing environment, and the growth of the above ground portion of the plants will be strong and well developed. The farmers say that "water is the blood, and soil is the meat. When the plowing is deep, the fertilizer is sufficient, there will be more grains." Therefore, to increase the depth of the plowing layer is an important measure. Practice and experiments over large areas proved that an increase in the depth of the plowing layer so that it is 5 to 7 ts'un deep, may bring an increase of 10% in yield, sometimes as much as 20%. If the soil had difficulty in releasing fertility, deep plowing combined with proper maturing measures may even double the yield.

(2) Increasing Organic Content and Nutrients

In order to cultivate a thick plowing layer, the soil's organic content and nutrients should be improved while practicing deep plowing.

Although paddy soil generally contains more organic matter than ordinary dry fields, if we judge by the standard of the high yield paddies, many of the paddies do not contain sufficient organic matter. Applications of fertilizer and a crop rotation of legumes [green fertilizer] are the means of improving the content of organic matter and nutrients.

In the various rice growing regions of our country, the general system is to depend upon an initial application of organic fertilizer which has a delayed effect; then, there is a secondary application of a quickly effective organic or inorganic fertilizer. This system is undoubtedly a fine tradition of our farmers. Besides, there is also a practice of planting a crop of green fertilizer in alternate years, or once in several years. Our laboring farmers

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created this fine system of crop rotation many years ago. In the future, we may combine these methods with animal husbandry. A crop of feed may be rotated with green fertilizer and the main rice crop so as to increase the organic matter and nitrogen content of the soil.

Table 6-24 The Effectiveness of a Green Fertilizer Crop in Improving Soil Fertility

	地 (1) 点	土 (6) 壤	轮作方式 (11)	綠肥占冬作 (16) (%)	常年綠肥产量 (17) (斤/亩)	有机质 (18) (%)	全氮 (19) (%)
(2)	金山县	(7) 壤粘土	(12) 水稻綠肥	80	2,500	5.44	0.324
(3)	金山县	(8) 壤粘土	(13) 水稻綠肥	40	1,500	3.41	0.199
(4)	昆山县畬墩乡	(9) 粉砂粘壤土	(14) 水稻—小麦—油菜—綠肥	30	5,000	2.82	0.147
(5)	太仓县八里乡	(10) 粘质壤土	(15) 稻—麦—棉—綠肥	20—30	3,000	1.93	0.120

1. Place 2. Chin-shan-hsien 3. Chin-shan-hsien 4. Yu-teng-hsiang, K'un-shan-hsien 5. Pa-li-hsiang, T'ai-ts'ang-hsien 6. Soil 7. Clay 8. Clay 9. Powdered sand and clay 10. Sticky soil
11. Crop rotation system 12. Paddy rice and green fertilizer
13. Paddy rice and green fertilizer
14. Paddy rice - wheat - oil cabbage - green fertilizer
15. Rice - wheat - cotton - green fertilizer
16. Green fertilizer for winter crop
17. Year's yield in green fertilizer (chin/mou) 18. Organic matter (%)
19. Whole nitrogen (%)

(3) Improvement of the Conditions of Air, Moisture and Temperature in the Soil

The three factors of soil, fertility, and water are mutually related and inseparable. Therefore, the measures of irrigation, drainage, and adjustment of soil moisture are important in raising the level of fertility. For the paddies with year long stale water, and high ground water table, the drainage condition must be corrected first, before the soil may be deeply plowed for increased maturity. For the sandy soil, especially for the newly converted paddies with sandy soil, where the water leaks quickly to cause the nutrients to be washed away, measures must be taken to correct this condition. In most cases, soils from a different region should be mixed into these paddies to insure proper drainage and reduce the loss of nutrients.

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3. IMPROVE LOW YIELDING FIELDS SO THAT LOW YIELDS CAN BE CHANGED INTO HIGH YIELDS [p 170]

For the low yield paddies, aside from the aforementioned measures of raising soil fertility, certain characteristics of the particularly bad paddies must be corrected. The corrective methods may be described as follows:

(1) The Low Yield Paddies of Too Sandy or Too Sticky Soils

This type of paddy is distributed in every region. When the soil is too sandy or too sticky, the paddy is not suitable for the growth of rice plants. When there is too much sand, the soil does not hold water and nutrients well, and in the process of growth, the condition may retard the plants in any of the stages of growth. The inflorescence may degenerate, or the grain may fail to become full.

If the soil is heavy with too much clay, then it has a tendency to become pasty when wet, and hard as a board when dry. Plowing will be very difficult. When this kind of paddy is flooded with water, the ventilation is so poor that the anaerobic condition caused by lack of oxygen may produce poisonous gas to harm the root system of the rice plants. When the paddy is drained for sunning, large cracks will appear, and the roots may thus be damaged. When the paddy is flooded again, the water may leak through these large cracks. The major corrective measures are as follows:

a. Increase the Organic Matter of the Soil

Applications of such organic fertilizer as manure or rotated crops of green fertilizer may change the characteristic of the soil. An increase of the organic content of the soil may improve the soil consistency as well. When the soil granules are in better condition, it will be better ventilated also.

b. Mix in Soil of a Different Region

To mix sandy soil with clay soil, is a direct and effective method of improving soil consistency. Generally speaking, 30% sand and 70% clay or 40% sand and 60% clay are considered to be the best proportion. If the silts of ponds are used for the mixing, a certain amount of organic matter is added also. This measure is particularly good for the low yield soils.

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(2) The Low Yield Soils of Cold, Damp, Poisonous, or Otherwise Harmful Characteristics

The common characteristic of this type of soil is the high ground water table. The consistency of the soil is often heavy with clay. Due to weak physical and chemical reactions, organic decomposition is extremely slow, and its very difficult for fertilizer to take effect. The rice plants of this type of soil usually do not grow well. The seedlings take a long time to turn green after being transplanted. Tillers are not abundant, and the yield is low. Treatment must be devised for the particular problems, and it includes mainly the following aspects:

a. To dig ditches for drainage

This is the important measure for the cold and damp low yield paddies. The ditches may be open, covered, or in the shape of round wells. In practice, the farmers often use all three kinds. Open ditches are dug in the vicinity of the mountains to drain off the flood water. In the fields, the covered ditch is good for draining the excessive moisture in the paddies. If rust water is damaging the rice plants, open ditches should be dug to drain if off the surface of the paddy and to bring down the ground water table, so that the paddy will become dry during the winter.

b. To convert the wet paddy into dry field with crop rotation

When the accumulated water is drained off during the winter, the paddy may be deeply plowed and sunned, so that the reduction products which are poisonous to the rice plants may be oxidized. The lumps may be loosened, and the soil granules may be improved. The hard to decompose organic matter may thus be mineralized. When these conditions have been reached, the paddy may be converted into an alternated dry and paddy field. This rotation is especially effective for further improvement of the soil. It was adoped in Hsing-hua-hsien, Kiangsu, in 1953 and was found to be very effective. The yield from these cold and wet fields of the past has been constantly improving.

c. Frequent application of slow working fertilizer

The farmers of Kiangsu believe that "green fertilzer, the manure of a pig sty, and garbage are the three treasures for a fertile field." These organic fertilizers

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may increase the humus content of the soil to make the soil fluffy. Lime, gypsum, and wood or grass ashes may accelerate organic decomposition and raise the temperature of the soil. While these measures are being taken, quick effective fertilizer should be mixed in proper amounts in the initial fertilizer application so as to supplement the slow effectiveness of the others.

(3) The Quick Settling Pai-t'u on the Low Yield Paddies

This type of paddy may be found in the plains as well as the hills. They include Pan-chiang Pai-t'u, Ting-chiang Pai-t'u, and Hsiao-fen-pai-t'u. The soil contains a great deal of coarse sand and very little organic matter. The color is white and there are not enough minerals, it does not hold fertility, and the soil structure is so bad that it quickly settles after flooding. It is said that "if little fertilizer is applied, no effect is seen; if a great deal of fertilizer is applied, the rice plants fall." There are not many tillers, and during the later stages of growth, it is hard to judge when to apply additional fertilizer. The farmers describe this type of soil in the following words: transplanting seedlings is like pounding nails; the weeds float like they were skating. To harvest the plants is like participating in a horse race, and no energy is needed to beat down the grain."

Although the formation of Pai-t'u is related to the parent material, the cause of the aforementioned defects is largely rough plowing and infrequent fertilizer application. The measures to be taken are as follows:

a. The application of organic fertilizer

Such organic fertilizer as the legumes, manure, and pond silts is rich in organic matter and nutrients, and is also good for improving soil granules.

b. In addition to fertilizer the plowing layer should be made thicker

Since the mottled layer of Pai-t'u is generally very low in fertility, under normal condition of fertilizer application, one hardly dares to practice deep plowing. There-

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fore, the plowing layer is only about 3 ts'un deep. When additional fertilizer is applied, the plowing layer may be gradually made thicker.

c. A supplement of phosphorus, potassium and other minerals such as iron and manganese should be emphasized.

d. To rotate the crops with green fertilizer

In order to improve organic content and soil granules, a crop of legumes should be rotated with the other crops.

e. To dig ditches to improve the drainage

Ditches should be dug to improve the drainage so as to insure the effectiveness of the other measures.

(4) The Low Yield Saline and Soda Soils

Saline and soda soils are scattered in the interior and the coastal regions in small and large pieces. If water is available, these soils may be improved after they are turned into rice paddies.

Certain measures must be taken to insure soil improvement and to raise soil fertility. According to the experience of the last three years obtained by Huai-an Farm in Kiangsu, when the soil of chloride salts containing more than 0.05% of salts has been planted with single-seasoned rice plants, the salt content of the 1 m surface layer of the soil may be reduced to less than 0.015% in one year. The salt content may be basically eliminated in three years. The yield of the saline soils of Kiangsu is generally about three to four hundred chin, better than that of the dry crops. In the Autonomous Region of the Hui Nationality in Ninghsia, the water of Huang-ho was drawn to irrigate certain areas of sulfuric and chloric salts. After one rice crop, the salt content of the soil was down to 40 to 70% of the original amount. The yield was generally 250 to 300 chin. The large scale soil improvement project in Tientsin and its tremendous achievement has been famous all over the country, and a great deal of useful experience has been obtained.

The experience of planting rice for the improvement of saline soils obtained from the various areas is summarized as follows:

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a. When saline soils are converted to rice paddies, the flooding and drainage inevitably raise the ground water table; although the saline content may be washed away with the drainage water, the soil may not be suitable for either wet or dry farming. Therefore, it is important to plan ahead of time and to divide the area into paddies and dry farming fields so as to gradually wash off the salts without harming the soil.

b. Paddy rice requires a leveled paddy, so as to maintain an even layer of water above the surface. When the saline soil is converted into paddies, leveling the field is particularly important, so that the saline content of the high place will not be washed off and accumulate in the low areas to harm the seedlings. Mud dikes may be built to divide the areas into smaller and level paddies.

c. The saline soils are often very tight. At the time of rice planting season, when the soil is beginning to become dry, the saline content is often concentrated in the surface layer of the soil. It is important to practice deep plowing and fertilizer application so as to make the salts more soluble, and at the same time to improve the ventilation of the soil. This measure may improve soil fertility also.

d. Rice is not saline resistant. Before the salts are completely washed away, if there is water on the surface, the rice plants may grow normally. If the water is suddenly drained off, the salts may come back to the surface soil, and do serious damage to the rice plants. Therefore, a continuous operation of irrigation and drainage is very important to drain off the soluble salts as well as to enable the rice plants to grow normally.

e. Before transplanting, the paddy should be plowed and turned and then soaked in water for a few days. Then, the water should be drained off. This measure may quickly and effectively reduce the saline content of the plowing layer. After the seedlings are transplanted before they turn green again, the young seedlings are too weak to resist salt damage; therefore, the paddy should be irrigated with fresh water. The constant flow and renewal of the water will benefit the seedlings.

f. As the rice crop is planted and the soil is desalinized by the paddy water, crops of green fertilizer

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should be rotated with the rice so as to improve the organic content, and the soil structure. This is an important measure for thorough improvement of the saline soils.

Besides, there are the so-called alkali-acid soils along the coast of Kwangtung and Fukien. They contain more than 0.03% of salts, and at the same time, a past Mangrove forest has been decomposed and turned into a layer of marl to be buried under the saline soil. Under anaerobic conditions, sulfides were formed. When the soil is drained, these sulfides again oxidize to become sulfuric acid to make the soil extremely acid. Sometimes, the pH value is below 3. The young seedlings cannot turn green in this soil. The root may turn black. When the root is pulled out, one can smell the odor of hydrogen sulfide. Sometimes, orange colored "rust water" may be seen on the surface of the paddy. This condition is particularly serious when the rainfall is not enough. The young seedlings may all die. To improve this condition, we must dig ditches for drainage, then draw water to wash off the salts. At the same time, apply 100 to 150 chin of lime to every mou so as to eliminate the residual sulfuric radical. Then, the other measures of soil improvement may also be applied.

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CHAPTER 7. CHINA'S RICE CROP REGIONS

[p 175]

There are rice paddies almost everywhere in China. The difference in natural conditions and the methods of cultivation has resulted in a great number of local varieties, which may be classified into various types according to their morphological differences. In accordance with the environmental conditions, the cultivating systems, and the morphological characteristics of the rice plants, we shall, in this chapter, divide the rice growing regions into zones. This regional classification is particularly significant for the introduction of new varieties, improvement of the cultivating techniqes, and the enlargement or creation of new areas of rice culture.

SECTION 1. ENVIRONMENTAL CONDITIONS OF RICE CROP REGIONS [p 181]

In the past, there have been attempts at classifying our country's rice growing regions, but, since there was not enough information, the content of these classifications lack material basis. Since the liberation, the Central Ministry of Agriculture organized in 1955 the related departments to proceed with the work of agricultural classification of each province and the entire country. Rules for the classification were formulated and they have become important bases for the classification of the rice growing regions. On these bases, Ting Ying (0002 4481) divided the rice growing regions of China into 6 major districts. This

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classification is based first upon the environmental conditions or the factors which cause the morphological difference in plants. They are daylight, rainfall, and temperature. Secondly, it is based upon the terrain, the type of field, the nature of the soil, and the insects and diseases. The following is a description of these districts according to these climatic, geographical, and soil conditions.

1. TEMPERATURE [p 175]

Rice plants like warm temperature; therefore, the cultivation of rice is always done in the warm areas or during the warm seasons. The distribution of the varieties, therefore, is affected by the temperature first. All of the historical varieties with stable yield in the various regions have a growth season corresponding with the normal temperature of that locality.

During the rice growing season, the temperature should be relatively low during the seedling stage. The temperature should be higher during the tillering, heading, and blooming stages. It may again be lower during the ripening stage. The lowest temperature for sprouting is 10° to 12°C. During the ripening stage, although the temperature requirement is not so high, it should average above 15°C. According to the actual conditions of the various localities, if there are 7 to 8 months in a year, with average temperatures of more than 10°C, and the average temperature of the entire year is above 20°C, two crops of rice may be cultivated. If there are four months with average temperature of more than 10°C, and the daily average temperature of the year is about 15.7°C, a single crop of rice of the early varieties may be planted.

The temperature for rice culture in our rice growing districts drops from the south to the north, and the rice growing season shortens also. If the aforementioned temperature standards are used (the monthly average of above 10°C) South China has 9 to 12 months, Central China has 7 to 9 months, North China has 5 to 7 months, the Northeast has 4 to 5 months, the Northwest has 5 to 6 months, and the Southwest has 7 to 10 months in which the rice varieties may be cultivated. Aside from the Northwest and the Southwest

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districts, the temperature distribution of the rice growing season generally parallels the latitude; therefore, the division of the rice growing season is also in the latitudinal direction.

2. SUNLIGHT [p 176]

The rice varieties and the cultivating methods vary with the number of hours of daylight in each locality, which is determined by the latitude. Generally speaking, the varieties of the keng subspecies have darker leaves than those of the hsien subspecies. The unit leaf area of the former contains more chlorophyll (about 1/3 more), therefore, the former are more suited for areas of weaker daylight and lower temperature. Among the varieties of the hsien subspecies, the leaves of the mountain varieties are darker than those of the plain varieties.

Tests show that rice is a short daylight crop, but the early and medium varieties react to light exposure differently compared with the late varieties. The early varieties of the Pearl River Valley and the early and medium varieties of the Yangtze Valley have weak reactions toward daylight. They may be planted in the long or the short daylight seasons. The late varieties are very sensitive to light exposure. If they are planted during the spring and summer with long periods of daylight, they will not come to a head or become ripe until the fall and winter when the daylight is short. Therefore, the number of hours of daylight is the factor which distinguishes the early, medium, and late varieties. The difference in the daylight condition of the various areas makes them suitable for the various different varieties. Therefore, daylight becomes an important factor for the classification of the rice growing regions.

From the south to the north, the the number of hours of daylight increases with the latitude. For example, in the summer, the number of hours of daylight is 13 in Ya-hsien, Hai-nan-tao; and 16 in Hei-ho, Heilungkiang. The difference is as many as three hours. The difference in the daylight condition of the area of origin constitutes the daylight requirement of a particular variety. Judging from the

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entire country, the period of daylight hours during the rice growing season is the shortest in South China and the southern part of the Southwest, generally below 14 hours, a little longer in Central China, about 14 hours, and longer in North China and the Northeast, generally above 14 hours.

Due to the difference in daylight requirements, both the keng and the hsien subspecies may be divided into the early, the medium, and the late varieties. All of those which are planted in the spring or the summer, which require less than 14 hours of daylight in order to complete the light exposure stage of development, are the short daylight, late varieties; while those which may complete their light exposure stage of development with either more than or less than 14 hours of daylight, are the weak or neutral light sensitive , early or medium varieties. The early varieties of South China, the early and medium varieties of Central China, and the early or medium varieties of North China, the Northeast, and the Northwest all belong to this type. The special daylight characteristic of the various regions created the special daylight requirements of the various species. Thus, another special basis for classifying the rice growing regions is the daylight conditions of these regions.

3. Rain [p 177]

Rainfall, or artificial irrigation is another important factor which determines the distribution of rice plants, when the temperature and daylight conditions are fulfilled. The water condition guarantees the growth of the entire development period of rice plants, and thus, determines the possibility of high and stable yield. Our ancestors understood this principle and were taking advantage of the abundant rainfall of the southeast monsoon regions for the development of rice culture. On the other hand, they exerted all effort to build irrigation equipment in the regions with less natural rainfall, and to build dikes and ditches in the low areas, so that rice culture became very important in agricultural production in the vaious areas of the south and the north.

The Pearl River Valley and Hai-nan-tao have an average rainfall of 1,500 to 2,000 mm a year; in the Yangtze

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Valley to the south of Huai-ho, it is 1,000 to 1,500 mm. Most of the rains come during the rice growing season of high temperature and intense daylight. This condition of rainfall makes these regions either our country's important double-seasoned rice region, or capable of developing into a double-seasoned rice region. The highlands of Yunnan and Kweichow have more than 1,000 mm of rainfall a year. However, rain is scarce in the spring and the temperature is low; single seasoned rice is generally the case. Double-seasoned rice crops are the practice in the well irrigated low and flat areas below 1,000 m in altitude. The Huang-ho Valley, to the south of Heilungkiang has a yearly rainfall of 500 to 750 mm. The areas of the Northwest have a yearly rainfall of less than 400 mm. Although these regions are relatively arid, with irrigation equipment, high yield in rice crops may still be obtained.

4. Humidity [p 177]

Relative humidity normally corresponds with rainfall. If rainfall is adequate, relative humidity does not constitute an important factor in rice distribution. In South China and Central China, during the rice growing season, the relative humidity is about 74 to 84%. In North China, it is about 58 to 72%. In the Northeast, it is aobut 67 to 74%. In the Northwest, it is about 34 to 45%. In the Southwest, it is 62 to 78%. It is higher in the south and lower in the north, and is the lowest in the Northwest, to make that region an arid rice culture zone. If irrigation water is sufficient, rice culture is not curtailed by lower humidity in the air.

5. TOPOGRAPHY [p 178]

Within the same region, the terrain is also important in the distribution of rice culture. In our country, rice paddies are found in the coastal lowlands of the southeastern provinces and the highlands of the Southwest, 2,600 m above the sea level. In the coast, there are varieties which resist salts and damp soil. In the lower reaches of the streams, only those varieties which can withstand deep water and prolonged soaking may be cultivated. In the

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alluvial plains of the river valleys, the hills, and the mountainous regions, there are particular varieties to suit each of the regions.

In Yunnan Province, the hsien subspecies are distributed in areas of below 1,750 m elevation. The areas of 1,750 to 2,000 m are distributed with a mixture of hsien and keng subspecies. In areas from 2,000 m to 2,600 m only the keng subspecies are distributed.

In Kweichow Province, the areas below 1,000 m in elevation are distributed with the early and medium ripening hsien varieties. The areas from 1,000 to 1,500 m are distributed with medium late varieties primarily, and medium varieties secondarily, very few early varieties, and some highland keng varieties. The areas of 1,400 to 1,600 m are mixed zones of hsien and keng. The areas above 1,600 m are mainly for the highland keng varieties, with very little of the hsien varieties.

In the northwestern part of Kwangsi, the northern part of Kwangtung, the northern part of Fukien, the central part of Taiwan, and the mountainous areas such as Wu-chih-shan of Hai-nan-tao, are all normally areas of the keng varieties, obviously different from the normal varieties of the plain areas of the same region. Therefore, terrain becomes an important factor to be considered in the classification of rice growing regions.

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SECTION 2. RICE CROP REGIONS [p 178]

Based upon the natural conditions, the distribution of the varieties, the cultivating system, and the administrative division of the rice growing regions, they are divided into the South China double-seasoned rice culture zone, the Central China single and double-seasoned rice cul-culture zone, the North China single-seasoned rice culture zone, the Northeast early ripening rice culture zone, the Northwest arid rice culture zone, and the Southwest highland rice culture zone. (Map 7-1)

According to this classification, the rice acreage is proportionally small in North China, the Northeast, and the Northwest, especially the Northwest. Due to the fact that these three regions are different in their natural conditions they are here divided into three zones. The areas of Hsin-yang and Nan-yang of Honan and the Han-chung Plain of Shensi have similar rice culture to the areas of Central China; therefore, they are included in the Central China single and double-seasoned zone. The areas north of Huai-ho in Anhwei, and the southeastern part of Kansu are included in the single-seasoned zone of North China for similar reasons. The eastern part of the Autonomous Region of Inner Mongolia is included in the early ripening rice culture zone of the North-east. The classification of the rice growing regions is not limited by the administrative divisions.

The northwestern part of Fukien and the northwestern part of the Autonomous Region of the Chuang Nationality in Kwangsi belong to the South China double-seasoned rice culture zone, although the temperature there is relatively low. The natural conditions of these areas are such that if the cultivating techniques can be improved, they may easily be converted to double-seasoned rice culture. Meanwhile, it is not proper to let geographical environment and adminstrative divisions affect the classification of rice growing regions.

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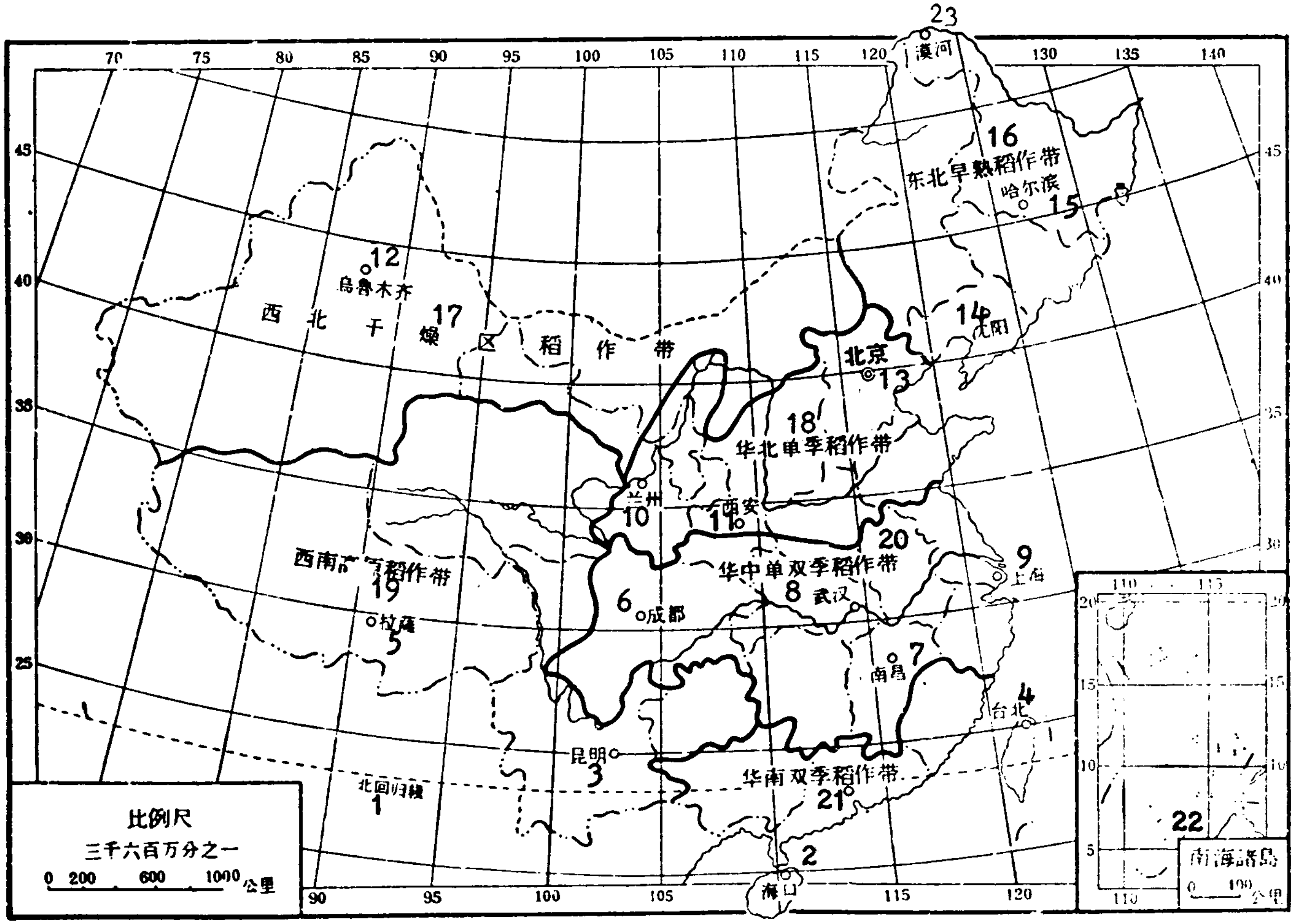

Map 7-1 A Brief Map of the Rice Growing Regions of China Scale 1:36,000,000 km

1. Tropic of Cancer 2. Hai-k'ou 3. K'un-ming 4. Taipei 5. Lhasa 6. Ch'eng-tu 7. Nan-ch'ang 8. Wu-han 9. Shanghai 10. Lan-chou 11. Hsi-an 12. Urumchi 13. Peking 14. Ch'en-yang 15. Harbin 16. the Northeast early ripening rice culture zone 17. the Northwest arid rice culture zone 18. North China single-seasoned rice culture zone 19. Southwestern highland rice culture zone 20. Central China single-double seasoned rice culture zone 21. South China double-seasoned rice culture zone 22. the South Sea Islands ... km 23. Mo-ho.

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The southern part of Yunnan, Hai-nan-tao, and the Province of Taiwan have climatic conditions for triple-seasoned rice culture; however, at present, there is not much difference in the arrangement for the repeated cultivation in these regions from the double-seasoned South China. There is, therefore, no need of separating these areas and creating a triple-seasoned rice culture zone.

The following is a description of the boundaries of these zones, the climatic conditions, the distribution of rice paddies, the soil, the cultivating systems, the rice varieties, the diseases and insects, and the natural calamities.

1. DOUBLE SEASON RICE CROP ZONE OF SOUTH CHINA [p 180]

The South China double-seasoned rice culture zone is located to the south of Nan-ling, including Kwangtung, Fukien, the province of Taiwan, the Autonomous Region of the Chuang Nationality, and the islands under its administration. The rice paddies of this zone amount to 27% of the total rice acreage of the country, and the yield amounts to 22% of that of the entire country. (The acreage of rice and the yield of Taiwan province are not included. Future surveys are needed to locate the figures.)

(1) Climate

This zone belongs to the tropic monsoon and subtropic humid climate. It has the highest temperature, the richest heat energy, the most abundant rainfall, the longest rice growing season, and the highest index for repeated crops in the entire country. The monthly average temperature is above $10^{o}C$. The year's rainfall averages more than 1,500 to 2,000 mm. The rains come during the period from April to September, which is the major rice growing season. During this period the temperature averages 22^{o} to $26^{o}C$. The temperature difference between night and day is 5.4^{o} to $8.1^{o}C$, and the relatively humidity is about 80%. The regions are, therefore, suitable for double-seasoned crops. The areas to the south of the line from Tai-pei, Hsia-men, Canton, to Nan-

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ning, have an average temperature of more than 22°C throughout the year. The average January temperature is 13.6° to 15.2°C. Therefore, rice may be planted all year long. Triple seasoned rice crops are the practice of Hai-nan-tao. Kan-chiang Special District and the banks of Hsi-chiang to Pai-she Special District are the areas of winter rice crops.

The areas of this zone such as P'u-ch'eng and Kuei-lin, are cooler, with an average temperature of 18°C, and nine to ten months of the year, the monthly average is only 10°C. However, in view of the actual practice, double-seasoned rice culture is still perfectly suitable.

In this zone, rice is generally planted in March and grows through November. The early varieties of Hai-nan-tao are planted in October, when the winter rice is planted in the banks of Hsi-chiang. In southern parts of Kwangtung, Kwangsi, and Fukien, planting is done in February, or even January. The late varieties are harvested in November to December. There are more than 290 days in a year, or all the days in a year, during which rice grows in this zone.

(2) The Distribution of the Paddies and the Soils

The rice paddies of this zone are distributed on the alluvial plains of the banks of the streams, in the alluvial basins of the valleys, and on the hills. In Kwangtung Province, there are Pearl River Plain, Han-chiang Plain, Chien-chiang Plain, and Lei-chou Plain; in Fukien Province, there are Fu-chou Plain, Chang-chou Plain, Ch'uan-chou Plain, Fu-tien Palin, and the alluvial plains along the banks of Hsi-chiang and Ch'ien-chiang in the Autonomous Region of the Chuang Nationality. The paddy soils are formed from the alluvium, the red soil, and the yellow soil, after many years of cultivation. Saline soils and alkali soils with strong acid reactions are found in the Pearl River delta and the coastal region of this zone. Saline resistant varieties are the only ones for these areas.

(3) The Cultivating System

The cultivating system of this zone is mainly the double-seasoned rice culture. A few areas such as Wan-ning, Ling-shui, and Ya-hsien of Hai-nan-tao practice the continuous cultivation of a triple-seasoned rice culture.

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There are also few areas of winter rice crops such as Kan-chiang Special District and Kao-yao Special District of Kwangtung, and Pai-she Special District of Kwangsi. On the paddies along the coast and in the mountain regions of lower temperature, there are alternate rice crops. In the cold water paddies of the mountain valleys, there are mixed crops of early and late varieties. In a few places in the northern parts of Kwangtung and Fukien, there is also single-seasoned rice culture. Besides, on the banks of Hsi-chiang, in Kao-yao Special District, there are also low paddies for the deep water rice culture. In the mountains and the slopes of this zone, there is a small amount of upland rice culture.

Wherever a rotation system is practiced in this zone, the practice is a double-seasoned rice culture; a three crop system of wheat, Pisum sativum, and rice; or a two crop system of rice rotated with a dry crop of potatoes, peanuts, or soybeans. The system of rice rotated with sugar cane in every two, three, or four years is also practiced in some areas.

(4) The Varieties

At present, the varieties used in this zone are mainly those of the hsien subspecies. The keng varieties are planted only in the Lien-shan mountain region of Kwangtung, Wu-chih-shan region of Hai- nan-tao, the mountain region of the Autonomous Region of the Chuang Nationality in Kwangsi, the mountain region of the northwest of Fukien, and in some areas of Taiwan Province. Many rich varieties of the keng subspecies may be found in the Autonomous Region of the Chuang Nationality and in Fukien Province. They make a precious source of seeds for the future development of this subspecies. Besides, in some areas of this zone, there are several varieties of early upland rice; and in the northern and eastern parts of Taiwan, there are also late upland rice varieties.

(5) Diseases and Insects

The prevailing rice disease in this zone is the Tao-wen, and the most common insect is the San-hua-ming. [similar to the blight disease and the weevil] During recent years, cultivation methods and insecticides have been used for the elimination of San-hua-ming, and the extent of its damage has been greatly reduced. Besides, the rice plants are also being damaged by straightheads, fungus, and

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leaf spots; and there are also several other insects. The extent of the damage sustained varies from year to year and from place to place. In some years, there may be flood or drought; the early varieties may be damaged by abnormally low temperature, and the late varieties may be damaged by cold currents during the blooming season. Typhoons may occur during the heading, blooming, or ripening stages of the early varieties. These are the disadvantageous climatic conditions in this zone of double-seasoned rice culture.

2. SINGLE AND DOUBLE SEASON RICE CROP ZONE OF CENTRAL CHINA [p 181]

This zone is located to the north of Nan-ling and to the south of Huai-ho and Ch'ing-ling, including Kiangsu, Shanghai, Chekiang, the central and southern parts of Anhwei, Kiangsi, Hunan, Hupei, Szechwan (except the Autonomous Region of the Tibetan Nationality in Kan-mu), and the southern parts of Shensi and Honan. The rice paddies of this zone amount to 63% of the national total, and the yield amounts to 66% of that of the country.

(1) Climate

This zone belongs to the central and northern parts of the monsoon subtropical humid zone. The temperature is warm but there may be attacks of cold currents in the winter. In the summer the solar radiation is very strong. The average temperature during the rice growing season from March to October in more than 20° to 22°C in the southern part of this zone, in such areas as Kung-chou, Heng-yang, and Hsi-ch'ang (it is 23.5° in Kung-chou). The temperature difference between night and day is more than 8°. The average temperature in March is more than 11°C, and the average temperature in October is more than 17°C. In the south, the early varieties are planted in the beginning of March, and this system makes it possible for the late varieties to be ripe in October. In the north, in such areas as Nan-cheng, ku-ch'eng, Ho-fei, Nanking, and Shanghai, the average temperature during the rice growing season is about 22 to 23°C. The temperature difference between night and day is also more than 8°C. In the later part of March and the early part of April, the temperature is higher, and planting may begin.

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ine average temperature in October is more than 16°, and the varieties of the keng subspecies and some varieties of the hsien which are capable of withstanding cold may be ripe in the early or middle part of October.

Thus, in regions to the north of Nan-ling and to the south of Ch'in-ling and Huai Ho, i.e. the entire Yangtze Valley, it is very possible to have double-season rice crops. The rainfall is generally more than 1,000 mm. In some individual areas such as Huai-nan, it is only 750 mm, and in Ch'uan-pei, it is about 900 mm. The rains come mostly in the rice growing season, during which the relative humidity is about 80%. The rice growing season is generally from the later part of March to October. In some areas, such as Ch'uan-nan, planting may be done in the middle part of March. In some other areas, such as the T'ai-hu region, harvest is over only in the beginning of November.

(2) The Rice Paddies and the Soils

Rice paddies are mostly distributed along the banks of the rivers and lakes, in the hills and mountain basins, and on the slopes. The plains such as T'ai-hu Plain, Li-hsia-ho Plain, Wan-chung Plain, P'u-yang-hu Plain, Tung-ting-hu Plain, Chiang-han Plain, and Ch'eng-tu Plain are all famous rice producing areas. On the plains, the soils are alluvial. In the hills and mountains, there are red, yellow, brown, and purple soils. In the central, western, and southern parts of Kiangsi, and the central and southern parts of Hunan, the paddy soil is usually the result of many years of cultivation of the red soil. The soils of the various areas generally contain a high percentage of clay, rich in organic matter, acid in reaction, with medium fertility. The areas of the eastern part of Kiangsi, the southern part of Hunan, and the province of Szechwan have paddies of purple soil origin, and they are relatively more fertile.

(3) The System of Cultivation

It is primarily a single-seasoned zone in rice culture. Double-seasoned rice culture is practiced only in the western part of Kiangsi, southern part of Chekiang, and eastern part of Hunan. During the recent years, due to improved cultivating conditions, double-seasoned rice culture is being spread to many other areas. The major cul-

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tivating system of this zone, however, is still a single-seasoned rice alternated with winter crops of wheat or oil cabbage, and beans. There are some areas of repeated crops of double-seasoned rice and legumes.

(4) Varieties of Rice Plants

The varieties of this zone are mainly those of the hsien subspecies, while the T'ai-hu Region is the major producer of the keng varieties. Among the hsien varieties there are the early, medium, and late varieties of the single seasoned rice, and the early and late varieties of the double-seaoned rice. The keng varieties may also be divided into the early, medium, and late varieties. Both the late hsien and the late keng are sensitive to light exposure. The T'ai-hu Region has a long history of cultivating the keng varieties, and is very special area of rice culture. During recent years, in regions of Kiangsu and Hupei, there has been a movement popularizing the keng varieties, and it has been quite successful. Besides, this zone also has some acreage of upland and deep water varieties.

(5) Diseases, Insects, and Natural Calamities

The blight, the white-leaf, and the leaf-spot are the major rice diseases of this zone. Damage from the blight disease vary from place to place, while the white-leaf disease is concentrated in the middle and the lower reaches of the Yangtze. The leaf-spot disease is heavier in the three provinces of Kiangsu, Chekiang, and Hunan. The conditions of the weevils and other rice field insects are similar to those of the South China. Spring drought and summer flood occur much too often; and the cold currents of the spring and fall sometimes affect the seedlings of the early varieties and the harvest of the late varieties.

3. SINGLE SEASON RICE CROP ZONE OF NORTH CHINA [p 183]

This zone is located to the north of Ch'in-ling and Huai-ho, and to the south of the Great Wall , including Pek-

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ing, Hopei, Shantung, Shansi, the northern part of Honan, the part of Anhwei that is to the north of Huai-ho, the central part of Shensi, the part of Kansu that is to the east of Lan-chou, and the Autonomous Region of the Hui Nationality in Ninghsia. The rice paddies of this zone amount to 1.5% of the national total, and the yield amounts to 1.3% of that of the country.

(1) Climate

This zone belongs to the monsoon temperate zone of semi-humid climate. The southern part of this zone, from Chi-nan to Cheng-chou to Hsi-an has an average temperature of 21.4° to 22.6°C. The temperature difference between night and day is 11.3° to 13.3°. Therefore, the temperature variation is greater than that of Central and South China. However, there are still 7 months during which the montnly average temperature is above 10°C.

In the northern part of this zone, from Yin-ch'uan through T'ai-yuan, Peking, to Tientsin, the average temperature during the rice growing season is 19° to 21°C, and the temperature difference between night and day is 12.4 to 14.5°C. There are only 6 months during which the monthly average temperature is above 10°C.

This zone is located on the great plain of North China,and during the rice growing season, there is not much difference in temperature between the various areas. For example, Peking and Cheng-chou are only 5°'s different in latitude, and the average temperature in April of the two places is only 0.4°C. The average temperature between April and October of the various areas is above 10°C. It is slightly lower in the northern part. In the southern part, the October temperature is also not high enough, therefore, this zone is only suitable for single-seasoned rice culture.

The year's average rainfall is generally above 500 mm. However, it is only 148 mm in Yin-ch'uan. The rains come mostly in the period from June to August. The relative humidity during the summer is 60%, and it is 75° in the fall. The province of Kansu is located on the loess plateau, and id therefore arid. The relative humidity in the summer is only 50%, about the same as that of Sinkiang. The southeastern part of this zone, such as Pai-lung-ho Valley, has a climate more like the northern part of Szechwan.

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In the central and southern parts of this zone the rice growing season is from April to October; in the northern part , it is generally from May to October. Planting is generally done from the middle of April to the early part of May. The harvest is in the later part of September to the early part of October.

(2) The Rice Paddies and the Soils

The rice paddies of this zone are distributed on the shores of the Gulf of Pohai, the river valleys of the four streams of Sha, Ju, Ying, and Hung, the two special districts of Chi-ning and Ho-tse, and Lin-i Plain of Shantung. The soils are mostly chestnut soil, brown soil, meadow soil, and saline soil, containing a large percentage of such minerals as calcium, magnesium, phosphorus, and potassium. Erosion is light. The saline soils of the Gulf of Pohai contains less than 1% of salts. When water is used to wash the salts and convert the fields into paddies, the measure proves to be very effective here.

(3) Cultivating System

Generally speaking, only the single-season rice culture is practiced here. The rice growing season is relatively short. The varieties are generally the late or the medium ripening ones. After the harvest of the rice, the paddies either stay fallow, or are used for another crop of wheat or barley.

(4) The Varieties of Rice Plants

The rice plants used in this zone are largely the varieties of the keng subspecies. There are also some hsien, upland, and deep water varieties. There are more of them in the provinces of Honan and Hopei. In the north, most of them are early ripening keng varieties; while in the central and southern parts of this zone, they are mostly late ripening keng varieties. Upland varieties are found mostly in the provinces of Hopei and Honan, and the deep water varieties are distributed in the areas of Wa-ting of Hopei.

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(5) Diseases, Insects, and Natural Calamities

The diseases of rice in this zone are mostly the blight, the stem rot, and the seedling blight. There is also damage from rice field insects, but the weevils are few , due to the low temperature in the winter and the spring.

4. EARLY MATURING RICE CROP ZONE OF NORTHEAST CHINA [p 184]

This zone is located on Liaotung Peninsula, the north of the Great Wall, the east of Ta-hsing-an-ling, and the south of Heilungkiang, including Liaoning, Kirin, Heilungkiang, and the eastern part of the Autonomous Region of Inner Mongolia. Rice paddies of this region amount to 2.6% of the national total, and the yield amounts to 2.2% of that of the country.

(1) Climate

The climate of this zone belongs to the monsoon temperate, the cold temperate moist, and the semi-moist. The areas of An-tung and Ch'en-yang of Liao-ning have an average temperature of 19° to 20°C during the rice growing season. There are 6 months in a year during which the monthly average temperature is above 10°C. Further north, in the areas of Chang-ch'un of Kirin and Ch'i-ch'i-ha-erh and Hei-ho of Hei-lungkiang to the northern border of our rice culture, Mo-ho, the average temperature during the rice growing season is 16 to 19° C, and the temperature difference between night and day is 12° to 14.1°C. There are only 5 months in the year, during which the monthly average temperature is above 10°C (in Mo-ho, there are only 4 months.). Aside from Mo-ho, the temperature in May of the various areas averages above 10°C, planting may thus be done. In Mo-ho, the average temperature in the later part of May comes to 10.4°C; therefore, planting may begin then. The average temperature in September is more than 70°C in An-tung and Sh'en-yang; further north, it is less than 15°C, however, in these localities, rice is already ripe at that time.

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The eastern part of this zone has an annual rainfall of 750 mm; while in western and northern parts, it is about 500 mm. In the summer, the relative humidity is 65% in the central and southern parts, and it is 75% in the fall. The northern part of this zone is more arid. Throughout the year, most of the days are clear in this zone, but in July and August when the rice plants grow, rain is more plentiful. From August to September, the wind is not very strong. All these conditions are favorable for rice culture.

The rice growing season of this zone is from May to September. In the south, there are 170 days in a year with a daily average temperature of above 10°C; 150 days in the central part, and 120 days in the northern part (in the areas of Mo-ho, only about 110 days.) If seedlings are protected against low temperature, planting may be few days ahead of present schedule, for example in the middle of April in Yen-chi and the later part of April in Chia-mu-szu.

(2) The Rice Paddies and the Soils

The rice paddies of this zone are distributed largely on the banks of the streams, the plains such as the middle and lower reaches of Liao-ho and the mountain regions of the northeastern part of Liaoning, the Sung-hua-chiang plain of Kirin, the middle and lower reaches of Sung-hua-chiang in Heilungkiang, the mountain regions of Mao-tan-chiang, Tieh-li-chiang, and Yen-shou-shan, and the regions along Hei-ho. The soils are mostly alluvium, meadow soil, marsh soil, and saline soil.

(3) Cultivating System

This is entirely a single-seasoned zone. In the north, the direct planting method is used in most cases. In the central part, direct planting or transplanting are both in practice. In the south, the method of transplainting is used in most cases. When the growing season is short, it is better to use the direct planting method. When the transplanting method is used, the seedlings may be cultivated by the temperature protection method, so as to bring the season ahead of schedule to obtain a higher yield.

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(4) The Varieties of Rice Plants

The varieties used in this zone are the early ripening ones of the keng subspecies; even the upland varieties belong to the keng subspecies. The ones used in the southern part are slightly later varieties of the early ripening ones. The daylight hours are longer in this zone, and the high temperature season is shorter. The light exposure stage of growth must proceed during the long daylight period; therefore, only these varieties which are not sensitive to light exposure may be used in this zone. These varieties, when they are introduced to the southern parts of the country, grow obviously faster. If the southern varieties are brought to this zone, aside from the very early ripening ones, the ordinary varieties can seldom grow normally to come to a head or to ripen. We must pay attention to this factor when we attempt to introduce new varieties.

(5) Diseases, Insects, and Natural Calamities

The blight disease is the most common in this zone, while the damage is more severe in An-tung of Liaoning, T'ung-hua of Kirin, Ho-chiang and Mao-tan-chiang of Heilungkiang, and others. There are a few kinds of rice field insects. Among the natural calamities, the spring drought and the autumn frost are the more prominent. If the temperature drops too early in the fall, the varieties which are relatively late to ripen may not seed properly.

5. DRY RICE ZONE OF NORTHWEST CHINA [p 185]

This zone is located to the west of Ho-hsi Tsou-lang in Kansu, and to the north of the Ch'i-lien Mountains, including the western part of Kansu, the western part of the Autonomous Region of Inner Mongolia, and the Autonomous Region

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of the Uigur Nationality in Sinkiang. The rice paddies of this zone amount to 0.03% of the national total, and the yield amounts to 0.03% of that of the country.

(1) Climate

This zone belongs to the arid climate. The area from Pao-t'ou of the Autonomous Region of Inner Mongolia to Urumchi of the Autonomous Region of the Uigur Nationality of Sinkiang, the average temperature during the rice growing season is 18.3° to 18.8°C. The temperature difference between night and day is 14.5 to 11.1°C. There are only five months in the year during which the monthly average temperature is above 10°C. In K'u-che of the southern part of Sinkiang, the average temperature during the rice growing season is 21.8°C, and the temperature difference between night and day is 11.1°C. There are 6 months here, during which the monthly average temperature is above 10°C.

The average rainfall of the year is generally below 200 mm. It is 324.2 mm in Pao-t'ou; 276.3 mm in Urumchi; and 68.4 mm in K'u-che. The rains come in June and July mostly. This is a favorable condition for rice culture. From May to September, the relative humidity is 45 to 69%, while the average is 47%. In the summer, when the temperature is high, if it is also very arid, the tip of the leaves of the rice plants often becomes yellow and withered. If the irrigation water is sufficient, and the night temperature is low, high yield is still possible. The rice growing season of this zone is from May to September in northern Sinkiang, and from April to October in A-ko-su.

(2) The Rice Paddies and the Soils

The rice paddies are distributed in the southern part of the Autonomous Region of Inner Mongolia, Ho-hsi Tsoulang of Kansu (Chiu-ch'uan), Urumchi, Mi-ch'uan, K'u-che, and A-ko-su of the Autonomous Region of the Uigur Nationality in Sinkiang. In such places as the lowlands, the river swamps, and the yellow soda area of A-ko-su, the paddy soils are usually formed from the saline and soda soils, the meadow soil, and the marsh soil.

(3) The Cultivating System and the Varieties

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This is a zone of the single-seasoned early ripening varieties. The planting is done with the direct method in wet soil. In A-ko-su, direct planting is done in dry soil or wet soil, and sometimes, the method of transplanting is also used. The varieties are all early ripening ones of the keng subspecies. The local varieties are very drought resistant and are suitable for the arid climate of this zone.

(4) Diseases, Insects, and Natural Calamities

The most serious damage to the rice plants of this zone is from blight and water flies. The study of the the Pa-i College of Agriculture in Sinkiang proved that the water flies are related to the saline and soda soils. They multiply the fastest in soils of pH value 7.5 to 9. Thus, it was suggested that a change of water and a thorough cleaning of the drainage system should be effective if accompanied with a spray of 666 powder.

6. HIGHLAND PLATEAU RICE CROP ZONE OF SOUTHWEST CHINA [186]

This zone includes Kweichow, Yunnan, Chinghai, the Kan-mo Autonomous Region of the Tibetan Nationality in Szechwan, and Tibet. The rice paddies of this zone amount to 6.1% of the national total, and the yield amounts to 8.8% of that of the country. The main rice producing area of this zone is the Yu-Kwei Plateau.

(1) Climate

This zone includes the monsoon tropic, the subtropic, the temperature moist, and the semi-moist climate. Sinee the topography and terrain of this zone are very complicated, the vertical climatic distribution is very obvious. During the rice growing season, from April to October, the average temperature is 16.5 to 15.6°C in the central part of Kweichow; 17.7 to 15.5°C in K'un-ming of Yunnan; 13.3 to 15.6°C in Hsi-ning of Chinghai; and in Lhasa of Tibet, from May to September the temperature averages 19 to 13.6°C. The rice growing season is generally from March to October in the entire area of Yu-Kwei Plateau; in Ch'ien-nan and Tien-nan, the planting may be done in the later part of February, and in a few areas, it may even be earlier. The temperature

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difference between night and day is about 9 to 11°C in Kweiyang and the areas of Yunnan, and about 13°C in Hsi-ning Of Chinghai.

The southern part of this zone has higher temperatures; therefore, is suitable for double-seasoned rice culture, or old stems may be cultivated to head and ripen once more after the first harvest.

Areas of the Yu-Kwei Plateau have an average annual rainfall of more than 1,000 mm. It is less in Hsi-ning of Chinghai, only about 377.2 mm. The rains come mostly in the period from June to August; therefore, there is often drought during the planting and transplanting seasons. The rainy season starts in the central part of Kweichow in April. It is often cloudy in the mountains there, and the relative humidity may reach 70 to 80%. This is a favorable condition for the rice plants; however, the lack of daylight becomes a shortcoming. In the areas of Yunnan province, the rainy season is from June to October, and the other months are basically dry.

(2) Rice Paddies and the Soils

The rice paddies of this region are concentrated in the Yu-Kwei Plateau, from 100 m to above 260 m in elevation. There are some paddies in Ching-Tsang Plateau, but not very many. The paddies of Yu-Kwei Plateau are mostly formed from the red and the yellow soils, with a high percentage of clay. They hold water and fertilizer well.

(3) The Cultivating System

This is mainly a single-seasoned zone. After the paddy rice is harvested, a few paddies are used to store water, while others are used for another crop of lima beans, or wheat. Sometimes, rice is also rotated with green fertilizer, or oil cabbage. In the southern part of Kweichow, in the plains along Hung-shui-ho, and in the southern part of Yunnan in the areas below 1,400 m in elevation, and the Chinsha-ho Valley in the north, double-seasoned and rejuvenated rice crops are being introduced and practiced. The results have been very good.

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(4) The Varieties of Rice Plants

Most of the varieties in Yunnan and Kweichow belong to the hsien subspecies, while the areas of high elevation and low temperature have mostly the keng varieties. Therefore, the vertical distribution is rather obvious. For example, in Yunnan, in the areas from 1,750 to 2,000 m, and in Kweichow, in the areas from 1,400 to 1,600 m, are mixed areas of the keng and the hsien subspecies. The areas above this zone are predominantly keng, while the areas below this zone are predominently hsien. In Yunnan, in areas below 1,200 m, there are quite a few varieties of the glutinous rice, and some soft varieties. These varieties require a longer period to grow and become ripe, but the quality is very good. Besides, deep water varieties are cultivated in Hu-ping of Yunnan. The local farmers call them "Shui-chang-ku." There are also quite a few upland varieties in the provinces of Yunnan and Kweichow. The varieties of Ching-Tsang Plateau are all single-seasoned early ripening keng varieties.

(5) Diseases, Insects, and Natural Calamities

Blight, fungus, weevils, and rice flies are the more common ills of rice plants. Among the natural calamities, spring drought is the most serious. Snow may also do damage to the seedlings before transplanting.

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CHAPTER 11. DEEP PLOWING AND PREPARATION OF THE FIELD

[p 301]

SECTION 3. FIELD PREPARATION TECHNIQUES FOR EACH TYPE OF PADDY FIELD [p 310]

Before a rice crop, the work in China's rice paddies may be divided into four types: a winter crop, a winter green fertilizer crop, winter fallow, and a continuous crop of one of the early rice varieties. The first three types precede an early rice crop or the single-seasoned medium or late rice crop, and the last type precedes a late rice crop of the continuous planting system of rice culture. These four different types call for different forms of land leveling, and the following is a description of each.

1. WINTER CROP FIELD [p 311]

In the areas south of Huai-ho, where there are two or three harvests in _a_ year, the winter crop consists of wheat, barley, Yuan-mai [a variety of wheat], oil cabbage, and lima beans. After the harvest of the paddy rice, the land is prepared for the winter crop. The preparation is not only important for the yield of the winter crop, it also affects the yield of the rice crop next year. In the Yangtze Valley, there are one or two months after the rice harvest before the planting of the winter crop; there is enough time to plow the paddy twice and to rake it twice; or even to plow it three times and to rake it three times.

Before the paddy rice is entirely ripe, the paddy should be drained, so that the soil will become just right for plowing. According to the experience of the farmers of Hsiao-kan-hsien, Hupei, the best time for draining the paddy

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is 15 days before the rice harvest. When the water is gone for about a week, water should be poured into the paddy again to rinse it and the rinse water should be drained immediately. Then, wait for one week before the rice harvest. At that time, the soil is not too dry nor too wet; the plowing should be very easy. If the soil is found to be too dry after the harvest, it may be rinsed once again before plowing. If the paddy is very low, and the water does not drain fast enough, a ditch may be dug in the paddy temporarily to hasten the draining process.

In the areas of the Yangtze Valley, the first plowing should be as deep as possible, and the soil should not be raked afterward, so that it may be sunned thoroughly. The second time, the plowing should not be as deep as the first time, and the soil should be carefully raked immediately afterwards, so that the surface soil may be loosely broken and well leveled, while the layer below is fairly tightened. Then, the winter crop of wheat or oil cabbage may be planted. This type of crops is benefited by deep plowing also.

The harvest of the late rice crop in the south is at about the same time as the time for planting the winter crop. There is not enough time for plowing and raking more than once. Most of the time, the soil is not sunned either. The land preparation work must be delayed until after the harvest of the winter crop. However, at that time, the temperature has risen, and the soil evaporation is fast. A slight delay may cause the soil to be too hard to plow. Before the plowing is done, there is the application of the initial fertilizer, and normally plowing should not be deeper than the depth of the winter crop. According to experience in the province of Anhwei, if the weather is fair, the soil should be left to sun a few days after plowing before it is raked and leveled. Locally there is the practice of harvesting, plowing, sunning, and burning all at once, so as to prepare the soil in time for the next crop. Such practice may bring as much as a 15% increase in yield.

2. WINTER GREEN MANURE FIELD [p 311]

In the areas of the Yangtze and Pearl River Valleys, the paddies of the double-seasoned rice or single-seasoned late varieties are often used to plant

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a green fertilizer crop with such legumes as Astragalus sinicus, Shao-tzu, Medicago denticulata, and turnip greens. In order to raise the yield of these legumes, their planting is done before the rice is harvested /by seeding the space between the rows/, this condition makes it impossible to plow. If the paddy is low, ditches should be dug all around the paddy to help the drainage. After the rice havest, more ditches should be dug every 10 ch'ih or so in order to hasten the draining and to help the legumes to grow.

In the spring, after the green fertilizer crop has been turned under, a certain time should lapse for it to become decomposed. Generally, the first plowing should be done just when the green fertilizer plants are at the peak of flowering, and this is usually about 10 to 15 days before transplanting. At that time, the pond silts should also be applied to the paddies, and the soil should be dry plowed and sunned for a few days. Usually, plowing is done as deep as the plowing layer so as to cover the green fertilizer. The paddy is immediately flooded after sunning; then it is raked and leveled. When the green fertilizer is mostly decomposed, the soil should be lightly plowed again so that the fertilizer may be mixed with the soil. Just before transplanting, an application of fast working fertilizer is also necessary.

3. WINTER FALLOW FIELD [p 312]

(1) The Southern Winter Fallowing Fields

The practice of winter fallow is for the two types of field in the south, the winter dry field and the water storage field. For both type of fields, it is best to plow it twice or three times. The first time should be done as early as possible so as the help the soil to mature.

In most areas, the winter dry fields are plowed deeply the first time, and not so deeply the second time. In some areas, the soil is too hard to plow deeply the first time, then, the process may be reversed. This process may accentuate the weathering effect of the winter rains, winds, and snow. In the spring, such fields should be plowed dry and sunned. They should be raked and leveled just before transplanting. As a rule, the winter plowing should be deep and the spring plowing should be shallow. Then, the soil should be plowed very lightly once more just before transplanting.

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There are two kinds of water storage fields. The first kind is the low field, and there is no way of draining it in the fall or winter. The other kind is the field of the hills or the mountain regions, where winter precipitation must be stored to help alleviate the possible damage of a spring drought. The first type is often plowed and raked while wet. The water storage field may be plowed dry and leveled in the fall before storing water. Plowing in the fall is mainly to get rid of the weeds.

(2) The Northern Winter Fallowing Fields

Most of the rice paddies are fallowed in the north. In the fall, they are plowed to 6 to 8 ts'un, and the plowing must be done before the ground freezes. This fall plowing may improve soil structure, eliminate weeds, and kill insects. For sandy soil, plowing should be done early in the fall, while the clay soil should be plowed late. After the soil is plowed, it is usually not raked or picked, and is left to freeze. The lumps should be very easy to break next spring. In some cases, the soil is raked once after plowing, so that manure may be applied in the winter.

These fields usually have a thick frozen surface layer throughout the winter, and in the spring, when this layer thaws, it is very difficult to work in the fields. In the northern parts of Heilungkiang, the field must be raked before it is thoroughly thawed, so that when the thawing is complete, the fertilizer may be applied, the mud dikes repaired, and the paddy leveled for flooding. If water is available, the paddy may be flooded early so that the weeds may sprout and grow. Just before transplanting, the soil is wet turned and raked once more to kill all the weeds. If water is not sufficient, then early plowing may give the field a chance to be sunned so as to accelerate the weathering process. When the sun dries the soil thoroughly, then, immediately after the paddy is flooded, the soil becomes soft and fluffy to make a good bed for the seedlings to turn green and tiller.

For the saline soils of the north, autumn and winter plowing is very important. It cuts off the cappilaries to prevent winter drought, during which the saline content of the ground water may rise to increase the saline content of the surface soil. Then, in the winter, plowing may bring the saline content to the surface so that it may be washed away

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in the spring. As a rule, in the spring, after the soil is washed, it may be wet plowed and raked once before it is ready for transplanting. Saline soil is very easy to become tight; therefore, it should not be raked too often, unless the drainage is very good (such as in the area of Tientsin). In the north, the paddies are washed in May and June which are the dry season locally. Water must be used very efficiently for the benefit of more paddies.

During recent years, in Szechwan, a new water saving method has been devised. First of all, instead of deep water, this method uses shallow water. As soon as the soil is barely covered, instead of waiting one or two days, it is immediately plowed and raked, and the work is completed as soon as possible. The edges and the mud dikes are repaired while plowing and raking are in process. After the paddy is carefully raked, it is leveled immediately. This method may save 20 to 50% of water. This is due to the fact that immediate plowing improves the water absorbing capacity of the soil granules. The plowing and raking cover up all the cracks in the paddy, and the water cannot leak out. When the edges and the mud dikes are repaired early, more water is stopped from leaking out. This method has been tried and proven effective for saving water in Huai-pei and the new rice growing areas of the Northwest.

4. SUCCESSION CROP DRY RICE FIELD [p 313]

In the continuous planting rice culture, after the early rice harvest, the late varieties must be planted. The farmers of these areas always use the fastest method to prepare the paddy. In the past, the soil was picked and raked a few times only. In this manner, the soil is neither deep nor fluffy, and transplanting is rather difficult. Practice proved that plowing instead of merely raking before transplanting increases the yield. According to the survey conducted by Chekiang Provincial Institute of Agricultural sciences in the seven agricultural cooperatives in Shao-hsing-hsien and others, the increase in yield may be as much as 30%. In 1957, surveys were conducted again in the ten cooperatives in Yu-yao; the increase was found to be 6.1 to 15.8%. Besides, plowing before transplanting makes the work of weeding lighter. Therefore, during the recent years, the practice is to plow and turn the soil after the early rice harvest. The plowing may be done with the initial application of fertilizer for the late rice crop. In some areas, the stem is left to about one ch'ih above the ground when the early rice is harvested. Then, immediately the soil is plowed and turned; then it is applied with fertilizer before raking. The late variety is planted as soon as the soil is thus made ready.

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5. FIELD PREPARATION TECHNIQUES USED IN CHANGING DRY FIELDS INTO WATERED FIELDS [p 314]

The key is to plow and rake, then, to build a good dike. A good plow sole and strong dikes will keep the water from leaking out. The experience of converting dry fields into paddies in the areas of Huai-pei is as follows:

First of all, the field should be leveled. Either ditches may be dug to obtain fill dirt or the fill dirt may be obtained from digging up below the surface. With the first method, we start from the higher ground to dig a ditch every two to three ch'ih. The ditch may be one to two shovels wide. The soil thus dug up is brought to the low area. The second method is to take off the surface soil of the higher ground; then the subsoil is dug up and brought to the low areas. After the field is thus leveled, the surface soil is put back. The essence of both methods is to avoid digging up the surface soil to cause uneven fertility.

When the surface is leveled, then water is quickly poured in. Plowing and raking are done at the same time so as to mix the soil and the water and to fill all the cracks. Then, wait till the water settles for one or two days; the paddy is plowed again and again to create a layer of plow sole. Wet plowing should be deep first, then gradually shallow so that the plow sole may be formed quickly.

The soil of the dry field is generally loose, and the newly built dikes are usually not good for holding water. Every time the paddy is wet plowed, the wet mud is used to cover the dikes once more. In some places in Kiangsu, the farmers use a mixture of one part lime, one part loess, and one part fine sand to build the dikes for the paddies. This is a very effective method.

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CHAPTER 12. SEEDLING CULTIVATION

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SECTION 2. SOWING [p 321]

1. SOWING PERIOD [p 321]

(1) The General Conditions During the Planting Time in the Various Regions

The planting time is related to the local climate, cultivating system, special characteristics of the variety used, the occurrence of rice diseases and insects, and labor arrangement. In practice, when the concrete conditions are under control, the earlier the planting is done the higher is the yield. The following is a description of the planting time of the various regions.

a. The Planting Time of the Northern Single-Seasoned Zone

In the single-seasoned North China, the early ripening Northeast, and the arid zone of the Northwest, the Frost-free period is very short, and only one rice crop is possible. The planting time is generally in April or May (Table 12-2). From North to Northeast, to Northwest, the temperature becomes lower, and the frost-free period becomes shorter; therefore, the planting time is later too. But, the difference is not very much.

b. The Planting Time of the Central and Southwest Double-Seasoned Rice Crops Areas

These areas have sufficient rainfall and the frost-free period is longer; therefore, the cultivating system is more complicated. There are the original single-seasoned varieties of early, medium and late rice plants; then, there are also the double-seasoned varieties developed since

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the liberation. Thus, the planting season is prolonged for a length of time. Table 12-3 shows that from the middle of February to the early part of July, a period of almost five months makes up the planting season for tthese zones. Generally speaking, the south line (including Szechwan, Hunan, Kiangsi, the southern part of Anhwei, and Chekiang) has earlier planting time for the early and medium varieties, and a later planting for the late varieties of the double or single seasoned crops. The north line (including the southern part of Shensi, Hupei, the central and northern parts of Anhwei, and Kiangsu) has a latter planting season for the early and medium varieties, while the late varieties of the double or single seasoned crops are planted earlier. This is due to the fact that in the north the temperature is lower and the frost-free period is shorter. During recent years, due to the improved techniques of seed selection, seedling protection, and planting, and the continuous development of the double-seasoned rice culture in the Yangtze Valley, the plantting season is being stretched even longer.

Table 12-2 The Planting Time of the Single-seasoned Rice Culture in the North

(1) 地 区		(21) 三月	(23) 四月			(27) 五月			(31) 六月	资料来源 (33)
省(区) (2)	县(市) (12)	下旬 (22)	上旬 (24)	中旬 (25)	下旬 (26)	上旬 (28)	中旬 (29)	下旬 (30)	上旬 (32)	
3) 河南	洛阳 13									省农科所(34)
4) 山东	济南 14									省农科院(34)
5) 河北	天津 15									品种材料(35)
6) 辽宁	铁岭 16									县农科所(36)
7) 吉林	公主岭 17									省农科所(34)
8 黑龙江	牡丹江 18									省农科所(34)
9) 内蒙	哲里木盟	19								盟农科所(37)
10 宁夏	王太堡	20								农试站 (38)
11 新疆										农家栽培經驗(39)

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1. Place 2. Province (region) 3. Honan 4. Shantung
5. Hopei 6. Liaoning 7. Kirin 8. Heilungkiang
9. Inner Mongolia 10. Ninghsia 11. Sinkiang
12. Hsien (shih) 13. Lo-yang 14. Chi-nan
15. Tientsin 16. T'ieh-ling 17. Kung-chu-ling
18. Mao-tan-chiang 19. Che-li-mu-meng 20. Wang-t'ai-pao
21. March 22. First 10 days 23. April 24. First 10 days
25. Middle 10 days 26. Last 10 days 27. May
28. First 10 days 29. Middle 10 days 30. Last 10 days
31. June 32. First 10 days 33. Source of information
34. Provincial Institute of Agricultural Sciences
35. Materials describing the varieties
36. Hsien Institute of Agricultural Sciences
37. League Institute of Agricultural Sciences
38. Agricultural experimental station
39. Farmers' experience
40. Note: The cross lines indicate the duration of the plantting; the black dots indicate the time most of the planting is done.

c. The Planting Time of the Double-seasoned South China

This is the southmost rice growing zone of our country. The temperature is high, the rainfall is plentiful, and the frost-free period is long. Sometimes, there is no frost all year long. Aside from a few small areas, double-seasoned rice culture is the practice of the entire zone. Along the coast, and to the southern part of this zone, planting is early for continuous rice crops. For example, in Taiwan and Hainan, the early varieties are planted in November and December of the year before. The late varieties of the continuous crops are planted rather late. Toward the north, the early varieties are planted a little later, while the late varieties are planted a little earlier. (Table 12-4)

(2) The Experience and the Conditions for Moving the Planting Time Still Earlier

The early varieties of the south and the single-seasoned varieties of the north are planted at a time when the temperature is rather low, with considerable fluctuations. The farmers' experience is to soak the seeds just when a cold wave is about to be over, and to have everything ready

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except the weather. When the cold wave is over, the seeds are planted immediately. During the few warm days before the coming of the next cold wave, the seeds have germinated and sprouted. When the second cold wave does come, the seedlings have had roots, so that water may be poured into the seed bed to protect them against the low temperature. The seedlings are bigger by this time, and they will not float in the water or become decomposed.

In the Northeast, there are also such rules as "following the third cold wave and the fourth warm wave. During the recent years, such experience is summarized and put to practice to move the planting time earlier, and increased yield has been the result. Table 12-2 compares planting at the end of a cold wave and the beginning of a warm wave with planting at the end of a warm wave and the beginning of another cold wave. We can easily see that planting must be done in accordance with the changes of the local weather.

According to a study of the Kiangsu Branch of the China Academy of Agricultural Sciences, the planting time for the early keng varieties is when the average temperature of a 10 day period during the last few years has risen to 9° to 11°C. The planting time for the early hsien varieties (such as Nan-t'e-hao) is when the average temperature of a period of 10 days during the last few years has risen to 12° to 14°C. The planting time of the hsien varieties is thus about 5 to 10 days later than the keng varieties.

With this rule in mind, planting should be done very swiftly following the local weather prediction, and there should be a few days left in the current warm wave to insure a good start for the seedlings.

The planting time for the medium and late varieties is different. The temperature is no longer an element to worry about. It is the harvest time of the previous crop and the labor arrangement which determine the planting time. For such varieties as Lao-lai-ch'ing, Che-ch'ang No.9, 10509, and T'ieh-keng-ch'ing, (all late varieties) the planting must be done in the later part of May to the early part of June in the Yangtze Valley, so that the heading and blooming time will not be too late for the local rice growing season. If the medium ripening varieties are used, then, planting must

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be done in early or middle June; if the early ripening varieties are used, planting must be done in the later part of June, and not later than the beginning of July so as to guarantee suitable weather for the heading and blooming time and to obtain a high yield.

Table 12-3 Planting Time for the Single and Double-seasoned Rice in Central China and the Southwest

(1) 地 区		(32 二月			(33 三月			34 四月			35 五月			36 六月			37 七月	资料来源 41
(2) 省(区)	县(3)(市)	上	中	下	上	中	下	上	中	下	上	中	下	上	中	下	上	
		38	39	40	38	39	40	38	39	40	38	39	40	38	39	40	38	
4 四川	14 泸州																	专区农科所
5 湖南	15 衡阳																	〃
	16 常德																	〃
6 江西	17 赣州																	赣州农科所
	18 南昌																	省农科所
7 浙江	19 杭州																	〃
	20 嘉兴																	双桥农場
8 湖北	21 武昌																	省农科所
	22 荆州																	龙令桥农試站
9 江苏	23 苏州																	专区农科所
	24 扬州																	〃
10 陕西	25 汉中																	汉中农試站
11 安庆	26 芜湖																	专区农試站
	27 阜阳																	专区农科所
12 云南	28 蒙自																	省农业厅
	29 普洱																	〃
13 贵州	30 罗甸																	試验站
	31 湄潭																	县农科所

55 注：双线系双季稻播种期范围，单线系中稻播种期范围，虚线系单季晚稻播种期范围（以下同）。

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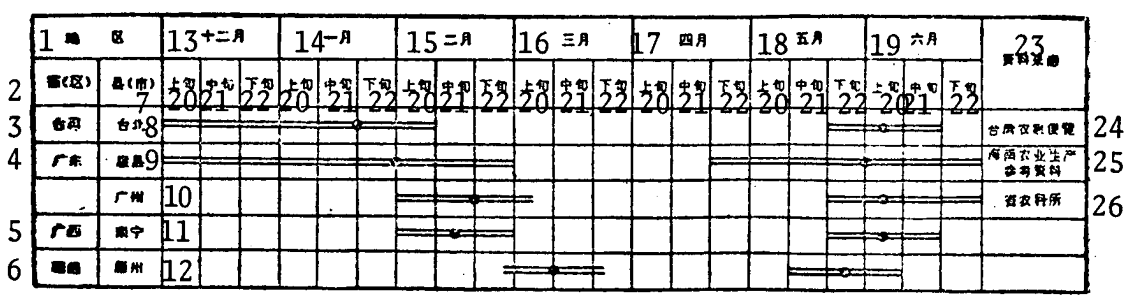
1. Place 2. Province (region) 3. Hsien (shih) 4. Szechwan
5. Hunan 6. Kiangsi 7. Chekiang 8. Hupei 9. Kiangsu
10. Shensi 11. Anhwei 12. Yunnan 13. Kweichow
14. Lu-chou 15. Heng-yang 16. Ch'ang-te 17. Kung-chou
18. Nan-ch'ang 19. Hang-chou 20. Chia-hsing 21.Wu-ch'ang
22. Ching-chou 23. Su-chou 24. Yang-chou 25.Han-chung
26. Wu-hu 27. Fu-yang 28. Meng-tzu 29. P'u-erh
30. Lo-tien 31. Li-hui 32. February 33. March 34. April
35. May 36. June 37. July 38. First part 39. Middle part
40 Later part 41. Source of information 42. Special District Institute of Agricultural Scineces 43. Kung-chou Institute of Agricultural Sciences 44. Provincial Institute of Agricultural Scineces 45. Shuang-ch'iao Farm 46.Same as 44.
47. Lung-ling-ch'iao Experimental Station 48. Same as 42.
49. Han-chung Experimental Station 50.Special District Experimental Station 51. Same as 42. 52. Provincial department of agricultrre 53. Experimental station 54. Hsien Institute of Agricultural Sciences
55. Note: The double lines indicate the duration of the planting time for the double-seasoned varieties; the single line indicates the duration of the planting for the medium varieties; the dotted line indicates the duration of the planting time for the single-seasoned late varieties. The same applies to the next table

Table 12-3 The Planting Time of the Double-seasoned Varieties in South China



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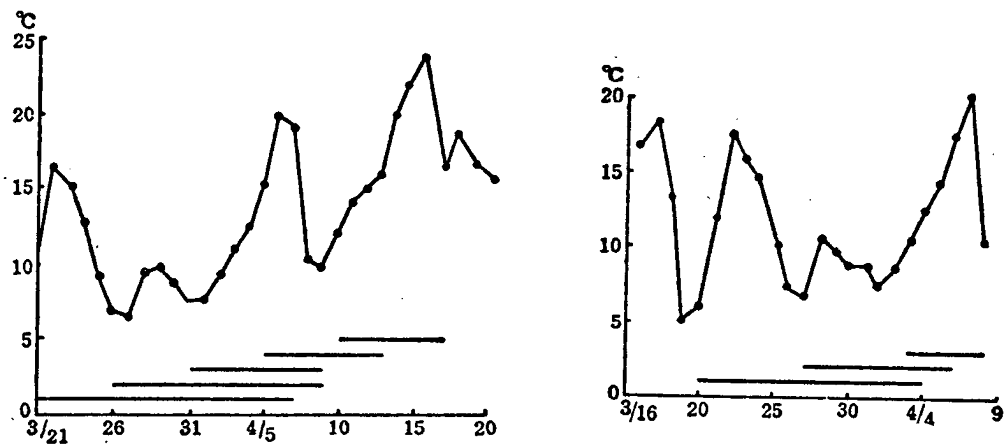
1. Place 2. Province (region) 3. Taiwan 4. Kwangtung 5. Kwangsi 6. Fukien 7. Hsien (shih) 8. Tai-pei 9. Ya-hsien 10. Canton 11. Nan-ning 12. Fu-chou 13. December 14. January 15. February 16. March 17. April 18. May 19. June 20 First 10 days 21. Second 10 days 22. Last 10 days 23. Source of information 24. A Brief Survey of Taiwan Agriculture 25. Hai-nan agricultural production materials 26. Provincial Institute of Agricultural Sciences

Graph 12-1 The Relationship between Planting Time and Sprouting Time (Variety No. 503)



出苗经过日数 (月/日)
1

出苗经过日数 (月/日)
2

1. The number of days for the sprouting process(month/day) Based upon the planting tests of 1956, conducted by Chekiang Provincial Institute of Agricultural Sciences
2. The number of days for the sprouting process (month/day) Based upon the planting tests of 1957, conducted by Ningpo Special District of Chekiang Province, Institute of Agricultural Sciences. The dark horizontal lines indicate the number of days between planting and sprouting.

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(3) The Relationship between Planting Time and the Growth Period

When the most suitable planting time is being calculated, we must consider not only the normal growth temperature for the seedlings, but also the condition of growth all the way to harvest after the seedlings are transplanted. If planting is done too late, the plants may not have enough time to ripen normally. However, the growth period of the various varieties varies in length, and each variety behaves differently in different locations, and at different planting times. For example, Table 5-8 show the different behavior of Nan-t'e-hao, Yuan-tzu No.2, Che-ch'ang No.9, and Lao-lai-ch'ing, when planted in different places and at different times.

Table 12-5 The Growth Period of Nan-t'e-hao when Planted in Difference places and at Different Times

地点 1	播种期(月/日) 11	出穗期(月/日) 12	播种至出穗日数 13	地点 15	播种期(月/日) 26	出穗期(月/日) 27	播种至出穗日数 28	地点 29	播种期(月/日) 26	出穗期(月/日) 27	播种至出穗日数 28
2 雅县	2/9	4/19	69	长沙 16	4/2	7/5	94	成都 30	5/16	7/23	68
3 南宁	2/28	6/14	106	合肥 17	4/3	6/29	89	北碚 31	5/22	7/24	63
4 泸县	3/7	6/26	111	南昌 18	4/5	6/25	81	泸县 32	6/4	8/18	75
5 开远	3/13	5/20	68	桂林 19	4/5	6/25	81	成都 33	6/16	8/16	61
6 成都	3/16	7/1	101	成都 20	4/5	7/8	94	武昌 34	6/17	8/31	75
7 赤水	3/20	6/7	80	成都 21	4/16	7/10	86	武昌 35	7/5	9/14	71
8 福州	3/22	6/10	82	昆明 22	4/16	9/8	145	南京 36	7/9	9/29	82
9 广州	3/27	6/24	89	贵阳 23	4/19	8/24	127	成都 37	7/16	9/21	67
10 成都	3/27	7/2	97	成都 24	5/1	7/16	77				
11 武昌	4/2	6/24	83	北碚 25	5/2	7/14	73				

1. Place 2. Ya-hsien 3. Nan-ning 4. Lu-hsien 5. K'ai-yuan 6. Ch'eng-tu 7. Ch'ih-shui 8. Fu-chou 9. Canton 10. Wu-ch'ang 11. Planting time (month/day) 12. Heading time (month/day) 13. Number of days between planting and heading 14. Ch'eng-tu 15. Place 16. Ch'ang-sha 17. Ho-fei 18. Nan-ch'ang 19. Kuei-lin 20. Ch'eng-tu 21. Ch'eng-tu 22. K'un-ming 23. Kuei-yang 24. Ch'eng-tu 25. Pei-p'ei

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26. Planting time (month/day) 27. Heading time (month/day)
28. Number of days from planting to heading
29. Place 30 Ch'eng-tu 31. Pei-p'ei 32. Lu-hsien
33. Ch'eng-tu 34. Wu-ch'ang 35. Wu-ch'ang 36.Nanking
37. Ch'eng-tu 38. Planting time (month/day) 39. Heading time
40. Number of days from planting to heading

Table 12-6 The Growth Period of Che-ch'ang No.9 When Planted in Different Places and at Different Times

地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4	地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4	地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4
5 北碚	4/1	9/1	153	9 成都	5/13	9/4	114	13 雅安	5/30	9/18	111
6 昆明	4/6	—	未成熟	10 赤水	5/20	9/3	113	14 南昌	6/10	9/24	106
7 南京	4/23	9/3	134	11 北碚	5/22	9/10	111	15 武昌	6/17	9/26	101
8 北碚	5/2	9/4	125	12 泸县	5/27	9/23	119	16 合肥	6/17	9/30	103

1. Place 2. Planting time (month/day) 3. Heading time (month/day) 4. Number of days from planting to heading
5. Pei-p'ei 6. K'un-ming 7. Nanking 8. Pei-p'ei
9. Ch'eng-tu 10. Ch'ih-shui 11. Pei-p'ei 12.Lu-hsien
13. Ya-an 14. Nan-ch'ang 15. Wu-ch'ang 16. Ho-fei

Table 12-7 The Growth Period of Yuan-tzu No.2 When Planted in Different Places and at Different Times

地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4	地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4	地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4
5 武昌	3/11	6/17	98	9 杭州	4/7	6/30	84	13 沈阳	4/28	8/4	98
6 福州	3/19	6/16	86	10 昆明	4/6	8/12	128	14 南京	4/28	7/12	75
7 南昌	3/29	6/25	88	11 蕪湖	4/11	7/2	82	15 公主岭	5/9	8/20	103
8 成都	4/6	7/2	87	12 广州	4/16	6/15	60	16 灵武	5/18	8/10	84

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1. Place 2. Planting time (Month/day) 3. Heading time (month/day) 4. Number of days from planting to Heading
5. Wu-ch'ang 6. Fu-chou 7. Nan-ch'ang 8. Ch'eng-tu
9. Hang-chou 10. K'un-ming 11. Wu-hu 12. Canton
13. Ch'en-yang 14. Nan-king 15. Kung-chu-ling
16. Ling-wu

Table 12-8 The Growth Period of Lao-lai-ch'ing When Planted in Different Places and at Different Times

地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4	地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4	地点 1	播种期 (月/日) 2	出穗期 (月/日) 3	播种至出穗日数 4
5 福州	3/20	7/30	132	芜 9 湖	4/26	9/6	133	杭 13 州	5/22	9/8	109
6 南昌	4/7	8/22	137	丹 10 阳	5/17	9/15	121	雅 14 安	5/31	9/15	107
7 北碚	4/13	8/29	138	兴 11 化	5/17	9/13	119	合 15 肥	6/19	9/30	103
8 昆明	4/16	10/4	171	高 12 邮	5/21	9/16	118	南 16 京	7/9	10/5	88

注：生长期是指播种到出穗的日数。17

1. Place 2. Planting time (month/day) 3. Heading time (month/day) 4. Number of days from planting to heading
5. Fu-chou 6. Nan-ch'ang 7. Pei-p'ei 8. K'un-ming
9. Wu-hu 10. Tan-yang 11. Hsing-hua 12. Kao-yu
13. Hang-chou 14. Ya-an 15. Ho-fei 16. Nanking
17. Note: Growth period means the number of days between planting and heading

Tables 12-5 to 12-8 show the various effects of different temperature and daylight conditions. The most important thing to consider is whether the temperature will be right for the development of the young heads. For example, when Che-ch'ang No.9 was planted in K'un-ming on the 6th of April, it did not have time enough to become ripe; in Ho-fei on the 17th of June, it was too late to have a high yield. When Lao-lai-ch'ing was planted in Ho-fei on the 19th of June, and in Nanking on the 9th of July, no yield was obtained in either case. Therefore, even though the seedlings may be growing nicely when planted at certain times, the temperature may not be right for the other stages of the plant's growth.

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Generally speaking, the temperature requirement of the single-seasoned varieties of our country corresponds with the natural temperature variations from low to high and from high to low again. For the continuous rice crops, however, the growth stage of the early crop is from low temperature to high temperature, and during the growth stage of the late crop, the temperature is from high to low. Therefore, we must combine the characteristics of the varieties and the temperature of the various growth stages in order to determine the planting time.

According to the studies of Hunan Provincial Institute of Agricultural Sciences, after an analysis of the weather information of the various places of that province, the weather of that province during the later part of June is most suitable for the heading and blooming stages of growth of the early varieties; therefore, such variety as Nan-t'e-hao should be planted in Ch'ang-sha and Yu-yang Special Districts along the last 10 days of March. Planting of this variety may be moved up to about the 15th of March in Hunan; while in Hsiang-hsi and the high mountain regions, it may be slightly delayed, so long as sprouting may be completed before the early part of April. Of course, the planting time for the various varieties must be determined in accordance with the local climatic conditions of each locality.

In Szechwan, during the growth stage of the early varieties (middle of May), cold waves have been experienced for a number of years. Temperature sometimes dropped to below 20°C. On the 12th and 13th of May, 1958, the average temperature of the various places of that province was mostly below 13°C, and the extremely early varieties were damaged severely. According to the survey of the Lo-chou Institute of Agricultural Sciences, Ch'ing-sen No.5 came to a head between the 15th and the 19th of May, and the rate of empty hulls was above 60%. The bearded early keng came to a head between the 22nd and the 26th of May, and the rate of empty hulls was above 70%. Nan-t'e-hao came to a head in the middle and later part of May, and the rate of empty hulls was above 50%. Lei-huo-chan came to a head in the later part of May, and the rate of empty hulls was above 80%. In other areas, whenever the rice plants came to a head along the end of May or the beginning of June, the rate of empty hulls was high, but if the rice plants did not come to a head until the middle of June, there was a good harvest. This is a good example for

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explaining the fact that we should consider the entire growth season of each of the varieties for the purpose of determining whether the planting time is suitable for any particular locality. The safe standard is that the temperature must never be lower than 20 to 23°C during the stages of head evolvement, heading, blooming, and ripening.

In the Yangtze Valley, if such varieties as Nan-t'e-hao and Yuan-tzu No.2 are chosen, they must be planted earlier because their growth season is longer than such varieties as beardless early keng, Ch'ing-sen No.5, and Shih-shou-pai-mao.

With regard to the late crop of the continuous rice culture, in the Yangtze Valley, the heading time of the late varieties is in September, when the temperature varies a great deal. During the month of September, the first 10 days are always warm. In some areas, the temperature of the middle 10 days may be close to 20°C, while the temperature of the last 10 days of that month is even more uncertain. According to experiments of Hunan Provincial Institute of Agricultural Sciences, the late varieties must be classified in accordance with the length of their growth seasons. Such varieties as Che-ch'ang No9, Yao-fan-tzu, and 10509 take longer to grow, and must be planted in the middle or the later part of May. Such varieties as Hupei-tsao and Pai-mi-tung-chan grow faster, and should be planted in the first 10 days of June. Some of the varieties that grow very fast, such as Fan-tzu and Hung-mi-tung-chan, should be planted in the last 10 days of June. The rule that those varieties which require less time to grow may be planted later, and those which require more time to grow should be planted earlier applies to other places and other provinces also.

In a word, for all the varieties, early or late, we must consider the climatic conditions and the characteristics of the variety during its entire season of growth, and plant the seeds as early as possible. One of the important measures in rice culture is to determine the most suitable planting time.

2. SOWING AMOUNT [p 327]

(1) Different Amount to be Plant in Different Areas

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Dense planting has been practiced everywhere; basically one to two times the amount planted in the past is the current practice. In the high yield paddies, the practice is 20,000 to 30,000 seedlings per mou. If each chin of rice amounts to 20,000 grains, then, each mou of paddy requires about 10 to 15 chin of rice to plant. Reasonable density practice demands sufficient numbers of seedlings, but the seed bed can hardly be very big. This is indeed a new technical problem. The experience of the masses proved that a proper adjustment of the age of the seedlings may help increase the yield in seedlings. The statistics of 1959 regrading the amount planted in the various areas are shown in Table 12-9.

Table 12-9 The Amount of Rice Used for Planting in the Various Regions of the Country (1959) (chin/mou)

地 (1) 区	(6)北方单季稻区			(7)华中及西南单双季稻区			(8)华南双季稻区		
	一般 (9)	最高 (10)	最低 (11)	一般 (9)	最高 (10)	最低 (11)	一般 (9)	最高 (10)	最低 (11)
(2)单季稻	150—250	300	100	—	—	—	—	—	—
(3)中稻	—	—	—	150—200	300	50	—	—	—
(4)连作早稻	—	—	—	200—250	300	100	150—200	250	50
(5)连作晚稻	—	—	—	100—150	200	60	80—120	150	60

1. Place 2. Single-late variety 3. Medium variety
4. Early crop of the continuous rice culture
5. Late crop of the continuous rice culture
6. Single-seasoned North zone
7. Single and double-seasoned Central and Southwest zones
8. Double-seasoned South zone
9. Normal 10. Maximum 11. Minimum

Table 12-9 shows that the seedling production varies with the various areas according to the difference in temperature and daylight conditions.

For example, the highest record in the North was 300 chin and the lowest was 100 chin. The early varieties

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of Central China require 200 to 250 chin per mou, while the late varieties in South China only require 80 to 120 chin. It seems that the early varieties require more than the medium varieties, and the late varieties require still less. With regard to regions, the North, Central, and Southwest regions require more than the South where the temperature is higher.

(2) The Relationship between the Amount required for Planting and the Quality of the Seedlings

An important experience tells us that when a smaller amount is planted in a given seed bed, the seedlings grow stronger. However, in some areas, the seedlings used for transplanting are no more than 3 to 4 ts'un tall, and when they are in that size, a large number of them does not affect their normal growth. Practice proved that if seeds are planted early, and the seedlings are transplanted early, then more seeds may be planted in a given seed bed. The experiment of Hupei Provincial Institute of Agricultural Sciences also proved this point.

Table 12-10 Planting Time, Amount Planted and the Growth Speed of the Seedlings (Nan-t'e-hao Variety)

播种期 (月/日)1		3/26			4/5			4/15		
播种量 (斤/亩)2		200	250	300	200	250	300	200	250	300
苗高(厘米)3	播后 10 天4	1.71	1.79	1.61	2.67	2.80	2.64	5.88	5.15	5.77
	播后 15 天4	5.03	5.09	4.35	6.07	5.20	5.30	9.16	9.52	9.40
	播后 20 天4	5.42	5.67	5.44	12.13	8.28	11.35	11.00	10.75	13.01
	播后 25 天4	9.00	9.40	8.08	14.06	12.85	12.28	15.20	14.40	15.60
	播后 30 天4	13.82	14.83	14.42	—	—	—	21.38	21.60	20.40

1. Date planted (month/day) 2. Amount planted (chin/mou)
3. Height of the seedlings (cm)
4. ... days after planting

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Table 12-10 shows that there is an obvious relationship between the planting date and the height of the seedlings, and the relationship between the amount planted (200 to 300 chin per mou) and the height of the seedlings is not obvious. It seems that if the amount planted varies between 200 to 300 chin per mou, the seedlings of less than 30 days old show well balanced growth, and are healthy after being transplanted. Chekiang Provincial Ning-po Institute of Agricultural Sciences observed the relationship between the amount planted and the growth of the seedlings, using bearded early keng for their experiment. It was discovered the final yield is similar, if the seeds planted vary between 200 and 300 chin per mou. However, the amount planted should not reach 400 chin per mou.

Table 12-11 The Amount Planted, the Quality of the Seedlings, and the Final Yield

(1) 插秧期 (月/日)	播种量 (斤/亩) (2)	株高 (厘米) (3)	叶片数 (4)	叶宽 (毫米) (5)	基部宽 (毫米) (6)	根数 (7)	鲜重 (克) (300株) (8)	干重 (克) (300株) (9)	干物质 (%) (10)	每亩产量 (斤) (11)
4/20	200	12.3	4.4	3.9	2.6	7.3	31.3	4.2	13.2	678
	300	11.7	4.0	3.9	2.5	6.0	30.7	4.3	13.5	672
	400	10.5	3.9	3.5	2.4	4.6	28.3	3.6	12.9	609
4/30	200	19.3	3.8	4.3	3.6	13.4	59.9	10.2	17.0	648
	300	18.1	3.7	4.1	3.2	12.5	48.1	8.8	18.2	636
	400	17.6	3.4	3.9	3.1	11.9	48.5	8.3	17.2	576

注：根据原资料表1和表3改制，播种期均为3月18日。(12)

1. Date of transplanting (month/day) 2. Amount planted (chin/mou) 3. Height of the stalk (cm) 4. Number of leaves 5. Width of the leave (mm) 6. Width of the base (mm) 7. Number of roots 8. Fresh weight (g/300 stalks) 9. Dry weight (g/300 stalks) 10. Dry substance (%) 11. Yield per mou (chin) 12. The above table is made on the basis of the original Tables 1 and 3. The planting time was the 18th of March.

In case of the medium and the late varieties, we may also adjust the age of the seedlings at the time of transplantation; then, properly increase the amount planted per

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mou. The experience of the areas of the Yangtze Valley tells us that if the seedlings are about 30 days old at the time of transplantation, the amount of 150 to 200 chin is quite reasonable for every mou.

However, the late varieties of the continuous rice culture should be watched closely. Some of them take a long time to ripen. In order that the seedlings have enough time to grow and ripen, after transplantation, they must be quite big. If we try to plant them early, we must wait till the early crop is harvested before we can transplant them into the paddies. In the Yantze Valley, the early crop is harvested mostly in the middle or later part of July, as late as the early part of August in some cases; therefore, the seedlings are often 50 to 70 days old when they are transplanted. During the planting time, the temperature is high, and the seedlings grow fast. It is often necessary to plant them sparsely so that they will not compete with each for light. Ordinarily, only 60 to 80 chin are used for each mou. Thus, a large seed bed is needed. In a word, the selection of a suitable variety, and a proper delay of the planting time are the important factors for increasing the amount of seeds used for planting in every mou of seed bed.

Hunan Provincial Institute of Agricultural Sciences used such varieties as Che-ch'ang No.9, Fan-tzu, and Sung-ch'ang No.261 for an experiment. For those varieties as Fan-tzu and Hung-mi-tung-chan, which have a shorter growth season, it was discovered that if 110 to 150 chin of seeds are used for every mou of seed bed, the yield was not greatly affected. For Sung-ch'ang No.261, which has a medium length of growth season, 80 to 110 chin may be used for every mou. For such varieties as Che-ch'ang No.9, which take a long time to grow, only 50 to 80 chin may be used. This is due to the fact that the longer the growth season, the earlier the seeds must be planted, and the older the seedlings at the time of transplantation.

Chekiang Provincial Ning-po Institute of Agricultural Sciences discovered that if the age of the seedlings is 35 days (planted on the 25th of June, and transplanted on the 30th of July), then there is not too much difference in yield if either 80 chin or 100 to 120 chin are used for planting.

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experimented with the varieties of 10509 and Huang-mao-chan and discovered the same rules. The growth season of Huang-mao-chan is shorter, and between 100 and 120 chin of seeds may be planted in every mou of seed bed. However, if the transplantation is delayed until the end of July or the be-binning of August, only 80 chin may be used. No.10509 takes a longer time to grow. It must be planted in the early part of June. The seedlings have to be older at the time of trans-plantion; therefore, fewer may be planted in every mou of seed bed.

In conclusion, the amount of seeds used for planting is closely related to the age of the seedlings when used for transplantation. For strong seedlings and reasonable utilization of seed beds, a proper adjustment of the age of the seedlings is the only method.

3. SOWING METHODS [p 330]

There are the damp method, the clear water method, the muddy water method, and the dry method. With the damp method, after the seed bed is prepared, the water is drained. The seeds are planted with the soil not too dry and not too wet; then they are covered with ashes of the stalk, or the hull. When the seedlings begin to look green, a small amount of water is poured into the bed. With this method, it is easy to see whether the seeds are planted evenly, and when the soil is soft, the seeds cannot sink too deeply.

With the clear water method, after the seed bed is prepared, we wait until the water settles and becomes clear, before we plant the seeds. This method is usually used in case the soil is fine but contains a large amount of clay.

The muddy water method is used when the soil is sandy. Since the seeds have difficulty in penetrating such soils, we plant them when the rake has stirred up the water and made it very muddy. Thus, when the mud settles, it brings the seeds down and covers them.

The dry method is the same as the method used for planting dry crops. After the seed beds is prepared, we plant the seeds and cover them with a thin layer of soil. Then, unless it is an extremely dry season, we do not flood the

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bed. Sometimes, with the dry method the seeds are planted in small ditches dug specially for that purpose.

In early spring, bamboo baskets may be used to cover the seeds planted in the damp paddies to protect them from the cold weather. They are also used in the summer to keep the seeds from being washed away by the rain. If the seeds are exposed in the soil, they may not all sprout. If the soil is alkali, ashes should not be used to cover the seeds. Sometimes, the farmers use wooden boards, which afford good protection against frost, sun, and rain. It is used and proved effective in Li-hsia-ho of Kiangsu and in the areas of Shantung.

Huai-yin Shih Institute of Agricultural Sciences of Kiangsu Province discovered with experiments that with the board protection, the sprouting rate is 91.2%; with a manure cover, it is 90%; with a soil cover, it is 88.5%; with an ash cover, it is 85.7%; without cover, it is 83%. It is the same if the seeds are planted in the big paddies. In South China, it is best to use charcoal ash, which is loose, permeable, yet cannot be washed away, and can absorb some heat also.

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SECTION 3. SEEDLING CULTIVATION METHOD AND CONTROL [p 331]

1. SEEDBED SELECTION, PREPARATION AND FERTILIZATION [p 331]

Good seed bed management is the basic condition for preventing the seedlings from decomposition. The method varies with the region and the season.

(1) The Previous Crops

The temperature and the cultivation system vary from place to place, so do the crops before the field is used as a seed bed for rice plants. According to survey, there are more than 10 different types:

Table 12-12 The Previous Crops of the Seed Beds

前1作种类	单季早稻 (12)	单季中稻 (13)	单季晚稻 (14)	双季早稻 (15)	双季晚稻 (16)
冬闲或冬水田2	16	30	19	29	9
綠肥田3	5	6	7	6	3
蔬菜田4	2	10	1	8	6
早中稻秧田5	—	—	8	—	11
小麦或油菜田6	—	—	3	—	12
饲料田7	—	—	—	2	—
豆类8	—	—	—	—	2
馬铃薯9	—	—	—	—	2
早玉米10	—	—	—	—	1
甘薯11	—	—	—	—	1

(17)注：1. 资料来源是全国各农业科研机构供给，反映了各所在地区秧田前作的一般情况，从广东海口到内蒙古哲里木盟都有，其中以长江流域的为多，只可作为一个概况的参考。

2. 表中冬闲或冬水田一栏内，包含有北方稻区的河北、山东、山西、河南、陕西、宁夏、内蒙古、辽宁、吉林、黑龙江等地区，但其他各栏，沒有北方稻区的资料。

3. 表中数字，是各类前作的地区数。

1. Type of previous crops 2. winter fallow or water storage
3. Green fertilizer fields 4. Vegetable garden
5. Seed beds for the early and medium rice varieties
6. Wheat or oil cabbage fields
7. Feed produce 8. beans 9. Potatoes
10. Early corn 11. Sweet potatoes
12. Single-seasoned early varieties
13. Single-seasoned medium varieties
14. Single-seasoned later varieties
15. Double-seasoned early varieties
16. Double-seasoned late varieties
17. Note: a. Above information is gathered from the various agricultural research agencies of the country, and reflects the actual conditions of the various areas, from Kwangtung to Inner Mongolia, with emphasis on the Yangtze Valley. This information is only offered as a reference.

b. The northern areas of Hopei, Shantung, Shansi, Honan, Shensi, Ninghsia, Inner Mongolia, Liaoning, Kirin, Heilungkiang belong to the first type of winter fallow or water storage fields. The other type does not include information from these provinces (region.)

c. The figures in the table indicate the number of areas where this type of crops are reported.

The incomplete information of Table 12-12 shows that the previous crops of the early and medium varieties of the single-seasoned rice culture are the three types of water fallowed fields, or winter water storage fields, the green fertilizer fields, or the vegetable garden, with the winter fallowed fields as the major type. The previous crops of the late varieties of the single-seasoned rice culture are five different kinds. In some areas (Szechwan, Hunan, Hupei, Kiangsi, and Anhwei) the medium variety paddies are used as seed beds for the late varieties.

(2) The Selection of Seed Beds

The soil must be loose and soft, fertile, clean, well drained, and with a good water supply. Seed beds for the early and medium varieties must be in an area facing the sun and well protected against the wind. Those of the late varieties must be cool and well ventilated. They should be a distance from the roads and the villages so that the animals will not tramp on them, but they should be conveniently located for management purposes. In the north, proper wind barriers should be built for the seed beds. The late varieties of the double-seasoned culture should have seed beds in a higher location, with only medium fertility, because the warm temperature may cause the seedlings to grow too fast. In Yunnan, there is not much rain in the spring; the seed bed is often selected in the low areas such as the winter water storage fields. In Pearl River delta, the farmers plant the seeds of the early varieties in the fish ponds, which are always fertile. In the north, the seed bed soil must not contain more than 0.02% of salts. The soil of a seed bed is best to be sandy, and it is always nice to be close to the paddy to which the seedlings are to be transplanted, to save trouble of transportation.

(3) Preparing The Seed Bed

a. Plowing

When the seed bed was used previously as a winter fallowed field or for water storage, it is usually plowed in the fall or winter, then leveled in the spring. If the previous crops are wheat, green fertilizer, vegetables, beans, or an early rice crop, the the selected seed bed is plowed when that crop or crops are harvested. After being left in the sun for a few days after plowing, it is raked and prepared. In North China, and the Northeast, the practice is to plow in the fall, but sometimes, the farmers may wait until the spring.

b. Preparing the seed bed

Seed beds must be plowed early, carefully, and not very deeply, normally not deeper than 3 ts'un, so that the roots of the seedlings will not grow too deeply. When the seed bed is being raked, all residual roots, weeds, and stones must be removed, to create a better environment for the young seedlings. The dry seed bed must have very fine soil, and the surface must be level, so that after it is flooded, the water level will be even. Otherwise, some seedlings may drawn, and other do not have enough water.

(4) Fertilizer Application

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According to available information, the initial fertilizer used for the seed beds in the various areas is as follows:

Southern Areas (Central, South, and Southwest China)

a. Night soil, mud ash, ammonium sulfate
b. Night soil, manure
c. night soil, pond silt
d. Green fertilizer, manure
e. Night soil
f. Night soil, night soil mixed with soil, any other fertilizer
g. Soil, mixed fertilizer, grass and wood ash, night soil
h. Night soil, manure, grass and wood ash.
i. Night soil, manure, oil residue, grass and wood ash,
j. Green fertilizer, night soil, grass and wood ash
k. Lime, night soil
l. Night soil, ammonium sulfate
m. Night soil, frozen soil
n. Night soil, burnt soil
o. Lake weeds, green grass, green fertilizer
p. Pond silt, manure, oil residue, burnt soil
q. Night soil, oil residue, ammonium sulfate
r. Green fertilizer, night soil
s. Night soil, chemical fertilizer
t. Night soil, pond silt
u. Night soil, Pond silt, green grass
v. Night soil, hair
w. Ammonium sulfate
x. Green fertilizer

Northern Areas (North, Northeast, Northwest China)

a. Night soil, manure, ammonium sulfate
b. Soil mixed with manure, ammonium sulfate
c. Night soil, soil mixed with fertilizer
d. Dry manure, night soil
e. Pond silt, night soil, soil
f. Night soil, manure
g. manure
h. Green fertilizer, manure, night soil
i. dry manure, burnt soil, manure, ammonium sulfate

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j. Manure, ammonium sulfate
k. Soil and manure
l. Ammonium sulfate
m. Night soil, manure, ammonium sulfate
n. Night soil, manure
o. manure

It is apparent that the farmers always gather locally available fertilizer for their seed beds. Although the combination is thus very complicated, it is equally obvious that in the north and the south, night soil with a mixture of other things constitutes the major ingredients, and a single fertilizer is seldom used. Such chemical fertilizer as ammonium sulfate is used for the mixture more often in the north than in the south, and nowhere has such phosphorus fertilizer as calcium perphosphate been reported as part of the mixture.

Generally speaking, the initial fertilizer for the seed beds of the early and medium varieties is more complicated than that which is used for the seed beds of the late varieties. In the latter case, initial fertilizer is not used at all in some places; in others, only green fertilizer is used.

The amount of fertilizer applied varies with the climate and soil, 400 to 500 chin per mou at least. It is common to apply 1,500 to 3,000 chin, but rarely over 5,000 chin. Night soil is used more in the north than in the south.

For the second application, the fertilizer is simpler. In the south, night soil, ammonium sulphate, grass and wood ashes, and oil residue. Calcium perphosphate is used in very few cases. For the late variety of a continuous rice crop, additional fertilizer is generally not applied. In the north, the second application consists of ammonium sulfate in most cases, and in some cases night soil is used, but rarely any other fertilizer. The amount of ammonium sulfate is usually 10 to 20 chin in the south, 40 to 60 chin in the north.

In the south, for the early and the medium varieties, generally one or two additional applications are used. In the north, there may be as many as three additional applications. In some cases, there are even more than three.

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The fertilizer application system seems to vary a great deal in accordance with the difference in regions and varieties, however, the farmers always use less fertilizer when the temperature is high, and therefore, more fertilizer is used for the early and medium varieties. The dry seed beds are applied with more fertilizer initially. If organic fertilizer is used, it must be decomposed first so as to be effective for the seeds.

2. SEEDLING CULTIVATION METHOD [p 334]

In the past, seedlings were cultivated in water. At present, the methods of damp soil cultivation, water cultivation, dry cultivation, dry and wet cultivation, temperature protection method, and the warm temperature method are all being practiced.

(1) The Various Methods

a. Damp cultivation

It is also called semi-dry, dry mound, ash, or board seed beds. It is really similar to the wet seed bed, except the soil is neither dry nor very wet. When the soil is just right for the seeds to sink half way into the soil when they are cast by hand, then a small amount of water is poured into the seed bed before planting. When the seeds have sunk into the soil, the surface water is slowly drained, and a layer of burnt hull, grass ash, or fine dry soil is carefully spread on the surface. This layer is just thick enough to cover the seeds. The seed bed is kept constantly moist before the sprouts appear. In some areas water is not poured in until the sprouts have appeared. If the soil contains salts, mud dikes should be built to separate the irrigation channels and the drainage chennels as indicated in Figure 12-3, so that the irrigation water enters the seed bed directly, while the water containing salt is drained from the lower part. Thus the salt content of the soil may be gradually reduced. This type of seed bed is always prepared when it is dry, and after the preparation work, the soil is washed twice (two days apart) before the dikes are closed for planting.

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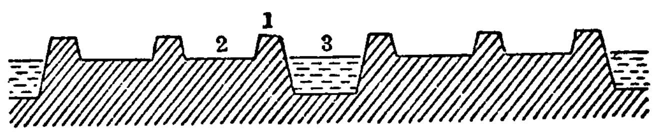
The advantage of this method is that the soil is better ventilated. The temperature of the surface soil is generally higher than that of the wet seed bed, and the seedlings generally grow better. There is less chance of decomposed seedlings. After transplantation, they grow better, ripen earlier, and the yield is higher too.

According to the study of Anhwei Provincial Institute of Agricultural Sciences, with this method there is a 2 to 19% higher sprouting rate, and the seedlings are ready 1 to 4 days earlier. The yield may be 2.4 to 18.3% higher.

Figure 12-3 A Profile of a Seed Bed with Ditches Outside and Channels Inside



1. Mud dike 6 ts'un high, with the top of 6 ts'un wide.
2. The surface of the seed bed, 2 ch'ih wide
3. Drainage ditch, 2 ch'ih wide at the bottom, and one ch'ih deep.

b. Water Cultivation

The first step of this method is to apply the initial fertilizer, then, pour the water into the paddy, and close the dike. The paddy is then repeatedly plowed, to stir up the soil and to mix the fertilizer. The paddy is then leveled, and the seeds are planted after the water settles. During recent years, the water is often drained when it begins to become clear. Then, seed beds about 8 ts'un wide, three to four ts'un deep are prepared, (sometimes called seedling boards) (Figure 12-4). When the surface is dry enough so that the mud does not stick to the hands (if the soil has a tendency to become pasty, it should not be drained) then water is poured once more before planting the seeds.

If the soil contains too mucn clay, it should not be stirred up too much because stirring may cause the soil

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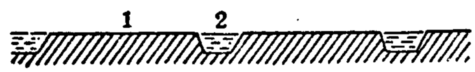
to lose all air. If organic fertilizer is used, it should be completely decomposed first so as to eliminate such harmful substances as the marsh gas, organic acid, and hydrosulfide. Meanwhile such management measures as draining should be emphasized so that the seedlings will develop good root systems and grow.

Figure 12-4 A Profile of an Improved Water Seed Bed



1. the surface of the seed bed, 4 to 5 ch'ih wide
2. Ditch for both draining and irrigation, about 3-4 ts'un deep

c. Dry Seed Bed

It is made out of dry fields or other dry ground, and water is not used in the entire process of cultivation. It is not every easy to plow the soil and make it very fine when it is dry, and more organic fertilizer is thus needed. It must be thoroughly decomposed first. When the soil is made fine, shallow ditches are made for planting, and after the seeds are spread, they are covered with a layer of fine soil or grass ash. Sometimes straw or wild grass may also be used to cover the seeds before sprouting. The seeds planted in a dry seed bed take longer to grow, however, after transplantation, the seedlings can resist drought and other adversities better, and they turn green faster. If the soil of the seed bed is particularly dry, the growth of the seedlings may not grow evenly, and the seed bed is more liable to damage from insects, diseases, birds, and animals.

d. Water and Dry Seed Bed

This method is similar to the damp seed bed, except that after the seeds are covered, water is poured immediately like the case of the water seed beds. When

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three leaves appear on the seedling, the water is drained. From then on, the seedlings are left to grow in the dry paddy, so that they may not grow too big. This method is suitable for warm season or for the late varieties of rice plants. If this method is used, the soil of the seed bed must not have a high clay content, so that cracks will not develop after it is drained.

e. Other Methods of Cultivating Seedlings

(a) Plant seeds in between rows of Corn or Kaoliang

This method is used mainly for the seedlings of the late crop of a double seasoned rice culture, to solve the problem of seed bed deficiency. It is a method commonly used in the area of Lu-chou, Szechwan and the mountain region of Wan-nan, Anhwei. However, management must be emphasized to protect the seedlings against diseases and insects.

(b) The Method of Cultivating "old seedlings" or "seedlings with top cut off"

With these two methods, the planting is often done in April and the seedlings are kept through May, June, until the middle or later part of July before transplantation. The seedlings are cultivated more than 100 days. With the method of "old seedlings," the seed bed must be located on a high ground. The soil is lightly plowed. After the seedlings are placed in the soil, and begin to turn green, the water is drained. From then on, the soil is kept moist, with little or no fertilizer added. At the time of transplantation, the seedlings are old and strong, and the ends are cut off before being transplanted into the paddies.

With the method of "Cut-off seedlings," most of the measures are similar to the above method, except that the seedlings should be kept in more fertile soil so that they may grow fast. At the time of transplantation, the seedlings have tillers and nodes. The tip and the end of the seedlings are then cut off; only the space between the two nodes at the base is used. After it is transplanted, the node in the soil will develop roots, while the node above the soil will develop leaves. At present, the farmers of Lien-p'ing, Ho-p'ing, Hsin-feng, and Weng-yuan of Kwangtung Province practice this method.

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(2) The Methods of Planting and the Growth of the Seedlings

With the various methods, the moisture, and nutrient supply are different; so are the conditions of soil ventilation and temperature. Thus, the tissue structure of the seedlings, and their ability to adjust to environmental conditions are different also.

According to the experiment conducted by Fukien Provincial Institute of Agricultural Sciences, the various methods of cultivating seedlings of the early varieties affect the sprouting rate and the height of the seedlings. The result of the experiment is as follows:

Table 12-13 The Relationship Between the Planting Method and the Height of the Seedlings and the Sprouting Rate (Z) (Nan-t'e-hao Variety)

秧田种类 (1)	(5) 催芽长度				平均 (10)
	萌动 (6)	1 (7)分	(8) 2—3分	4 (9) 分	
水秧田 2	22.1	54.2	50.5	71.6	49.61
旱秧田砻糠灰及稻秆复盖 3	95.1	72.3	76.1	66.7	77.54
湿润秧田砻糠灰复盖 4	98.7	94.3	97.2	95.2	96.36

(11) 注：本表水秧田，原文有四种日夜不同的排灌和深浅的处理，这里只录其平均数。

1. Type of seed bed. 2. Water seed bed 3. Dry seed bed, with the seeds covered by straw and burnt hulls 4. Damp seed bed with the seeds covered with ash of burnt hulls 5. The height of the seedlings 6. Sprouting 7. 1 fen 8. 2-3 fen 9. 4 fen 10. Average 11. Note. Regarding the water seed beds, the original article listed four different ways of irrigating, draining, and deep and shallow plowing. For this table, only the average figure of the four ways of management is recorded.

In 1958, the same institute conducted another experiment. The first batch of seeds was planted on the 11th of March; the average sprouting rate was 93.5% for the water

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seed bed; 94.2% for the damp seed bed, The second batch of seeds was planted on the 21st of March, the sprouting rate was 83.5% for the water seed bed, and 89.6% for the damp seed bed. Not only was the sprouting rate of the damp seed bed higher than any other method; the seedlings from the damp seed bed were also stronger. The result of this experiment is shown in Table 12-14.

Table 12-14 The Growth of the Seedlings and The Different Types of Seed Beds (Nan-t'e-hao Variety)

秧田种类 (1)	5 3月11日播种，4月11日检查			8 3月21日播种，4月21日检查		
	秧苗高度（厘米）	叶片数	秧苗基部宽度（毫米）	秧苗高度（厘米）	叶片数	秧苗基部宽度（毫米）
(2) 水秧田	(5) 17.5	(6) 5.8	(7) 3.1	(9) 18.5	(10) 5.9	(11) 3.0
(3) 湿润秧田盖砻糠灰	21.6	6.2	3.7	19.2	6.2	3.5

(12) 注：水秧田的秧苗是录原文的三种日夜不同排灌和深浅处理的平均数。

1. Type of seed bed 2. Water seed bed 3. Damp seed bed, with the seeds covered by ash of burnt hull 4. Planted on the 11th of March and examined on the 11th of April 5. Height of the seedlings (cm) 6. Number of leaves 7. The width of the base (mm) 8. Planted on 21st of March, and examined on 21st of April 9. Height of the seedlings (cm) 10. Number of leaves 11. The width of the base (mm) 12. Note: The original article listed three different ways of managing the water seed bed. The figure used in the above table is the average of the three.

Lo-tien Agricultural Experimental Station of Kweichow Province also reported that for the early varieties, the damp seed bed method is better. The result is shown in Table 12-15.

The advantage of the damp seed bed method for cultivating the seedlings of the early varieties has been proven by the experiments conducted in many areas; therefore, within the short period of two years since this method was initiated, it has been adopted by many areas. The dry seed bed method of the north is also a form of the damp seed bed method, except

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that the seed bed is not flooded until the sprouts have appeared and the soil cover has been removed, and once the seed bed is flooded, it is not drained again. In this manner, planting may be done five to ten days earlier than by the water seed bed method, and the seedlings grow better. Therefore, in the south or in the north, when the temperature is unstable, it is better to use the damp seed bed method.

When planting the late varieties, the temperature is high and the daylight is intense; then, the water seed bed method is better. According to the experience of cultivating old seedlings in Kwangtung, the planting should be done in flooded paddies, but the water should be drained the next day; then the soil should be kept moist constantly. At about 20 days after planting, the seedlings have become 6 to 7 ts'un high; then, the soil should be sunned until there are small cracks so as to control the growth of the seedlings. The leaves will thus grow slowly, and the stem will not grow nodes. In Ch'ing-hsien of Fukien, this is called "roasted water seedlings." The so called "dry water seedlings" of Szechwan, Hunan, and Anhwei, which the farmers use for their late crop of the continuous rice culture all belong to this type.

Table 12-15 The Growth of the Seedlings of the Water Seed Bed and the Damp Seed Bed Compared

(1)秧田种类	秧苗高度（厘米）(4)	叶片长（厘米）(5)	叶片宽（厘米）(6)	干物质（%）(7)
(2)湿润秧田	35.1	25.2	0.65	12.16
(3)水秧田	31.4	22.6	0.61	11.89

(8)注：品种南特号，3月18日播种，4月11日移栽时调查，秧龄24日，调查数100株平均。

1. Type of seed bed 2. Damp seed bed 3. Water seed bed
4. Height of seedlings (cm) 5. Number of leaves (cm)
6. Width of a leaf (cm) 7. Dry substance (%)
8. Note: The variety Nan-t'e-hao was used for the experiment. The seeds were planted on the 18th of March, and examined on the 11th of April at the time of transplantation. The seedlings were 24 days old. One hundred stalks were examined for the experiment.

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3. SEEDBED CONTROL [p 337]

In the double-seasoned regions, if the temperature is not stale, there may be 10 to 30% decomposed seedlings for the early crop; in serious cases, as much as 50%. For the medium rice varieties, a loss of 10 to 20% is also a common occurrence. This type of loss is usually heavier in the hsien varieties than the keng varieties. When we say decomposed seedlings we mean dead seedlings. There are actually many pathogenic reasons for such an occurrence. Sometimes, instead of the shoots, the roots grow. Sometimes, the shoots are deformed or become black. Sometimes, the seedlings are struck by certain disease; in other times, physiological reasons or bad environment may also cause death. The seeds may have been damaged by heat, dampness,or insects. Or, they may have been poisoned in the process of seed treatments.

According to a survey conducted by T'un-kuang Commune of Hsiu-ning-hsien, Anhwei, the seeds of Peking Keng and No.503 were planted on the 19th of March in 1958. Those of No. 503 sprouted nicely, at a rate of more than 90%; while the seeds of Peking Keng had a sprouting rate of only 30%. It was discovered that in a hurry, the seeds of the latter variety were not soaked enough. On the 23 of March, the seeds of Nan-t'e-hao were planted. These seeds were soaked too long; the small sprouts have become tangled with the roots. While the seeds were broadcast, many of the roots are thus broken, and the final sprouting rate was only 60%. There was a portion of the same variety which was soaked properly, and the sprouting rate for that portion was more than 90%.

The factors of temperature, soil fertility, and irrigation system are also closely related to the occurrence of seedling decomposition. It is generally believed that if the temperature is low and it has been raining frequently, if the seed bed is not properly located, if the surface is not leveled properly, if the soil is not fine enough, if the irrigation and draining are not handled properly, if the soil contains too much reductive reaction or salts, if the fertilizer is not decomposed sufficiently, the seedlings may decompose as a result.

According to the survey in Li-hsia-ho, Northern Kiangsu, conducted by the Crop Plant Physiology Laboratory

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the following factors are very important:

(1) Low temperature does not directly cause the seedlings to decompose, it merely weakens them. When the temperature remains as low as 7 to 12°C for 9 days, the transpiration of the seedlings stays at its minimum level, and almost no growth is detected during these days. The depth and the oxygen content of the water does not seem to have an obvious effect on the activities of the seedlings.

(2) The death of the seedlings is determined not by the depth of the water during the low temperature period; but is determined by the water level during the warm temperature period after the cold spell. If the water level is low after the cold wave is over, there is little or no death; if the water level is deep, the death rate will increase. If the water is drained on the same day when the cold wave is over, or in the maximum of four days afterwards, transpiration may be recovered, and the seedlings may survive. If the water is not drained after four days, due to lack of oxygen in the warm temperature, transpiration is recovering very slowly, and the seedling dies.

(3) After the cold wave is over, and the warm temperature has arrived, the death of the seedlings is mainly caused by hydrosulfide. In Li-hsia-ho, the soil reduction is high, and more than 70% of the decomposed seedlings are black heads. These black heads do not occur during the low temperature period. Experiments have proved that the cause of these black heads is the ferrous sulfide, which is a product of hydrosulfide and iron. The occurrence of hydrosulfide is related to temperature and the organic content of the soil. It does not occur when the temperature is below 15°C, and easily occurs when the temperature is 20°C. Therefore, it is very important that a special group of workers should be made responsible for the management of the seed beds, so that all measures should be carried out properly and on time.

The Following is a description of these management measures:

(1) From Planting to the Time When the Seedling has Three Leaves

a. Inspection of the Preparation Work

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Before soaking, there should be a calculation of the amount of seeds needed, based upon past experience of the rate of sprouting of this particular variety and the acreage to be transplanted. In the process of disinfecting, soaking, and warm treatment, the density of the solution used, the type of water and its temperature, and the seed with which the roots and the sprouts appear should all be watched. Then, the work of seed bed preparation, the application of fertilizer, source of water, the insecticides and other drugs should all be carefully inspected.

When planting the seeds of the early varieties, in the north or in the Yangtze Valley, it is important to build wind barrier on the north, east, and west sides of the seed beds. The height of the wind barriers should be about 6 ch'ih. According to the estimate made in 1959 by the Institute of Crop Cultivation, China Academy of Agricultural Sciences, a 3 m high wind barrier may reduce the speed of the wind 60 to 80% within a distance of between 3 to 8 times the height of the barrier. In 1958, Hua-tung Institute of Agricultural Sciences calculated that a 2 m high wind barrier on the north side may reduce the speed of the wind 40 to 60% within a distance of 5 to 8 times the height of the barrier, and may raise the temperature of the seed bed 1 to 3°C.

b. Management after the seeds are planted and before the sprouts appear

After the seeds are planted, when the first true leaf appear it is called the sprouting stage. If the seeds have been treated and prepared, but the weather changes suddenly, then the seeds should be spread out and kept cool in order to wait till the weather changes for the better. When the damp seed bed method is used, if there is weather prediction of heavy rain after the seeds have been planted, then, the seed bed should be immediately flooded, to keep 1 to 2 ts'un of water above the soil surface, and the water should be immediately drained after the rain is over. For the water seed beds, the water should not be too shallow during the night in order to protect the seeds from night rain. Before sprouting time, we should watch out for the field mice and sparrows.

Sprouting is related to the temperature. For the early varieties, if the temperature is low, the sprouts come

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very slow, and the seeds may suffocate and die. For the late and medium varieties, the temperature is usually warm, and the sprouts come fast. But, if the seed bed has too much water, the seeds may fail to become established. Therefore, the water should be drained early so as to give the soil sufficient air.

In 1959, the Institute of Crop Cultivation of China Academy of Agricultural Sciences planted seeds on the 17th of April, and the temperature dropped sharply on the 22nd of April. The temperature of the ground surface was as low as 1.5°C below zero. At that time, 55% of the seeds had begun to have roots. The seeds were covered with grass ash, and there was no water to protect them on the ground surface. The seedlings grew very well throughout this experiment. Therefore, to control the water and the moisture content of the soil is important for the seeds to grow roots and for the young sprouts to develop resistance.

c. Management after the sprouts have appeared and before there are three leaves

During this period, the young sprouts need nutrients. At first, the endosperm supplies them, but toward the later part of this stage, the food of the endosperm has been used up, and the young sprout must live independently. This is a turning point in the life of the sprout, because, its resistance drops suddenly. If the seeds are in dry beds or damp beds a sudden deficiency of nourishment may be felt. It is necessary to apply quickly effective fertilizer such as ammonium sulfate or well decomposed night soil (five chin and five tan respectively), and they should be diluted and sprayed. If the seeds are in water beds, then weeds and moss must be cleared at this point. If the temperature drops suddenly (below 5°C for hsien varieties, and 3°C for keng varieties), then the beds must be flooded to protect the young sprouts. During this period, the sprouts of the water bed may develop signs of decomposition, and those of the dry or damp beds may begin to wither; measures must be taken to treat them properly.

(2) Management after three leaves have appeared and before transplantation

During this period, if there are signs of nutrient deficiency, an application of fertilizer is necessary; if

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there are signs of quick growth, the seed beds should be sunned to control too much tillering; if a cold wave or a storm are expected, the beds should be flooded to protect the seedlings. In the areas where irrigation water comes from cold springs or mountain water, channels must be arranged to lengthen the distance from the source of the water to the seed beds so that the temperature of the water may be raised before it reaches the beds.

For the seedlings of the late crop of a continuous rice culture, the water should be drained in time to control growth, especially after heavy rains, so that the seedlings may grow strong but not big.

Such rice diseases as the stem rot and seedling blight, and such insects as the borers, the weevils, beetles should be watched carefully. For the late varieties of the late crop, the diseases of leaf spot and leaf smut should be especially watched, and the weeds should be cleared in time.

About 7 to 8 days before transplantation, one more application of fertilizer may help the seedlings to grow better after being transplanted. This is not necessary if the paddy is fertile, or the seedlings are in perfect condition. If the paddy has "cold soil" or "pasty soil", some additional fertilizer such as grass ash, phosphates, or silicates in the seed bed at this time may improve the internal resistance of the seedlings. If the seedlings are too tall, they may be pruned 6 to 7 days before transplantation as much as 1/3 from the tip, followed with an application of ammonium sulfate at about 5 chin/mou.

For the dry or damp seed beds, water should be poured in a day before transplantation. Certain drugs may be sprayed for disease prevention at that time also.

When the seedlings are pulled up for transplantation, weeds, weak and bad seedlings should be carefully eliminated. After the seedlings are pulled up, wash the soil off in the water of the seed bed, and tie them in bundles. Make certain that they are not exposed to the sun while being transported to the paddy. Keep in mind the available labor and time before deciding how many seedlings are to be pulled up. They should be transplanted on the same day for best results.

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SECTION 5. TRANSPLANTING PERIOD AND SEEDLING AGE [p 349]

1. TRANSPLANTING PERIOD AND SEEDLING AGE OF PADDY RICE OF DIFFERENT REGIONS [p 349]

Transplanting time is determined just as the planting time, on the basis of temperature, varieties, previous crops, water condition, soil characteristics, insects and diseases, and labor arrangement. In the southern part of South China, transplanting is generally done in the later part of March to the early part of April. In the northern part of South China, Kiangsi, and southern part of Chekiang, it is done generally in the middle part of April. In the Yangtze Valley, to the east of I-ch'ang, it is usually in the later part of April. Further north, near Ho-fei and Nanking, it is mostly at the end of April to the beginning of May. In the Szechwan Basin, along the Yangtze, it is in the later part of April to the middle part of April. In the western part of Szechwan, it is in the middle and later parts of April; in Yunnan, the early part of April; and in Kweichow, the early and the middle parts of April. For the late crop of the continuous rice culture, transplanting is generally done in the month of July. In the Yangtze Valley, efforts are exerted to complete transplantation for the late crop in the first 10 days of August, the earlier the better. For the Single crop regions, in the northern part of Heilungkiang and the Autonomous Region of Inner Mongolia, transplantation is normally done in the early part of June; in the southern part of the Northeast, it is in the early part of May. It is earlier for the regions toward the south.

The age of the seedlings at the time of transplantation also varies with the regions. For the early varieties of the single-seasoned crop, it is generally about 30 days. Sometimes, it may also be 15 to 20 days, or 45 days. In areas of P'u-erh and Hsi-shuang-pan-na of Yunnan, the planting is done in November the year before, and the age of the seedlings is 90 to 110 days, more than the time they spend in the paddy.

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The seedlings used for the late crop of the continuous rice culture are usually 40 to 50 days old, sometimes 70 days. However, if medium maturing varieties are used, the seedlings may only be 30 to 35 days old when being transplanted, and they may also be 25 or 50 days old. In the northern regions, the seedlings are generally 35 to 40 days old at the time of transplantation.

2. DETERMINING THE QUALITY OF SEEDLINGS AND PROPER TRANSPLANTING PERIOD [p 350]

The farmers are in the habit of saying that "good seedlings are half of the grain" or "good rice comes from good seedlings." The seedlings may be divided into the tender, the strong, and the old. If the leaves are dark green, and if the seedlings lose moisture easily after being pulled up, then they are tender. When tender seedlings are transplanted, they turn green very slowly, with more withered leaves, and are easily damaged by a bad environment. The strong seedlings are good seedlings. Toward the later period, their growth has stopped slightly; their leaves are lighter, but straight and strong. Their tissue is slightly harder. The base is large and not very round. After transplantation, they lose very little moisture and turn green very fast. If the seedlings are too old, the leaves at the base may have all been withered, or all the leaves have turned yellow. They are difficult to pull, and do not grow well after being transplanted. However, for the late crop of the continuous or double-seasoned rice culture, sometimes seedlings are purposely cultivated in this manner. With reasonably dense planting, these old seedlings may bring very high yields. But, this is a specialized technique; we do not practice it ordinarily.

The quality of the seedlings may be judged by the internal proportion of carbon and nitrogen. After three leaves have appeared, the seedlings have used up the nutrients of the endosperm; they now begin to depend upon the root to absorb nutrients and moisture, and the leaves for their photosynthesis which manufactures carbohydrates. The absorption of nitrogen increases with the growth of the seedlings. Photosynthesis increases after there are four to five true

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leaves. At that time, the carbohydrate content increases, while nitrogen absorption decreases. For the strong seedlings, the proportion between carbon and nitrogen is generally about 14. When this coefficient is over 20, the seedlings are old seedlings. The nitrogen absroption has been reduced so much that high yield is rather difficult to obtain.

The quality of the seedlings may also be judged by the roots. At the time of transplantation, we may pull up a few, and cut off all the roots, then, plant them in culture broth or an ordinary paddy. After 7 to 10 days, pull them up again and see how many roots have grown back. When numerour roots grow up very fast, the seedlings are of good quality.

Transplanting time is determined by the factors which will enable the seedlings to become green again quickly after being transplanted. These factors are related to the quality of the seedlings and the conditions of the paddy (fertility, soil characteristics and water level). Meanwhile, temperature is also important. This is more so for the early crop of the double-seasoned rice culture. If transplanting is done on a clear day, with intense daylight and high temperature, the seedlings will turn green faster. Table 12-24 shows the relationship between temperature and the number of days it takes for the seedlings to become green again. When the average temperature is 13 to 14°C, it takes 14 days for the seedlings to become green, and there may be many dead ones. If the temperature is about 15°C, it takes 7 to 10 days, and the condition of the seedlings is much better. When the temperature is about 20°C, it takes only 4 to 6 days. In a word, 13°C may be said to be the minimum temperature for transplantation. For normal growth of the seedlings, the temperature should be an average of 15°C.

Table 12-24 Temperature, the Number of Days before the Seedlings are Green, and the Final Yield (Bearded Early Keng)

插秧期（月/日）(1)	返青期 (2)	返青期内平均气温 (°C) (3)	插秧至返青天数 (4)	返青情况 (5)	成熟期（月/日）(10)	每亩产量（斤）(11)
4/5	4/19	13.7	14	不良 (6)	7/20	687
4/15	4/20	20.5	5	良好 (7)	7/19	740
4/25	5/2	17.0	7	正常 (8)	7/24	767
5/5	5/16	15.1	11	正常 (9)	8/1	766

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1. Transplanting time (month/day) 2. Time when the seedlings turn green again 3. The average temperature in this period (°C) 4. Number of days between transplanting and the time when the seedlings turn green again 5. The condition of the seedlings 6. Not good 7. Good 8. Normal 9. Normal 10. Ripening time (month/day) 11. Yield per mou (chin)

Therefore, transplanting time should be determined by the age of the seedlings and the temperature at the time of transplantation. Generally speaking, for the early keng varieties such as the beardless early keng, the age of the seedlings should be about 20 to 30 days at the time of transplantation (when there are four to five true leaves); for the early hsien, such as Nan-t'e-hao, the age of the seedlings should be 25 to 35 days (when there are five true leaves.)

Besides, the soil condition of the paddy is also important. If the soil is not very good or contains a great deal of salt, the age of the seedlings should be older, and the temperature should be higher at the time of transplantation. According to common experience, for the "cold paddy", the seedlings should be dug with a shovel or wrapped in manure to protect the roots and to concentrate the fertilizer. In that case, transplantation may be done earlier.

For the late crop of the continuous rice culture, the temperature is always high at the time of transplantation. In South China, it may be above 40°C. The roots of the seedlings can hardly withstand such a high temperature, especially for the tender seedlings. This is the reason for the use of trained old seedlings, which are sometimes kept for 80 to 100 days. In this case, transplantation should be done on a cloudy day, or after 6 o'clock in the afternoon, when the temperature is lower somewhat. The work, then, must be done through the night to insure normal growth of the seedlings.

3. THE EFFECTS OF TRANSPLANTING PERIOD AND SEEDLING AGE ON PADDY RICE YIELD [p 352]

For the early varieties, transplanting is usually done in the middle of March to the middle or later part of April in South China and in the beginning of April to the

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beginning of May in the Yangtze Valley, when the temperature is low and unstable. If done too early, or if the seedlings are too young, their growth may be badly affected. On the average ., if the planting is done early, and the temperature is low, then the seedlings grow slow, and transplantation should be delayed until the seedlings are older. If the temperature is high, but the planting was late, then, the seedlings must grow fast, and transplantation should be done early when the seedlings are young. In 1959, Liu-chou Special District Agricultural Experimental Station of the Autonomous REgion of the Chuang Nationality conducted a test with Nung-lin No.3. The result is shown in Table 12-25.

Table 12-25 Effect of Planting Time, and the Age of the Seedlings on Yield for the Early Rice Crop

播种期 (月/日) (1)	插秧期 (月/日) (2)	秧龄 (3)	每亩产量（斤） (4)	嫩秧比老秧增产 % (5)	各播种期每亩平均产量（斤） (6)	比迟播的增产% (7)
3/6	3/25	19	945.1	9.93	902.4	17.44
	4/10	35	859.8	—		
3/16	4/1	16	870.4	1.01	866.1	12.71
	4/10	26	842.8	—		
3/26	4/10	15	842.4	21.33	768.4	—
	4/20	25	694.3	—		

1. Planting date (month/day) 2. Transplanting date (month/day)
3. Age of seedling 4. Yield per mou (chin)
5. Increased yield of tender seedlings compared with old seedlings (%) 6. Yield per mou on the average (chin)
7. Increased compared between early and late planting (%)

The planting time of the late crop of the continuous rice culture varies considerably in accordance with the variety used, so that the temperature may be just right for

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each variety when it blooms. In South China, such variety as T'ang-p'u-ai must be planted from the end of May to the early or middle of June so that it may bloom in the beginning of October for the highest yield. Therefore, the planting time for this variety does not fluctuate a great deal, but the transplanting time depends largely upon the harvest time of the previous crop. If the early crop is harvested at the end of July, then the late crop may be transplanted in the middle or later part of July, and the age of the seedlings may be 40 to 50 days. However, if the early crop is harvested at the end of July, then the seedlings may be more than 60 days old. Table 12-26 explains the suitable time for planting and transplanting, and it seems that the older the seedlings, the higher is the yield. The same condition seems to exist with Che-ch'ang No.9, 10509, and Lao-lai-ch'ing which are the late varieties for the late crop of the double-seasoned areas of the Yangtze Valley.

Table 12-26 Effect of Planting Time and the Age of the Seedlings on the Yield for the Late Varieties of the Double-seasoned Rice Culture

(1 移植期 (月/日)	2 秧龄 (日)	3 每亩平均产量(斤)	4 比35天秧龄增减(%)	5 本期每亩平均产量 (斤)	6 比8/10移植增减 (%)
	55	726.00	3.40		
7/10	45	781.80	11.36	736.62	6.57
	35	702.06	—		
	55	743.76	3.30		
7/20	45	737.40	2.41	733.70	6.14
	35	720.00	—		
	55	822.48	20.00		
7/30	45	759.00	10.77	755.56	9.31
	35	685.20	—		
	55	732.60	1.92		
8/10	45	622.20	13.40	691.20	—
	35	718.80	—		

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1. Transplanting time (month/day) 2. Age of seedlings (day) 3. Average yield per mou (chin) 4. Increased yield, compared with seedlings 35 days old (%) 5. Average yield for this period (chin) 6. Reduced yield, compared with seedlings transplanted on 10th of August (%)

However, if medium ripening varieties are used for the late crop of the continuous rice culture, for example such varieties as Huang-k'u-tsao, Kwei-hua-ch'iu, and Ch'uan-ta-keng, then, the planting may be delayed to the middle of June. With such early ripening varieties as Yuan-tzu No.2 and Wei-kuo, the planting may even be delayed to the later part of June or the beginning of July, while the transplanting time may still be determined by the harvest of the early crop. Thus, the age of the seedlings of the different varieties at the time of transplantation is very different indeed. For the varieties which have a short growing season, the seedlings should be young. During recent years, many early and medium varieties have been selected in this country as suitable for the late crop of a continuous rice culture. According to the studies of Szechwan College of Agriculture, the medium keng varieties of the Yangtze Valley and the North can all be used for the late crop of these regions. Early planting to obtain strong seedlings is the key to high yield.

Such varieties as Hsiang-wei-kuo, Huang-k'u-tsao, and Ch'uan-ta-keng may be planted 10 days to a month later than the late ripening varieties, while transplantation may still be adjusted to suit the harvest of the early crop. They become ripe just on time, and the yield is higher than such late ripening varieties as 10509. The Studies of the agricultural institutes of Kiangsu, Anhwei, Che-kiang, Hupei, Hunan, Szechwan, Kweichow, and Shensi brought similar results.

In conclusion, transplanting time and the age of the seedlings should not be determined permanently. For anywhere, with any variety, the principle is that the seedlings should be transplanted early. Old seedlings are not suitable for the early and medium ripening varieties, however, for the late ripening varieties, old seedlings are very suitable. This is an important principle of the transplanting technique.

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CHAPTER 14. APPLICATION OF FERTILIZERS [p 375]

[p 375]

Our farmers have accumulated rich experience in their long course of productive practice in the application of fertilizer for rice culture. Since the liberation, the masses of the entire country have been urged to store, to produce, and to plant fertilizer. There has been a constant increase in the amount and types of fertilizer. With regard to the technique of fertilizer application, the principle of primary application of organic fertilizer, supplemented with inorganic fertilizer was created. "Fertilizer is to fatten the soil, and soil is to fatten the seedlings." The farmers experience of applying fertilizer in accordance with the temperature or weather, the soil, and the seedlings has been summarized. A method of coordinating the initial fertilizer and additional fertilizer, the organic and the inorganic fertilizer, the quickly effective and the slowly effective fertilizer has been established. In this chapter, we shall discuss the technique of applying fertilizer to the rice paddies in accordance with the soil condition and the nutritional requirements of the rice plants in their development process.

SECTION 1. RELATIONSHIP BETWEEN YIELD AND THE AMOUNT OF FERTILIZATION [p 375]

In order to obtain high yields paddy rice requires a great deal of fertilizer. Experiments and practice proved that within a certain limit, the more fertilizer we apply the higher is the yield. However, if the fertilizer is applied improperly, the rice plants may grow abnormally as a result, and the yield may be reduced. Therefore, there is a definite relationship between fertilizer application and the yield; and the application of fertilizer must be considered in

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accordance with the variety, the soil, the density, and other environmental and cultivating conditions.

1. THE NEED OF PADDY RICE FOR FERTILIZERS [p 375]

Paddy rice plants must absorb nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, silicon, and other elements from the soil for their normal growth and development. The amount of these elements required varies with the varieties and the cultivating method. According to the study of Nan-k'ai University in the areas of Tientsin, the medium keng variety, Yin-fang yields 1,042 chin of rice per mou, with 1,058 chin of straw. The harvested substances contain a total of 24.7 chin of nitrogen, 11.5 chin of phosphorus, 21.2 chin of potassium. The medium keng, Shui-yuan, was tested and found to be similar to Yin-fang in nitrogen and phosphorus, but the potassium content was very different. Aside from the difference in varieties, this difference is also due to soil fertility and the amount of potassium fertilizer applied. (Table 14-1)

Table 14-1 The Nitrogen, Phosphorus, and Potassium Content of the Harvested Substance of Medium Keng Varieties (chin/mou) (Nan-k'ai University, 1955)

项 (1) 目		银 (7) 坊			(11)水 原 三 百 粒		
		稻 8 谷	稻 9 草	合10 计	稻12 谷	稻13 草	合14 计
(2) 吸收量 (斤/亩)	氮 (3) 素	15.2	9.5	24.7	15.1	8.8	23.9
	磷 (4) 酸	9.2	2.3	11.5	10.6	2.3	12.9
	氧 化 (5) 鉀	2.6	18.6	21.2	7.0	25.7	32.7
产 量 (斤/亩) (6)		1,042	1,058		1,001	1,009	

1. Items 2. Absorbed amount (chin/mou) 3. Nitrogen
4. phophorus acid 5. Potassium oxide 6. Yield (chin/mou)
7. Yin-fang 8. Rough rice 9. Straw 10. Total
11. Shui-yuan 300 grain 12. Rough rice 13. Straw
14. Total

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Hua-tung Institute of Agricultural Sciences conducted a study with medium hsien variety Chung-nung No.4. The harvested rough grain and straw were 1,000 chin each, and together, the nitrogen content was 21.4 chin, phosphorus, 9.2 chin, and potassium, 26.4 chin. Chung-shan University studied two continuous crops of early and late varieties (both belonging to the hsien subspecies), and found that when the harvested rough grain and straw weighed 1,000 chin each, the nitrong, phosphorus, and potassium content of the late crop was similar to the result of the study conducted by Hua-tung Institute of Agricultural Sciences, while that of the harvested substances of the early crop was obviously lower. (Table 14-2)

Table 14-2 The Nigrogen, Phosphorus, and Potassium Content of the two Crops of Early and Late Varieties (Four Year Average)

项 (1) 目	早 (5) 稻			晚 (6) 稻		
	氮素 (%) 7	磷酸 (%) 8	氧化鉀 (%) 9	氮素 (%) 7	磷酸 (%) 8	氧化鉀 (%) 9
稻 (2) 谷	1.132	0.740	0.749	1.504	0.762	0.743
稻 (3) 草	0.491	0.345	2.258	0.823	0.341	1.892
合 (4) 計	1.623	1.085	3.007	2.327	1.103	2.635

1. Item 2. Rough Rice 3. Straw 4. Total
5. Early crop 6. Late crop 7. Nitrogen (%)
8. Phosphorus acid (%) 9. Potassium oxide (%)

These studies explained that the nitrogen, phosphorus, and potassium content of the various varieties of paddy rice varies a great deal. For a production of 1,000 chin each of rough rice and straw, the plants must absorb from the soil, 17 to 25 chin of nitrogen, 9 to 13 chin of phosphorus, and 21 to 33 chin of potassium. The keng varieties absorb more than the hsien varieties, hence more fertilizer is needed to cultivate the former. Among the hsien varieties, the late

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crop absorbs more than the early crop.

Secondly, the various organs of the rice plants absorb different amount of these elements. More nitrogen and phosphorus are absorbed by the rough grain, while more potassium is absorbed by the straw. The absorbed amount is more when the proportion between the grain and the straw is large. Therefore, we must use the technique of fertilizer application to control the growth of the stem and the leaves, so as not to waste nutrients.

Aside from the difference in varieties, according to the study conducted by Kiangsi Institute of Agricultural Sciences, the nitrogen, phosphorus, and potassium content of the stalk varies also with the type of fertilizer applied. The study of the content of the harvested substances may be used as a reference in determining the amount of fertilizer to be applied, and we are thus made to understand that reasonable application of fertilizer may improve the environmental conditions and thus encourage the rice plants to absorb more nutrients.

Table 14-3 The Nitrogen, Phosphorus, and Potassium Content of the Stalk and Different Fertilizer Application (Kiangsi Institute of Agricultural Sciences, 1957)

生育阶段 (1)	施氮量(斤/亩) (5)		施磷量(斤/亩) (7)			(9) 施鉀量(斤/亩)			
	8	12	4	8	12	4	8	12	16
	植株含氮量(%) (6)		植株含磷酸量(%) (8)			(10) 植株含氧化鉀量(%)			
(2) 分蘖始期	4.036	4.265	1.270	1.252	1.674	2.704	3.128	3.924	4.231
(3) 幼穗分化期	3.352	3.442	1.197	1.191	1.245	2.226	2.487	3.015	3.550
(4) 出穗始期	1.740	2.150	0.919	0.895	0.913	1.422	1.724	2.480	2.929

1. Growth stage 2. The beginning of the tillering stage 2. The evolvement of the head 3. the beginning of the heading stage 5. Amount of nitrogen applied (chin/mou) 6. The nitrogen content of the stalk (%) 7. Amount of phosphorus applied (chin/mou) 8. The phosphorus content of the stalk (%) 9. The amount of potassium applied (chin/mou) (10) The potassium oxide content of the stalk (%)

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Table 14-4 The Relationship between the Amount of Fertilizer Applied and the Yield (Hunan Institute of Agricultural Sciences 1959)

稻谷产量 (斤/亩) (1)	(3) 肥料种类及每亩用量	15 三要素含量总计 (斤/亩)		
		16 氮	磷 17 酸	氧化鉀 18
800 以上 (2)	1. 綠肥28—30担、猪牛粪草30担、石灰0.8—1担 (4)	26.65	12.6	23.8
	2. 綠肥35—40担、安莞灰28—32担、石灰1—1.2担 (5)	24.48	14.4	24.4
700—800	1. 綠肥25—30担、凼肥60担、安莞灰25—30担、石灰0.8—1担 (6)	22.3	28.8	39.9
	2. 綠肥30担、猪牛粪10—15担、石灰0.8—1.1担 (7)	20.95	8.1	13.2
	3. 綠肥40担、磷矿粉0.4—0.5担、安莞灰20—25担 (8)	21.3	24.3	21.6
600—700	1. 綠肥20—23担、猪粪11—13担、石灰0.8—1担 (9)	15.5	8.0	10.5
	2. 綠肥20—25担、土肥80担、安莞灰20—25担、石灰0.8担 (10)	22.0	29.0	31.3
	3. 綠肥25—28担、土肥40—60担、石灰1担 (11)	19.0	13.2	22.6
500—600	1. 綠肥25担、土肥35—40担、安莞灰20—25担、石灰1担 (12)	19.2	18.5	29.2
	2. 綠肥30担、过磷酸鈣0.5担、安莞灰20担、石灰0.8担 (13)	16.0	11.4	16.7
	3. 綠肥30担、石灰1担 (14)	14.4	3.6	8.7

1. The amount of rough grain harvested (chin/mou) 2. More than 800 3. The type of fertilizer and amount used per mou 4. Green fertilizer, 28-30 tan, pig and cow manure 30 tan, lime 0.8-1 tan 5. Green fertilizer, 35-40 tan, mixed ash 28-32 tan, lime 1-1.2 tan, lime, 1-1.2 tan 6. Green fertilizer, 25-30 tan, silts, 60 tan, mixed ash 25-30 tan, lime 0.8-1 tan, 7. Green fertilizer, 30 tan, pig and cow manure 10-15 tan, lime, 0.8-1.1 tan, 8. Green fertilizer, 40 tan, phosphorus mineral powder, 0.4-0.5 tan, mixed ash, 20-25 tan 9. Green fertilizer 20-23 tan, pig manure, 11-13 tan, lime 0.8-1 tan 10. Green fertilizer, 20-25 tan, fertile soil 80 tan, ash, 20-25 tan, lime 0.8 tan 11. Green fertilizer, 25-28 tan, fertile soil, 40-60 tan, lime 1 tan 12. Green fertilizer, 25 tan, fertile soil 35-40 tan, ash 20-25, tan, lime,

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1 tan 13. Green fertilizer, 30 tan, calcium perphosphate, 0.5 tan, ash, 20 tan, lime, 0.8 tan 14. Green fertilizer, 30 tan, lime, 1 tan 15. Total amount of fertilizer content (chin/mou) 16. Nitrogen 17. Phosphorus acid 18. Potassium oxide

According to the survey conducted by the Yung-sheng productive brigade of Fu-yang-hsien, Chekiang, in 1953, the amount of manure applied was 12 tan per mou for the early crop; the average yield was 250 chin per mou. In 1955, the fertilizer applied was 37 tan per mou; the average yield was 380 chin per mou. In 1958, the fertilizer application was 99 tan, and the average yield was 909 chin per mou.

Hunan Province conducted a survey in 1959 and discovered that all paddies which yielded more than 800 chin of rough grain per mou required about 25 chin of nitrogen; when the yield was between 700 and 800 chin, the amount applied was 21 chin; when the yield was 700 chin, the amount applied was 15.5 chin; when the yield was 500 to 600 chin, the amount applied was about 15 chin, if some soil fertilizer was mixed in the application, then, the total was 19.2 chin in the last instance. (Table 14-4)

2. RELATIONSHIP BETWEEN THE AMOUNT OF FERTILIZATION AND OTHER FACTORS [p 378]

At present (Table 14-5) in the middle and lower reaches of the Yangtze, under normal cultivating conditions of the single-seasoned paddy rice, if the soil is medium or best quality, and if the yield is about 1,000 chin per mou, the requirement in nitrogen is about 30 chin (applying primarily organic fertilizer mixed with other fertilizer and some chemical fertilizer). From this region northward, the temperature is lower, and the growth period of similar varieties is longer, therefore, more nitrofertilizer is needed. According to actual practice, on the basis of sufficient nitrofertilizer, there must also be a certain amount of phosphorus and potassium. For some fields, such elements as calcium, sulfur, magnesium, and silicon are also required.

Within a given region, to determine the amount of

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fertilizer to be applied, we must consider the local temperature and soil conditions; then, at the same time, we must also consider the special characteristics of the selected variety, the density to be planted, the depth of soil plowed, the condition of the irrigation system, and the nature of the fertilizer used.

(1) In relation to the Special Characteristics of the Selected Variety

If the length of the growing period is similar, generally speaking, the keng varieties require more fertilizer than the hsien varieties. Hunan Institute of Agricultural Sciences reported its observation in the areas of Ch'ang-sha. The varieties of the keng subspecies require an amount of fertilizer double the amount required by the hsien varieties. Chekiang Provincial Institute of Agricultural Science conducted a survey in Yu-hsin Commune of Chia-hsing-hsien and discovered that when 20 tan of manure per mou was applied, the yield of the bearded early keng was only 350 chin per mou, that of the early hsien, Pai-p'i was 450 to 520 chin per mou. When about 70 tan of manure was applied to one mou, the yield of Pai-p'i reduced to 460 chin, while that of the bearded early keng reached 726 chin per mou. Therefore, when the type of variety which can withstand a considerable amount of fertilizer is selected, the amount of fertilizer applied must be adjusted to suit that variety.

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Table 14-5 The Amount of Fertilizer Applied to the High Yield Paddies

地 点 (1)	品种类别 (6)	调查点数及面积 11	产量 16 (斤/亩)	肥料种类及用量 (20)	折合三要素 (斤/亩) 25			年份 29	备注 30
					氮 26	磷酸 27	氧化鉀 28		
吉林省延吉市 2	粳稻元子2号等 7	长白人民公社新丰管理区十块田，每块面积均在15亩以上 12	810.3 (10块平均) 17	土粪163.1担、硫酸銨10.7斤。 21	36.18	15.48	25.75	1959	延吉市长白公社资料。土粪中青草綠肥30%，牛猪粪20%，泥土50%，泥土中肥料成分不计在内。 31
江苏省南京市 3	单季晚粳老来青等 8	中国农业科学院江苏分院四块田共10亩 13	995.6 (4块平均) 18	河泥128担、牛粪20.7担、草皮堆肥31.7担、硫酸銨41斤、菜籽饼88.1斤、人粪尿8.1担。 22	30.01	22.99	30.71	1959	原始资料由江苏分院供给。 32
浙江省杭州市 4	连作晚稻，粳稻老来青、新太湖青等 9	浙江省农业科学研究所四块共6.642亩 14	1,112.17 (4块平均) 19	河泥57.8担、厩肥25.2担、人粪尿17.0担、硫酸銨20.5斤、过磷酸鈣16.5斤、菜籽饼65.4斤、焦泥灰62.8担、草木灰15.0斤、硫酸鉀3.3斤。 23	32.15	20.84	34.64	1959	原始资料由浙江省农业科学研究所供给。 33
湖南省沅江县 5	早稻早粳16号等 10	三眼塘人民公社205亩 15	810.11	綠肥25担、人畜粪尿25—30担、土杂肥（包括塘土、火土灰、草皮等）500担。 24	28.25	10.25	31.00	1959	湖南省农业厅粮食生产处资料。 34

1. Place 2. Yen-chi-shih, Kirin 3. Nanking, Kiangsu 4. Hangchou, Chekiang 5. Yuan-kiang-hsien, Hunan 6. Varieties 7. Keng variety, Yuan-tzu No.2 and others 8. Single-seasoned Late Keng, Lao-lai-ch'ing and others 9. Late crop of the continuous rice culture, keng varieties of Lao-lai-ch'ing, Hsin-t'ai-hu-ch'ing, and others 10. Early crop of early keng No.16, and others 11. Surveyed areas 12. 10 paddies, belonging to Hsin-feng Management District of Ch'ang-pai People's Commune. The area of each paddy is more than 10 mou. 13. 4 paddies of the Kiangsu Branch of China Academy of Agricultural Sciences. The total area is 10 mou. 14. 4 paddies belonging to Chekiang Provincial Institute of Agricultural Sciences. The total area is 6.642 mou. 15. 205 mou of paddies belonging to San-yen-t'ang People's Commune 16. Yield (chin/mou) 17. 810.3 (an average of the 10 paddies) 18. 995.6 (an average of the 4 paddies) 19. 1,112.17 (an average of the 4 paddies) 20. Amount and type of fertilizer used 21. Compost, 163.1 tan, ammonium sulfate, 10.7 chin 22. River silts, 128 tan, cow manure, 20.7 tan, decomposed grass, 31.7 tan, ammonium

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sulfate, 41 chin, residue of oil cabbage seeds, 88.1 chin night soil, 8.1 tan 23. River silts, 57.8 tan, manure, 25.2 tan, night soil, 17.0 tan, ammonium sulfate, 20.5 chin, calcium perphosphate, 16.5 chin, residue of oil cabbage seeds, 65.4 chin, burnt wood mixed with mud 62.8 tan, burnt grass and wood ash, 15.0 chin, potassium sulfate, 3.3 chin 24. Green fertilizer, 25 tan, night soil and manure, 25-30 tan, compost (including mud, burnt mud ash and grass), 500 tan 25. Content of the three elements (chin/mou) 26. Nitrogen 27. Phosphorus acid 28. Potassium oxide 29. Year 30. Note 31. Information from the mayor of Yen-chi, Ch'ang-pai Commune. The compost contains green grass fertilizer 30%, cow and pig manure, 20%, soil, 50%. The fertilizer content of the soil portion is not included for tabulation of the content of the tree elements. 32. Original information obtained from Kiangsu Branch 33. Original information obtained from Chekiang Provincial Institute of Agricultural Sciences 34. Grain Production Information of Hunan Provincial Department of Agriculture

(2) In relation to field density

According to the study conducted by Liaoning Branch of China Academy of Agricultural Sciences, as the field density becomes higher, the roots of the rice plants are finer, but within a unit area of soil, the number of roots increased. (Table 14-6) These the total area of nutritional absorption is increased in case of dense planting. However, with regard to the individual plant the average weight of the root system drops as the density is increased, therefore, the amount of fertilizer applied should be increased also, in order to obtain increased total yield which is the goal of dense planting. According to Chekiang Provincial Institute of Agricultural Sciences, fertilizer application, being equal the yield of the paddy, with 20 000 seedlings per mou is obviously higher than that of the paddy with 20,000 or 10,000 seedlings per mou. If additional fertilizer is applied with the increased density, the increase in yield is even more obvious. (Table 14-7)

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Table 14-6 The Weight of the Root System under Various Conditions of Density (Liaoning Branch, China Academy of Agricultural Sciences 1959)

行科距 (1)(寸)	不同深度（厘米）1,000立方厘米土壤中根重（克）(2)				每层次（厘米）100株稻根重（克）4				备(6)注
	0—10	10—20	20—30	合3计	0—10	10—20	20—30	合5计	
6×3	7.72	0.95	0.40	9.07	9.19	1.13	0.48	10.80	每科9—10苗(7)
6×2	8.85	1.40	0.55	10.80	10.53	1.67	0.65	12.85	品种宁丰(8)
5×2	9.30	1.30	0.70	11.30	10.33	1.44	0.78	12.55	
5×1.5	9.65	0.90	0.65	11.20	8.85	0.83	0.60	10.28	
5×1	10.15	1.20	0.40	11.75	6.15	0.73	0.24	7.12	

1. Space between groups (ts'un) 2. The weight of the roots at various depth of soil (cm) of 1,000 cm^2 of soil (g) 3. Total 4. The weight of the roots (g) in each layer (cm) 5. Total 6. Note 7. 9-10 seedlings per group 8. Ning-feng Variety

Table 14-7 Density, Fertilizer Application, and the Yield (Chekiang Provincial Institute of Agricultural Sciences, 1958)

施肥水平 (1)	行科距(寸) (5)	每亩苗数(万) (6)	每亩穗数(万) (7)	产量(斤/亩) (8)	产量(%) (9)	以5×6的产量为100 (10)
重 2 肥	5×3	20	38.0	755.0	124.7	111.8
	5×6	10	33.2	675.0	111.5	100.0
中 3 肥	5×3	20	35.2	668.7	110.5	104.4
	5×6	10	30.0	640.0	105.7	100.0
轻 4 肥	5×3	20	30.8	622.5	102.8	102.8
	5×6	10	28.4	605.0	100.0	100.0

注：1. 重肥：每亩厩肥4,000斤、河泥100担、硫酸铵10斤。
(11) 2. 中肥：每亩厩肥3,000斤、河泥与硫酸铵用量与重肥相同。
3. 轻肥：每亩厩肥2,000斤、河泥与硫酸铵用量与重肥相同。
4. 品种：有芒早粳，每科插5苗。

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1. The level of fertilizer application 2. Heavy application 3. Medium application 4. Light application 5. Space between groups (ts'un) 6. Number of seedlings per mou (10,000) 7. Number of heads per mou (10,000) 8. Yield (chin/mou) 9. Yield (%) 10. If the yield of 5x6 area is 100 11. Note a. Heavy application: Manure 4,000 chin, River silts 100 tan, ammonium sulfate 10 chin per mou. b. Medium application: manure 3,000 chin, river silts and ammonium sulfate same amount as a. c. Light application: manure 2,000 chin, river silt and ammonium sulfate same amount as a. d. Bearded early keng is used for the survey. Each group consists of five seedlings.

(3) In relation to soil fertility

Many years of different cultivating systems, different fertilizer applications, and certain natural factors cause the soil fertility to be verv different from paddy to paddy. Thus, different amount and different types of fertilizer are needed for each type of paddy. For example, The Southwest Institute of Agricultural Sciences discovered from its studies that under the condition of no fertilizer application, the relatively fertile alluvial soil yielded 450.2 chin per mou; the purple soil yielded only 357.5 chin. The experiment in Kwei-yang conducted by the Comprehensive Agricultural Experimental Station of Kweichow proved that if no fertilizer is applied, the relatively fertile soil produced 474.8 chin while the underdeveloped soil produced only 241.6 chin. If we try to obtain high yield from a paddy of low fertility, more fertilizer must be applied to develop soil fertility first. However, there are many factores which may affect soil fertility the soil's water and fertilizer holding power, its permeability, its organic content, its cultivating system, and its rotation system, and so forth. Therefore, it is important to examine the soil first before deciding upon the method of fertilizer application. The soil survey of 1959 brought to us considerable experience regarding fertilizer application in connection with the nature of the soil. For sandy soil, pai-t'u, and Huang-ni-t'u, since their fertility is low, the fertilizer requirement is much higher than with such fertile soils as Shan-hsueh-t'u and Wu-shan-t'u, and there should be a higher proportion of such fertilizer as night soil and manure. Sandy soil is loose and very permeable. After an application of organic fertilizer, it may be easily mineralized; however, the soil is not

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fertile, and its fertilizer holding power is very low, therefore it is necessary to add river silts to help preserve the fertilizer. Huang-ni-t'u is sticky and is very poor in organic matter, therefore, it is important to add pig manure which is rich with organic matter. According to the study of the three production brigades of Chou-chuang Commune of Chiang-yin-hsien, Kiangsu, the paddy with an early crop of green fertilizer requires only half of the amount of fertilizer as the paddy which has wheat as the previous crop.

Table 14-8 The Amount and The Type of Fertilizer for the Different Types of Soil (tan/mou)

土 (1) 质	河 (7) 泥	猪 (8) 厩 肥	人 (9) 粪 尿
鱔 血 土 2	109	3.5	0
烏 山 土 3	84	10.9	3.9
黃 泥 土 4	109	28.2	9.2
白 土 5	112	19.4	14.2
砂 土 6	114	16.1	13.0

1. Soil 2. Shan-hsueh=t'u 3. Wu-shan-t'u
4. Huang-ni-t'u 5. Pai-t'u 6. Sandy soil
7. River silts 8. Pig manure 9. night soil

(4) In relation to deep plowing

When the plowing is shallow, the roots of the rice plants cannot develop deeply into the soil, and its nutrient absorbing capacity is therefore weakened. The plant easily falls. However, deep plowing is not very effective unless accompanied with fertilizer application. Hsing-fu-chih-lu Production Brigade of Hsiao-chan People's Commune, Tientsin, experimented with deep plowing without fertilizer application; there was only a very limited increase in yield, while in the experiment with fertilizer application, the increase was very obvious. (Table 14-9) These facts proved that deep plowing helps soil maturity if fertilizer is applied.

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Table 14-9 The Effect of Plowing Depth and Fertilizer Application on Yield

翻耕深度 (1)	施 肥 量 (斤/亩) (5)	每科穗数 (9)	每穗粒数 (10)	产量 (斤/亩) (11)	产量 (%) (12)
(2)深翻 1 尺	粗肥 4,000斤、鲜馬粪2,000斤 (6)	11.1	101.9	945	155.7
(3)深翻 1 尺	粗肥 4,000 斤 (7)	9.1	76.2	666	109.7
(4)浅耕 5 寸	粗肥 4,000 斤 (8)	8.1	74.3	607	100.0

1. Plowing depth 2. 1 ch'ih deep 3. 1 ch'ih deep 4. 5 ts'un deep (shallow plowing) 5. Amount of fertilizer applied (chin/mou) 6. Rough fertilizer, 4,000 chin, fresh horse manure, 2,000 chin 7. Rough fertilizer, 4,000 chin 8. Rough fertilizer, 4,000 chin 9. Number of heads per group 10. Number of grains per head 11. Yield (chin/mou) 12. Yield (%)

(5) In relation to the nature of the fertilizer

When the soil and the cultivating condition is the same, the effect of the fertilizer application often varies with the type of fertilizer and the different methods of mixing it. Generally speaking, the utilization rate of the organic fertilizer with high proportion of carbon and nitrogen and the soil compost is low. According to the study of the Kiangsu Branch of China Academy of Agricultural Sciences when the amount of nitrogen applied is 8 chin per mou, the nitrogen content of the river silt may be absorbed by medium hsien varieties to a maximum of 5.9%, that of residue oil cabbage seeds may reach 21.5%, that of green fertilizer may be 17%, and that of pond silts may be 14.9%. Therefore, if soil compost is the major fertilizer applied, the amount used must be increased considerably in order to be sufficient for the rice plants.

For most rice paddies, a mixture of fertilizer is generally used, for the purpose of more balanced nutrients and maximum utilization. After many experiments with several types of common fertilizer, the Kiangsu Branch of China Academy of Agricultural Sciences pointed out that when each of

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these is applied by itself, the effect is not so great. If this common fertilizer is applied with such chemical fertilizer as ammonium sulfate, the utilization rate is much higher. (Table 14-10) In the Yangtze Valley, the common fertilizer such as legumes and grass are very fast decomposing, but not long lasting. They often cause the soil to lose the needed fertility during the later part of the plant's growth. This defect is particularly apparent when any of the chemical fertilizers is used by itself. On the contrary, if river silts or pond silts are used, the fertility is long lasting, but during the initial period of growth, the nutrients are often not sufficient. Therefore, a mixture of these different kinds of fertilizer is most effective as well as long lasting.

Table 14-10 Effect of a Single Application of Common Fertilizer and Its use with Chemical Fertilizer on the Rate of Fertilizer Utilization (Kiangsu Branch of China Academy of Agricultural Science 1959)

处理 (1)	对照 (7)		草塘泥 8		猪牛粪 9		绿肥 10		堆肥 11	
	不追 12	追 13	不追 12	追 13	不追 12	追 13	不追 12	追 13	不追 12	追 13
施肥氮量（斤/亩）(2)		9	19.4	28.4	18.5	27.5	14.75	23.75	17.1	26.1
植株吸收氮量（斤/亩）(3)	4.31	10.22	8.2	14.54	5.65	10.95	8.75	16.75	5.39	13.1
农家肥料利用率（%）(4)			20.1		7.25		30.10		6.3	
农家肥料及速效肥利用率（%）(5)		66		36		24.1		52.4		33.7
化肥利用率（%）(6)		66		70		60		90		86
追比不追氮素吸收量增加% (14)	137		77.3		94		91.5		143	

注：追肥均为硫酸铵。(15)

1. Treatment 2. Nitrogen content of the fertilizer (chin/mou)
3. Amount of nitrogen absorbed by the stalk (chin/mou)
4. Utilization rate of common fertilizer (%)
5. Utilization rate of common fertilizer and quickly effective fertilizer (%)
6. Utilization rate of chemical fertilizer (%)
7. Control group 8. Pond silts 9. Pig and cow manure

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10. Green fertilizer 11. Compost 12. No additional application 13. With additional application 14. Increased nitrogen absorption with additional application of fertilizer (%) 15. Note: Ammonium sulfate is used for all additional applications

(6) In relation to the irrigation condition

Generally the irrigation water often contains nutrients, especially if city drainage water is used. Besides, if the water is drained from the paddy during the growth period of the rice plants, and the soil sunned, the fertilizer of the soil may decompose better, and as a result, less fertilizer is needed for the additional application. However, if the paddy is drained soon after a fertilizer application, many of the nutrients may be lost. In a word, the amount and the types of fertilizer should be determined locally in accordance with the soil, the production index, and the type of varieties selected. Fertilizer application should also be arranged in combination of deep plowing, dense planting, and irrigation and drainage, to form a reasonable cultivating system.

3. COMBINATION OF NITROGEN, PHOSPHORUS AND POTASSIUM [p 383]

The various nutrients supply different needs of the plant. They do not supplement one another; none of them may be left out; and none should be excessively accumulated in the plant. Otherwise the normal development of the plant may be affected. Therefore, we must be careful in coordinating the three elements of nitrogen, phosphorus, and potassium. According to the text result of the Northeast Institute of Agricultural Sciences, after gathering information on the soils of 73 places in the Northeast, if the yield of the area with a coordinated fertilizer application of the three elements is considered as 100, then, the area with no nitrogen application is 58, that of no phosphorus is 88, that of no potassium is 93, and that of no fertilizer at all is 54. This fact not only explains that nitrogen application is more effective than the applications of phosphorus and potassium, but also that a coordinated application of the

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three elements is the most effective.

In 1958, there was a test of the effect of the fertilizer of the three elements in Ning-po, Chien-te, Chin-hua, and Wan-chou of Chekiang. It was discovered that on the basis of common farm fertilizer application, if nitrogen is applied 6 chin per mou, the yield is increased 13.8 to 17% per mou; if 6 chin of phosphorus is applied per mou, the yield is increased 1 to 4%; if potassium is applied 6 chin per mou, the yield is sometimes not increased at all, and at other times, increased 3%; if each of the three elements is applied 6 chin per mou, together the yield is increased 19 to 21%.

It is certainly true that some soils contain more phosphorus or potassium, while the applications of organic fertilizer year after year must have added some phosphorus and potassium to the soil. This is why phosphorus and potassium fertilizers are not as obviously effective as nitrogen fertilizer. However, as agricultural development is accelerated, the production demand is on the rise also; therefore, we must not depend upon nitrogen fertilizer alone to satisfy the needs of the rice plants. According to the aforementioned chemical analysis of the harvested substance of rice plants, the proportion for nitrogen, phosphorus, and potassium should generally be 2 : 1 : 2.5. In actual application, we must consider the supply of phosphorus and potassium of the local soil, and the possible absorbing capacity of the local varieties of rice plants. We must not, however, consider the three elements as capable of mutual control. Additional application of phosphorus and potassium cannot overcome the defects of excessive nitrogen. This point should be especially emphasized.

4. METHOD TO DETERMINE THE AMOUNT OF FERTILIZATION [p 384]

First of all, the fertilizer used in the various rice growing areas is primarily local fertilizer. The soil and temperature conditions are also different. Therefore, after we summarized the experience of one region, and obtained the most suitable amount of fertilizer for that region, the figure can by no means be applied to the other regions. While

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the technique of rice culture is improving every year, we must continuously summarize the experience of the high yield paddies of each locality every year, and use the figure to guide fertilizer application the next year.

Secondly, we may also use the result of experiments and tests to plan fertilizer application. We must depend upon the nutrient content of the grain and the straw, the amount of nutrients supplied by the soil, and the content and the utilization rate of the various types of fertilizer for determining the amount of fertilizer needed. Chemical analysis of the grain and the straw may provide their nitrogen, phosphorus, and potassium content, and we may thus calculate the amount of nutrients needed to produce the given amount of grain and straw, to form the theoretical figure of fertilizer application. A portion of these nutrients are supplied by the soil; this figure may be obtained from the harvested substances of the soil to which no fertilizer is added. If we deduct this amount from the theorectical figure of fertilizer application, we may obtain the amount of nutrients to be supplemented by fertilizer application. Then, we may calculate the actual amount of fertilizer to be applied based upon the content of the three elements of the various types of fertilizer, and their utilization rate.

Since the nutrient content of the harvested substances varies with the different varieties, the effective fertility of the various types of soils is different. The nutrient content and the utilization rate of the various fertilizer are different also, and they are affected to a large extent by temperature and cultivation conditions. Therefore, the usefulness of the results of experiments is rather limited. At present, in actual production, we must adopt and summarize the experience of the masses, and keep a record of each of the paddies for future analysis in order to combine experience with the results of the experiments to arrive at a reasonable system of fertilizer application.

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SECTION 2. METHOD OF FERTILIZING PADDY RICE AND ITS BASIS [p 385]

In the rice paddy, the rice plant goes through the stages of turning green again, tillering, growing nodes, the evolvement of the head, the development of the head, the appearance of the head, blooming, seeding, and ripening. These stages may be divided into the two large periods of nourishing and reproducing, with the evolvement of the head as the turning point. During the nourishing period, the growth is primarily in the nourishing organs, and some nutrients are being accumulated by the plant for the later period. During this initial period, fertilizer application aims to strengthen the plant in order to guarantee a sufficient number of heads in a unit area. During the reproducing period, the reproductive organs are being formed, grow bigger, bloom, and seed. Fertilizer application during this period aims to guarantee large heads, numerous grains, and full grains. These two periods are mutually related. Only on the basis of good nutritional development may there be good reproductive growth. Therefore, the technique of fertilizer application should culminate in bringing about healthy growth during both of the periods. For the purpose of high yield, we must master the rules of fertilizer absorption during the various stages of growth of the plant life, and combine these rules with cultivating conditions, to apply a suitable amount of initial fertilizer and additional amounts of secondary applications, so that the various applications may function coordinately.

1. ABSORPTION OF THE THREE MAJOR FERTILIZERS DURING THE VARIOUS GROWTH STAGES OF PADDY RICE [p 385]

The various nutrients are absorbed by the plant at different rates during the different stages. According to the experiments of the Experimental Station of Chung-shan University, the early and the late varieties absorb a certain definite amount of nitrogen, phosphorus, and potassium from the time the seedlings turn green to the time the tillers have all appeared. The amount of absorption is the highest from

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the time the heads evolve to the beginning of heading. After this stage, the absorption becomes weaker again. During the first stage, the early varieties absorb a greater percentage of nutrients than the late varieties, while during the later stage of growth, i.e. from the time of seeding to the time of ripening, the late varieties absorb a greater percentage than the early varieties. (Table 14-11)

Table 14-11 The Rate of Nitrogen, phosphorus, and Potassium Absorption during the Various Stages of Growth of the Early and the Late Crops of a Continuous Rice Culture

项 (1) 目		移栽——分蘖期 (7)	稻穗分化——出穗期 (8)	结实成熟期 (9)	合 (10) 计
早稻 (2)	氮 (4) 素	35.5	48.6	15.9	100
	磷 (5) 酸	18.7	57.0	24.3	100
	氧化 6 钾	21.9	61.9	16.2	100
晚稻 (3)	氮 (4) 素	22.3	58.7	19.0	100
	磷 (5) 酸	15.9	47.4	36.7	100
	氧化 6 钾	20.5	51.8	27.7	100

1. Item 2. Early Crop 3. Late Crop 4. Nitrogen 5. Phsphorus acid 6. Potassium oxide 7. Transplantation--tillering 8. Evolvement of the head---heading 9. Seeding---ripening 10. Total

Hua-tung Institute of Agricultural Sciences conducted a study with the medium ripening variety Chung-hung No.4. An analysis of the nitrogen, phosphorus, and potassium content of the plants during the various stages of growth proved that the absorption of the three elements reaches about 50% at the time the tillering stops, while the average daily absorption is the highest at the time of tillering and also at the time the heads grow bigger.

Judging from the result of the above study, the early crop absorbs more nutrients during the early stage of growth; therefore, initial fertilizer should be emphasized. For the late crop, since the absorption is higher during the later stage of growth, secondary application of fertilizer

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should be emphasized. As for the medium ripening varieties, during the stage from transplantation to tillering, the absorption was found to be almost 50%; therefore, initial application of fertilizer should be emphasized also. However, since during some stages of growth, the daily average absorption is high, about 1/3 of the total amount of absorption in a short period of little more than 10 days, therefore, an application of quickly effective fertilizer is important for the heads to meet the high nutrient requirement of this stage.

Table 14-12 The Rate of Nitrogen, Phosphorus, and Potassium Absorption of the Medium Ripening Varieties During the Various Stages of Growth (%)

吸收量 (1)		移栽至分蘖盛期前（移栽后20天）6	分蘖盛期到分蘖停止后（20—43天）(7)	停止分蘖后到开始孕穗（43—54天）(8)	开始孕穗到齐穗后（54—70天）(9)	齐穗到收获（70—91天）(10)	吸收总量（斤/亩）(11)
(2) 氮素	每日 斤/亩 (5)	0.075	0.286	0.438	0.019	—	13.78
	本期占吸收总量的%	10.9	47.6	39.0	2.2	0.3	100
(3) 磷酸	每日 斤/亩 (5)	0.022	0.106	0.175	0.073	—	5.64
	本期占吸收总量的%	7.5	43.3	34.0	20.6	-5.4*	100
(4) 氧化钾	每日 斤/亩 (5)	0.058	0.433	0.744	—	—	22.26
	本期占吸收总量的%	5.2	43.9	36.7	14.2**		100

(12)* 表中-5.4%可能由于分析误差或由于成熟后茎叶萎缩的关系。

** 表中14.2%系推算数字，非实际分析结果，因齐穗后一次的氧化钾的分析结果太高，未予引用。

1. Amount of Absorption 2. Nitrogen 3. Phosphorus acid 4. Potassium oxide 5. Daily chin/mou; Percentage of the absorption during this stage compared with the absorption total during the entire life of the plant
6. from transplantation to the height of tillering (20 days after transplantation) 7. From the height of tillering to the time tillering stops (20-43 days) 8. From the time the tillering stops to the beginning of evolvement of the heads (43-54 days) 9. From the beginning of head evolvement to

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the completion of heading (54-70 days) 10. From the completion of heading to harvest (70-91 days) 11. Total absorption chin/mou 12. Note * the figure (-5.4%) in the table may be an error of analysis, or it may due to the fact that after ripening, the stem and the leaves wither.
** The figure (14/2%) is an estimate, not an actual result of analysis, because, the analysis made after the heading has completed gave a very high figure, which was not accepted as accurate.

2. MAJOR BASIS FOR APPLICATION OF FERTILIZERS AT EACH STAGE [p 386]

The difference in nutrient absorption results in the difference in nutrient requirement during the various stages of the plant's growth, and any change in the environmental conditions of the plant necessarily affects the nutrient absorption and metabolism of the plant. Therefore the amount of fertilizer should be determined not only in accordance with the different needs of the different stages; we must also taken into consideration the temperature, soil, the type of fertilizer, and other conditions. This is what the farmers mean when they say that fertilizer should be applied after looking at the sky, the soil, the fertilizer, and the seedlings.

(1) Looking at the seedlings

Applying fertilizer in accordance with the appearance of the seedlings is called looking at the seedlings before applying fertilizer. Our farmers have rich experience in that respect. For example, Ch'uan-nung-shu stated in the 16th century that we should look at the color of the seedlings before applying additional fertilizer. If the color is not yellow, additional fertilizer should not be applied at all. Ch'en Yung-k'ang (7115 3057 1660), the national model farmer is an expert in discovering the "three black and three yellow" during the growth process of the late keng of the single-seasoned varieties for applying fertilizer and obtaining high yield. Based upon his experience, the Kiangsu Branch of China Academy of Agricultural Sciences conducted a study in 1959. The result of this study proved that when the later

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keng, Lao-lai-ch'ing is planted in Nanking, from transplantation to heading, three growth stages may be clearly detected either from the viewpoint of growth and development or from the viewpoint of physiological characteristics.

The first stage is from transplantation (six leaves) to the appearance of the blue stem (12 leaves). During this stage, the leaves contain the highest amount of nitrogen in the life of the entire plant. This is a stage of nitrogen metabolism for the growth of the stem and the leaves, and is also the stage when the number of heads and their length and width are determined. Therefore, an application of fertilizer when the first "black" appears is very important.

At the end of the tillering stage, the nodes begin to appear on the stem. The leaves turn into a lighter color. This is the first appearance of the "yellow," and marks the beginning of the stage of carbon nitrogen metabolism. If the "yellow" does not appear, the protein nitrogen and non-protein nitrogen content of the leaves is apparently high. On the one side, due to the participation of carbohydrates in the protein synthesis, and on the other, due to the increased transpiration, the consumption of carbohydrates rises rapidly, hence; the reduction of the content of soluble sugars. (Table 14-13)

Meanwhile, if fertilizer is applied while there is no appearance of "yellow", then, the photosynthesis products may be all used up for the growth of the leaves, and the carbohydrate content of the tip of the leaves may thus drop to bring bad effects to the development of the nodes on the stems.

Table 14-13 Effect of Fertilizer Application during the Tillering Stage on the Sugar Content of the Entire Stalk

处 (1) 理	(4)功能叶片含糖量（7月10日）	(5)全株含糖量（7月16日）
对 (2) 照	0.92	0.56
不 现(3— 黄	0.79	0.43

1. Treatment 2. Control Group 3. No appearance of "yellow"
4. Sugar content of the functional leaves (10th of July)
5. Sugar content of the entire stalk (16th of July)

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The second stage is after the tillering peak is passed to the beginning of the evolvement of the head. The leaves are obviously thicker, and the leaf cells store a large amount of soluble sugar and starch. (Diagram 14-1) The proportion between protein nitrogen and non-protein nitrogen in the leaves rises from about 9.7 to 13, then to 14. (23 to 31 July) The rise of the soluble nitrogen content of the leaves brings about the second appearance of "black" and this appearance is beneficial for the development of the young head. After the beginning of the evolvement of the head, the soluble nitrogen is largely transferred to the young head, and as a result, the soluble nitrogen content of the leaves drops once more (Diagram 14-2), and the color of the leaves turns from "black" to "yellow" once again. At this time, the carbon metabolism has taken over the advantageous position. Ch'en Yung-k'ang (7115 3057 1660) applies organic fertilizer at the time the nodes begin to appear to encourage the leaves to turn "black". At the begin of the head evolvement stage, he suns the paddy to bring about the "yellow." Those stalks the leaves of which do not apear "yellow" the second time, often have a rise in the protein synthesis of the leaves, and thus cause a drop of the carbohydrates in the stem. The length of the leaf (the 16th leaf) is 8.2% longer while the second node above the ground is 27.9% longer, compared with the control group. This change may easily cause the stalk to fall.

The third stage is from the time the heads begin to evolve to their complete appearance. During this stage, the leaves grow slower, and the stem and the head become the center of development. The leaves contain less and less nitrogen, while the nitrogen content of the stem and the head increases. Moreover, the nitrogen content of the stem drops also as the head begins to grow bigger. During this stage, the plants need sufficient supply of nitrogen as well as carbohydrates to be transferred to the heads. Ch'en Yung-k'ang (7115 3057 1660) believes that the third "black" and "yellow" is the key to the prevention of fallen heads. If fertilizer application is excessive at this time, the third "yellow" does not appear, the non-protein nitrogen content of the stem may rise, while the protein nitrogen of the leaves is controlled by hydrolysis process; therefore, the top leaf grows large, while the stem becomes soft, and the plant falls easily. It is also easily attacked by the

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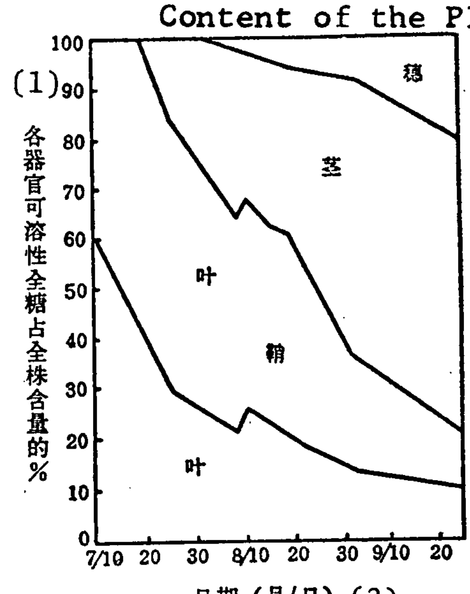
blight disease, and the starch accumulation of the stem will be delayed also. The grain will be filled up much slower, and consequently, there will be more empty heads. (Diagran 14-3)

Therefore, the "three black and three yellow" is a method of applying additional fertilizer, added with water, to help adjust the nitrogen and carbon metabolism of each of the growth stages, and is also the method of bringing the rice plants from strong seedlings to strong stalks, to large heads, and to full grains.

The early and medium varieties have shorter growth seasons, and the three changes of black and yellow cannot be obviously detected. However, when the heads begin to evolve, the leaves of both types can be seen as slightly lighter. If too much fertilizer has been applied previously, then the nitrogen metabolism is excessively high and carbon metabolism is thus weakened, (Commonly called "lazy blue" or "turning blue.") In this manner the source of the large amount of carbohydrates needed for the development of the heads and the grains is being limited, and yield will suffer. Therefore, in production practice, this condition is carefully watched. If fertilizer application is not sufficient, then, the leaves will become yellow too early, and the yield will suffer also. Therefore, fertilizer must be supplemented on time to bring about healthy development of the young heads, and the color of the seedlings is a good sign for determining the reasonable time for fertilizer application.

Diagram 14-1 The Variation in Soluble Sugar Content of the Plant Organs



1. The Soluble Sugar Content of each of the organs compared with that of the entire stalk (%) 2. Date (month/day)

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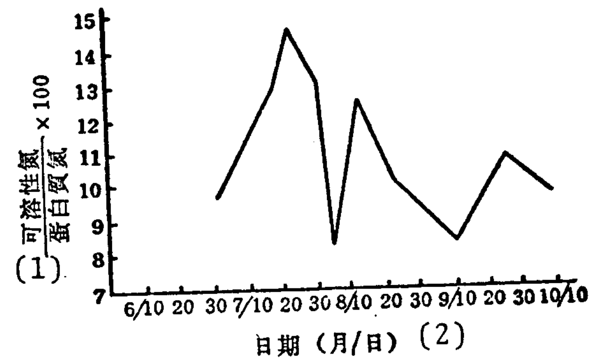
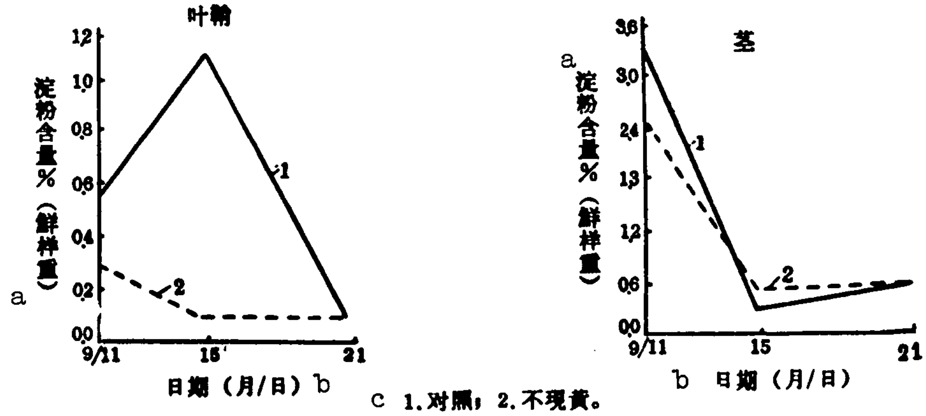
Diagram 14-2 The Variation of Soluble nitrogen and Protein nitrogen in the Leaves



1. Soluble nitrogen/protein nitrogen x 100
2. Date (month/day)

Diagram 14-3 The Variation of the Starch Content in the Third Leaf and the Stem



a. Starch content (%) (weight of fresh sample)
b. Date (month/day) c. 1. Control Group 2. The group with no appearance of "yellow"

(2) Looking at the Sky

Temperature often affects the decomposition of fertilizer as well as the absorbing ability of the plant. Generally speaking, in the flooded paddy, 30°C is the best

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temperature for the decomposition of organic fertilizer. When the soil loses moisture, or when the soil temperature is about $0^{\circ}C$, the microorganisms stop functioning, and organic fertilizer ceases to decompose. In the warm and humid south, organic fertilizer decomposes faster, and additional fertilizer application is, therefore, more important to prevent deficiency. For the early varieties, from transplantation to ripening, the temperature changes from low to high. Since the initial application takes longer to decompose in the low temperature, additional application should be done early. For the late varieties, from transplantation to ripening the temperature is from high to low, the initial fertilizer, therefore, decomposes very fast, and toward the later stage of the plant's growth, there may be a nutritional deficiency if additional fertilizer is not applied. Since the later varieties require more nutrients during the later stage of the plant's life, fertilizer application for the development of the heads should be especially emphasized. The farmers of Kwangtung like to say that the early rice looks for the beginning; the late rice makes late demands. In Hunan, the farmers also say the early rice is given through the mud, the late rice is sprayed three times. These are all results of many years of practice in looking at the sky for fertilizer application methods.

(3) Looking at the Soil

Fertilizer application should be varied in accordance with soil moisture, temperature, fertility, and ventilation. The loose soil is well ventilated. Fertilizer easily decomposes while the soil does not hold water and fertilizer well, therefore, there is a need for more applications of organic fertilizer. In order to stablize the effect of the fertilizer, it should be applied in many applications, while a small amount should be used each time. Clay soil is not ventilated very well, but it holds fertilizer well. Fertilizer may be applied less frequently but in larger volume so as to save labor. If soil fertility is not even on the same paddy, or in the different paddies of the same area, additional fertilizer may be applied in the weak spots only, so that the plants may grow more evenly. If the source of fertilizer is sufficient, it may be spread out; if there is not much available, it should be concentrated where it is needed most. If there is not enough fertilizer for secondary applications, then, it is more important to take care

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of the needs of the later stages of development, so that the heads will not be affected by the lack of fertilizer too much.

3. APPORTIONMENT AND APPLICATION OF BASE MANURE AND SIDE DRESSINGS [p 390]

Fertilizer application at the various stages of growth affects the plant differently. The technique of fertilizer application in rice culture is mainly to find the most economical as well as reasonable method of applying fertilizer.

(1) Initial Fertilizer

Initial fertilizer is the basic application before transplantation. It is to encourage the seedlings to grow early and to guarantee strong plants. On the other hand, according to the principle of "fertilizer fattens the soil; fat soil fattens the seedlings," sufficient fertilizer combined with deep plowing, an intensive leveling creates a deep, thick, loose, soft, and fertile soil condition for the growth of the plant above and below the ground. Therefore this should be relatively a larger application. The fertilizer used should be effective, stable, and long lasting, i.e. a large amount of organic fertilizer, such as manure, compost, green fertilizer, and silts. It is also important to adopt the method of using rough fertilizer for the initial application, while saving the fine fertilizer for supplements. A good coordination of the three elements of nitrogen, phosphorus, and potassium is also important. If phosphorus and potassium are allowed to be deficient, the rate of complete heads may drop. Phosphorus fertilizer is especially good for initial fertilizer, it may cause the tillering to be ahead of schedule, and is more beneficial than later applications.

The masses created many methods of applying initial fertilizer. Whenever the soil holds fertilizer well, they use more initial fertilizer, and they also use the slowly effective kinds. They apply the fertilizer in the entire plowing layer evenly to form a deep, soft, and fertile bed, so that the roots may continuously absorb nutrients. If the initial

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fertilizer is not in a large volume, then, they apply it in a shallow layer, where the root system is to be very dense. If the temperature is low, then a quickly effective fertilizer should be applied just before transplantation. For example, 10 chin of ammonium sulfate or 5 tan of night soil should be applied on the surface, so that the seedlings may receive nutrients in time. Sometimes, a small amount of inorganic phosphorus fertilizer may be used. For example, about 5 chin of bone powder or calcium perphosfate may be mixed into the mud, and the seedling is dipped in this mixture before planting, so as to encourage it to turn green faster. This is a very economical method and quite effective. It is especially good for the early varieties which have such a short growth season.

In the Yangtze Valley, acoording to the Technical Conference of the National Scientific Conference for High Yield Rice Culture, the early varieties take only one month after transplantation to enter the head evolvement stage of growth. There should be sufficient initial fertilizer and a secondary application should be given early also. In this case, more than 80% of the total fertilizer should be the initial application. For the late crop of the continuous rice culture, since the temperature is high, only 70 to 80% should be the initial application. In South China, the initial fertilizer is 70 to 80% for the early varieties, and 60 to 70% for the late varieties. In the north, and for the medium ripening varieties of the Yangtze Valley, from transplantation to ripening is only 130 days; the initial fertilizer is generally 70 to 80%. For the late varieties of the single-seasoned rice culture, the initial and the supplementary applications must both be emphasized. According to the experience of T'ai-hu Region of Kiangsu and Chekiang, while varying with the fertility of the soil, the initial fertilizer should be about 40 to 60%.

The above proportion should vary with the needs. For cold temperature, initial application is more important, so that the seedlings may grow faster. If the temperature is high, then, a large application of initial fertilizer will only cause fast decomposition and excessive initial growth.

Hua-tung Institute of Agricultural Sciences conducted an experiemnt in 1954 and 1955 with medium hsien Chung-nung No.4 for two continuous years. Their experiment proved

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that when the nitrogen applied is either 8 chin or 14 chin per mou, it is always better to divide a part of it to be used as a supplementary application than to use it entirely for the initial application (Table 14-14). This is even more important for the single-seasoned late varieties.

According to Huang-yen-hsien Institute of Agricultural Sciences of Chekiang Province, when the fertilizer amounts of 16.6 chin each of nitrogen, phosphorus, and potassium, the paddy with the 60% initial application yielded 13.1% more than the paddy with 80% initial application. However, when the total fertilizer used is doubled, then the paddy with the 80% initial fertilizer yielded 16.7% more than the paddy with 60% initial application.

According to the survey of Chen-chiang Special District Institute of Agricultural Sciences of Kiangsu Province, in the medium varieties region of Li-shui and Yang-chung, if the fertilizer application equals 30 tan of pig manure per mou, then the initial and the supplement should be divided 50, 50. If the total application is over 60 tan of pig manure, then, the initial application should be more than the supplement. If the initial fertilizer is adequate then the supplement may be applied later and in smaller quantitie and vice versaThe goal is to guarantee a balanced growth of the seedlings, and a high yield.

Table 14-14 The Effect of Multiple Applications of Fertilizer on the Yield of the Rice Plants

项 (1) 目			全部做基肥(1) (12)	部分做前期追肥(2) (13)	部分做后期追肥(3) (14)
1954年 (2)	每亩施8斤氮 (4)	产量(斤/亩)	568.7	570.3	623.0
		产量(%) (5)	100.0	100.3	109.5
	每亩施14斤氮 (6)	产量(斤/亩)	586.0	599.3	655.3
		产量(%) (7)	100.0	102.3	111.8
(3) 1955年	每亩施(8)8斤氮	产量(斤/亩)	602.1	632.2	663.6
		产量(%) (9)	100.0	105.0	110.2
	每亩施(10)14斤氮	产量(斤/亩)	640.3	649.6	712.7
		产量(%) (11)	100.0	101.5	111.3

注：1. 3/4氮为堆厩肥，1/4氮为硫酸铵

(15) 2. 3/4氮做基肥，全部用堆厩肥，1/4氮做追肥，用硫酸銨。

3. 3/4氮做基肥（其中4/5堆厩肥，1/5硫酸銨），1/4氮做追肥，用硫酸銨。

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1. Item 2. Year 1954 3. Year 1955 4. 8 chin of nitrogen per mou 5. Yield (chin/mou); Yield (%)
6. 14 chin of nitrogen per mou 7. Yield (chin/mou) Yield (%)
8. 8 chin of nitrogen per mou
9. Yield (chin/mou); Yield (%)
10. 14 chin of nitrogen per mou
11. Yield (chin/mou); Yield (%)
12. Used entirely as initial fertilizer (1)
13. Part of it used as an early supplement
14. Part of it used as a late supplement
15. Note: 1. 3/4 of the nitrogen is from compost, 1/4 is ammonium sulfate
2. 3/4 of the nitrogen is from compost, 1/4 of the nitrogen which is entirely used as supplement is ammonium sulfate
3. 3/4 of the nitrogen,used for initial application is made up of 4/5 compost, and 1/5 ammonium sulfate; 1/4 of the nitrogen, used as supplement is ammonium sulfate

(2) Supplementary Application of Fertilizer

It is applied after transplantation, at various times. Generally, there are tillering fertilizer, nodes fertilizer, and head fertilizer. The purpose of these supplements is always to satisfy the needs of the plant at the various stages of growth; however, each of the application functions differently, yet, all of the applications are closely related. For each application, we must consider the temperature and soil conditions, the previous application of fertilizer, and the growth of the plants.

a. The tillering fertilizer

This is applied either when the plant is about to tiller or during the tillering stage. According to the observations of Ting Ying (0002 7336) and co-workers, when 6-leafed seedlings of early and late varieties are cultivated under the condition of small groups, the plants all begin to tiller on the 8th day after transplantation. This stage is completed in about 14 days for the early varieties, and 20 days for the late varieties. Thus effective tillering days are 7 for the early and 9 for the later varieties.

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Therefore, quickly effective fertilizer should be used for this stage.

According to an experiment conducted by Chekiang Provincial Institute of Agricultural Sciences, when four chin of nitrogen is applied to the early variety of a continuous crop at the tillering stage, as compared with four chin of nitrogen applied at the head evolvement stage, the second space between the nodes is shorter, the stem grows longer faster during the tillering stage, there are more tillers, the weight of 1,000 grains is heavier, and the yield is 15.1% higher. With the application of four chin of nitrogen at the tillering stage, the second space between the nodes is 12.7 cm long; the stem grows 0.79 cm a day during the tillering stage; the total tillers of each group are 13.53; each thousand grains weigh 24.96 g; and the empty hull rate is 13.46%. With four chin of nitrogen application at the head evolvement stage, the second space between the nodes is 13.6 cm long; the growth during the tillering stage is 0.61 cm; the total tillers of each group are 12.03; each thousand grains weigh 23.96 g, and the rate of empty hulls is 22.51. However, there is 9% less heads in the former case, while each head contains less grains also. This situation is especially obvious in case of medium and late varieties of the single seasoned culture. Therefore, for these two types, there is no need of applying fertilizer at the tillering time, if there is sufficient fertilizer in the initial application, so as to avoid ineffective tillering. Experiments conducted by Huai-yin Institute of Kiangsu also proved the same point. (Table 14-15)

In general, if tillering fertilizer is used, it should be in small amounts only, and should best be a quickly effective fertilizer, so as not to prolong the stage of nourishing growth. At this stage, the roots are small. The fertilizer must be thin and spread apart. In Kwangtung, Kwangsi, Fukien, Chekiang, Kiangsi, and Hunan, the farmers sometimes mix a small amount of quickly effective fertilizer in mud, and drop a little near the roots. This is a very good way of using fertilizer economically.

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Table 14-15 Effect of Multiple-applications of Fertilizer on the Yield of the Medium Keng Varieties

基肥（厩肥）(1)（斤/亩）	(2)追肥（硫酸铵）（斤/亩）			稻谷产量6（斤/亩）	产量7（%）	最高分蘖数8（科）	有效分蘖率9（%）	有效穗数（科）10
	总3量	分4蘖肥	穗5肥					
2,000	15	15	0	613.0	100.0	13.5	51	6.9
	15	10	5	638.0	104.1	13.1	58	8.7
	15	5	10	696.7	113.4	13.3	64	8.8
	15	0	15	708.0	115.3	12.1	77	10.9
6,000	15	15	0	801.7	100.0	18.3	49	9.0
	15	10	5	814.5	101.5	17.0	56	9.6
	15	5	10	839.8	104.6	16.1	55	8.9
	15	0	15	850.0	105.9	14.0	61	8.5

1. Initial fertilizer (manure) (chin/mou)
2. Supplementary application (ammonium sulfate) (chin/mou)
3. Total amount 4. Tillering fertilizer 5. heading fertilizer 6. Yield (chin/mou) 7. Yield (%)
8. Largest number of tillers (per group)
9. Rate of effectual tillers (%)
10. Rate of effectual heads (per group)

b. Node Fertilizer

In the Yangtze Valley and points south in the areas of the single-seasoned late keng varieties, there are about 10 days between the time the nodes appear and the time the head begin to evolve. The evolvement of the heads for the early varieties often begins before the stem grows nodes. For the medium varieties, the two stages are often continuous. It is hard to separate them. Therefore, when we say node fertilizer, we means the application for the single-seasoned late keng varieties only.

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In the southern part of Kiangsu and the northern part of Chekiang, the farmers apply fertilizer when the stem begins to grow nodes to grow strong stems. According to the farmers of the southern part of Kiangsu, the application at the time of tillering should be light, the application at the time of node growth should be heavy, and when the head begins to evolve, there should be another application to supplement what seems to be still lacking. According to the experience of Ch'en Yung-k'ang (7115 3057 1660), the fertilizer application at this time should be based on the stage from"black" to "yellow" (i.e. when the nitrogen content of the leaves begins to drop, and the tip of the leaves begins to store more sugar,) therefore, stable and long lasting fertilizer should be used, so as to combine this application with the soil sunning measure just before the head begins to evolve. If such fertilizer as ammonium sulfate is used, its effectiveness does not last more than 3 to 5 days. In effect, for the single-seasoned late varieties, the fertilizer application at the time of node growth is an application before the evolvement of the heads, and is mainly used to satisfy the needs of the head growth.

c. Head Fertilizer

This is to encourage healthy growth of the heads and to improve the fullness of the grain. The function of the fertilizer varies with the time of its application:

(a) If fertilizer is applied just before the evolvement of the heads, it may prevent the degradation of the inflorescence and guarantee the size of the heads. On the other hand, it may also discourage the heads from shrinking and therefore increase the number of effective heads. Generally, for the early and the late varieties of the continuous crops the first stem begins its head evolvement at about 30 days before the heading time; it is about 35 days for the late varieties of the single-seasoned crop. The second stem begins to evolve a head about 5 to 6 days later for the early varieties, and about 3 days later for the late varieties. Therefore, for the purpose of increasing the number of flowers and therefore the size of the infloreacence, the fertilizer should be applied 30 days before the heading time. An application at this time may also prevent some of the secondary tillers from degradating, and thus increase the number of effectual heads.

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According to the experiment conducted by Hua-tung Institute in 1954, with medium hsien varieties, when the total fertilizer application is either 8 or 14 chin per mou, if 1/4 of it is seeded at this time, there may be an increase of effective tillers and head, when compared with the method of using the total fertilizer application for the initial application only. (Table 14-16)

Table 14-16 Effect of Multiple-applications of Fertilizer on the Heads of the Rice Plants

项 目 (1)	(7) 总氮量(8斤/亩)			(8) 总氮量(14斤/亩)		
	9全部基肥	3/4 基肥, 1/4 分蘖肥 (10)	3/4 基肥, 1/4 穗肥 (11)	全部基肥 (9)	3/4 基肥, 1/4 分蘖肥 (10)	3/4 基肥, 1/4 穗肥 (11)
(2)每科最高分蘖数	12.31	12.7	11.3	13.6	13.9	12.1
(3)每科有效穗数	8.4	8.6	9.1	9.0	8.3	9.9
(4)有效分蘖率(%)	68.2	67.7	80.4	65.3	59.6	81.6
(5)每穗粒数	110.4	112.1	116.3	100.5	112.1	122.7
(6)千粒重(克)	27.0	26.2	25.5	27.2	26.6	25.2

1. Item 2. The highest number of tillers per group
3. Number of effectual heads per group
4. Rate of effectual tillers (%)
5. Number of grains per head
6. Weight of a thousand grains (g)
7. Total nitrogen applied (8chin/mou)
8. Total nitrogen applied (8 chin/mou)
9. All for initial application
10. 3/4 for initial application, 1/4 for tillering time
11. 3/4 for initial application, 1/4 for heads

(b) Fertilizer may be applied when head is developing. This is what the farmers in the areas of Chekiang call "embryo price" or "head bait." This application may cause the head to be bigger and have more grains. Generally, when most of the flowers of a head are entering the stage of pollen development, the inflorescence often showssigns of

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degradation, therefore, an application of fertilizer at the time when the pollen cells divide, i.e. about 12 to 13 days before the heading time may improve the nutritional condition and increase the number of seeds per head.

(3) Fertilizer application just before or just after heading time is commonly called the seed fertilizer, for the purpose of increasing the fullness of the grain. According to research studies, about 2/3 to 3/4 of the starch needed by the seeds depends upon the synthesis of the chlorophyllous substance of the leaves and the stem, therefore, if the leaves and the stem become withered and turn yellow too early, the yield will suffer. Therefore, an application of fertilizer at this time may strengthen photosynthesis and increase production. According to the experiments of the medium variety Ai-chia-ma-ku and the late medium San-pai-pang, conducted by Pao Wen-k'uei (7637 2429 1145) and others, if 5 chin of each of the three elements of nitrogen, phosphorus, and potassium are used for initial fertilizer, and either 8 or 12 chin each are used for head fertilizer, an application of nitro-fertilizer at this time may reduce the rate of empty hulls.

The various applications of fertilizer are mutually related. If less fertilizer is applied before heading time, or if the effect of an application does not last long, then, a supplement at this time is needed. If there has been sufficient fertilizer, and the leaves have no sign of turning yellow prematurely, then any application of the head fertilizer may even cause too much growth in the leaves and stem, and the plant may fall.

In 1956, I-ch'un Experimental Station of Kiangsi conducted an experiment with the continuous crops of early and late varieties. The 20 chin of ammonium sulfate were divided into transplanting fertilizer, tillering fertilizer, and head fertilizer. Before the early crop was planted, legumes were plowed under and the soil fertility was thus raised. Then, for each mou, there was again an initial fertilizer application of fresh Astragalus sinicus, 1,500 chin, compost, 30 tan and night soil, 10 tan for the early crop. For the late crop, 21 tan of compost was used for initial fertilizer. A head fertilizer was applied for the late crop, and the yield of the early crop was not as much as the late crop. This is due to the fact that although the initial fertilizer of the late

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crop was less, the temperature was higher, and the initial fertilizer decomposed faster; toward the later part of the growth period, when nutrient supply began to wane, the application of the head fertilizer showed obvious effect.

Table 14-17 Effect of Multiple-Applications of Fertilizer on the Yield of the Early and Late Crops of a Continuous Rice Culture

追肥硫酸铵用量（斤/亩）(1)			早 (5) 稻		晚 (6) 稻	
秒口肥	分蘖肥	穗(4)肥	产量（斤/亩）	产(6)量（%）	产量（斤/亩）	产(8)量（%）
(2) 6	(3) 6	8	(5) 529.2	103.6	(7) 555.1	118.3
12	8		522.6	102.4	514.7	109.7
12		8	533.0	104.4	539.0	114.9
(9)对照（不施秒口肥及追肥）			510.4	100.0	469.0	100.0

1. Amount of ammonium sulfate used for supplementary fertilizer (chin/mou) 2. Transplanting time 3. Tillering time 4. Head fertilizer 5. Early ripening crop 6. Late ripening crop 7. Yield (chin/mou) 8. Yield (%) 9. Control group (no application of transplanting and tillering time)

In 1959, Chekiang Provincial Institute of Agricultural Sciences conducted an experiment on the subject of multiple applications of fertilizer. The late keng, Ch'ing-keng, was the variety used for this experiment. For each mou, 20 chin each of the three elements were used as initial fertilizer, and 8 chin of nitro-fertilizer were used as supplementary fertilizer. This is divided into five treatments: fertilizer for the seedlings to turn green, tillering fertilizer, head fertilizer, and seed fertilizer are the applications found to be most effective. (Table 14-18) This result explained that head fertilizer is a necessity for the late crop of the continuous rice culture, and an additional application of seed fertilizer (before the appearance of the

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head) often brings increased yield also. The farmers of Kwangtung believe in "green embryo" for the late crop, i.e. the leaves should remain green at the time of seed development. In essence, the experiment proved that when carbon metabolism is at its peak, nitrogen metabolism should not be allowed to become too weak either.

Table 14-18 Effect of Multiple-Applications of Fertilizer on the Yield of the Late Crop of a Continuous Rice Culture

(1) 追肥氮素用量(斤/亩)					产量(斤/亩) (7)	产量(%) (8)
总(2)量	返青肥 (3)	分蘖肥 (4)	穗(5)肥	粒(6)肥		
8	2	2	2	2	793.7	115.1
8	4	—	4	—	781.1	113.3
8	2	2	4	—	757.0	109.8
8	4	2	—	2	719.2	104.3
8	4	4	—	—	689.0	100.0

注：基肥每亩施用氮、磷、鉀各20斤。 (9)

1. Amount of nitrogen used for supplementary applications (chin/mou) 2. Total amount 3. For the seedlings to turn green again 4. Tillering fertilizer 5. Head fertilizer 6. Seed fertilizer 6. Yield (chin/mou) 8. Yield (%) 9. Note: Twenty chin each of nitrogen, phosphorus, and potassium are used per mou for initial fertilizer.

The growth season of the single-seasoned late varieties is long (most of them more than 130 days in the paddy), and during the nourishing period of their growth, the temperature is rather high. The initial fertilizer, and the supplement applied at the tillering time must have been all decomposed at the time the seeds are developing. Thus, an application of head fertilizer should be emphasized.

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The Comprehensive Experimental Station of Hupei Province conducted an experiment with the single-seasoned variety, Lao-lai-ch'ing in 1956. With an initial fertilizer of 70 chin of vegetable oil residue and 20 chin of calcium perphosphate, and an application of 30 chin of ammonium sulfate as supplement, the yield is the highest if the supplement is applied once at the time when the head is beginning to evolve. When this amount is divided into two or three applications, the yield is not as good. The yield is the smallest, if it is applied only once at the tillering time. (Table 14-19) However, if the soil is not so good, and the initial fertilizer is not sufficient, then some fertilizer at the tillering time is also necessary.

Table 14-19 Effect of Multiple-Applications of Fertilizer on the Yield of the Single-seasoned Late Varieties

处(1)理 项 目	(10)产 量（斤/亩）	(11)比对照增产（斤/亩）	(12)比对照增产（%）
稻穗分化期一次施 (2)	990.72	165.20	20.02
分蘖前、分蘖期、稻穗分化期三次施 (3)	944.49	119.06	14.42
分蘖期、稻穗分化期两次施 (4)	936.80	111.37	13.49
分蘖前、分蘖期两次施 (5)	917.26	91.88	11.12
分蘖前、稻穗分化期两次施 (6)	913.30	87.87	10.64
分蘖期一次施 (7)	902.91	77.48	9.38
分蘖前一次施 (8)	887.82	62.89	7.55
对照 (9)	825.43	—	—

1. Items 2. Once at the time of head evolvement
3. Three applications at the time before tiller, tillering and head evolvement
4. Two applications at tillering time, and head evolvement time.
5. Two applications at the time before tillering, and tillering.
6. Two applications, before tillering and head evolvement time
7. Once at tillering time
8. Once before tillering
9. Control group
10. Yield (chin/mou)
11. Increased Yield compared with control group (chin/mou)
12. Increased yield (%)

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For the early varieties, the growth period of which in the paddy is short (less than 90 days), since the temperature of the early period is low, fertilizer decomposes slowly, it is important to apply supplement at the tillering time in addition to a heavy initial fertilizer application. A head fertilizer should not be applied, if the initial and the tillering applications are sufficient. During the year of cloudy and rainy weather, less fertilizer or no head fertilizer should be applied if the soil is somewhat fertile, while such measures as draining and lime application should be adopted so that the soil may have a chance to release its fertility.

For medium varieties (the gowth period is about 120 days in the paddy), on the basis of sufficient initial fertilizer, an application of head fertilizer often results in increased yield. For example, Wang-ting Experimental Station of Kiangsu conducted an experiment in 1954 with medium keng on the subject of multiple applications of fertilizer. It was pointed out that if the initial fertilizer is about 60 to 80% of the total fertilizer applied, an application of supplementary fertilizer at the heading period is better than one applied at the tillering period. (Table 14-20)

Table 14-20 Multiple Applications of Fertilizer and the Growth and Yield of the Medium Keng Varieties

处 (1) 理	每科平均分蘖数 (3)	分 蘖 系 数 (4)	每科平均出穗数 (5)	产 量 (斤/亩) (6)
基—蘖—穗 (2)				
3—0—2	10.42	1.76	8.10	670.05
4—0—1	11.12	1.81	8.77	649.65
2—1—2	9.91	1.36	7.77	635.65
2—2—1	10.71	1.54	7.84	644.25
4—1—0	10.93	1.84	8.01	632.45
3—2—0	10.79	1.70	8.45	628.10

注：处理：1. 处理代号如 3—0—2 系指3/5作基肥，不施分蘖肥，2/5作穗肥，余类推。
(7) 2. 各处理施用肥料为风干河泥 4,000 斤/亩，豆饼80斤/亩，草木灰300斤/亩，过磷酸钙30斤/亩，硫酸铵 10 斤/亩，其中含氮量为 12 斤。

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1. Treatment 2. Initial--tillering--head
3. Average number of tillers per group
4. Tillering coefficient
5. Average number of heads per group
6. Yield (chin/mou)
7. Treatment: 1. the figures such as 3-02 mean that 3/5 is for initial fertilizer, there was no tillering fertilizer, and 2/5 for head fertilizer. 2. The fertilizer used for all the treatments is weathered dry river silt 4,000 chin/mou, vegetable oil residue, 80 chin/mou, grass and wood ash, 300 chin/mou, calcium perphosphorus, 30 chin/mou, ammonium sulfate, 10 chin/mou. The nitrogen content of all is 12 chin.

To apply the head fertilizer, the common method is to spread or to pour. Recently, there are also methods of spraying quickly effective liquid fertilizer.

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SECTION 3. TYPES OF FERTILIZERS FOR PADDY RICE AND THEIR EFFECTIVENESS [p 398]

Organic fertilizer can supply the numerous types of nutrients the rice plants need for growth, and at the same time, it also adds organic matter to the soil, improves its physical and chemical characteristics, and provides a beneficial condition for the activities of the microorganisms. For several thousands of years, the fertility of our rice paddies has been continuously on the rise with the continuous development of rice production. Frequent application of organic fertilizer is an important reason. However, organic fertilizer decomposes slowly in the rice paddies, and its utilization rate during the same season it is applied is low. It should be coordinated with fast action inorganic chemical fertilizers to bring obvious results. Meanwhile , the various kinds of organic fertilizer do not decompose with the same speed, and their nature and function are also different. A reasonable coordination is the key to satisfaction.

1. ORGANIC FERTILIZERS [p 398]

After organic fertilizer is applied to the soil, it must be mineralized through the activities of the soil microorganisms before it can be absorbed by the rice plants. When the paddy is flooded, the decomposition is primarily anaerobic, with a slower speed than that of the dry field. Although organic matter may be easily accumulated in the soil, the utilization rate of the current season is low, and the final decomposition product is different from that of the dry field also. The organic fertilizer in the paddy is mostly converted into nitro-ammonium, which may be absorbed by the soil granules, while in the dry field, it is converted into nitrates, which cannot be absorbed by the soil granules and are easily lost.

Under similar conditions of soil moisture and temperature, the different organic fertilizers decompose in different speeds. Generally speaking, if the cell wall is thick with tough or woody fibers, then the decompostion is

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slower, as with straw, wheat stalks, and old withered grass. On the other hand, tender green grass and green fertilizer decompose faster. Those organic fertilizers which contain a lower percentage of carbon and a higher percentage of nitrogen, with a small proportion between carbon and nitrogen soil (generally the turning point is 20), such as night vegetable oil residue, and legumes become effective faster.

Concerning the physiological function of organic fertilizer, the Institute of Pedology of Academia Sinica and the Wu-hsi School of Agriculture pointed out that the decomposition product of pond silt has a certain relationship with ferrous iron, therefore, it can eliminate the poisonous effect of the latter with regard to the rice plants. It may also reduce the bad effect of ferrous iron on phosphorus with the result of increasing the effectiveness of phosphorus fertilizer applied. After testing with the liquid obtained from soaking organic soil, the Institute of Plant Physiology of Academia Sinica discovered that the liquid may cause phosphorus to enter the plant roots quickly, with about three times the speed of the control group, and the phosphorus is transferred to the above ground parts of the plant 6 times faster than in the case of the control group. When tested with carbon, this liquid is found to cause the photosynthesis products to be transferred out of the leaves much faster.

In our country, there are numerous kinds of organic fertilizer for the rice paddies. With the varied temperature of the many rice growing areas, it is difficult to understand the rules of decomposition of the various kinds of organic fertilizer, and a complicated job to formulate reasonable methods of application to improve their effectiveness. The following is an explanation of the major types of organic fertilizer.

(1) Green Fertilizer

Green fertilizer of the Leguminosae family is often planted in the rotation system of the rice culture. This method has a very long history in our country. In the areas of Kiangsu and Chekiang, the farmers say: "pig manure and Astragalus sinicus are farmers' treasures." There are many kinds of green fertilizer plants. The major ones are: Astragalus sinicus, Pisum stivum, Astragalus melilotoides, lima beans /the genus Phaseolus/, turnip green, and Medicago

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denticulata, which are planted as a crop before rice to be turned under for fertilizer. There are also several types of beans which may be cultivated in dry fields, and to be used as green fertilizer in the Paddies. There are several kinds of hydrophytes which may be cultivated in the ponds and small streams to be used as fertilizer. Then, there are also many wild-grown grasses and shrubs, the tender leaves of which make very effective fertilizer. (See Table 14-21.)

Since forage legumes decompose rather fast, when the amount of nitrogen is about the same, then, they are more effective for the current year than some other organic fertilizer, such as compost, manure, pond silts, and others. According to the studies of the Kiangsu Branch of China Academy of Agricultural Sciences, forage legumes decompose in the paddies faster than most of the other common fertilizers, and they release nitro-ammonium faster also. (Diagram 14-4)

Table 14-21 Nitrogen Content of the Various Wild-grown Green Fertilizers

名 (1) 称	牡荆 (3)	胡枝子 (5)	葛 (7)	竹 (9)	盐肤木 (11)	蕨 (13)	茅草 (15)	艾 (17)	枫 (19)	芒萁骨 (21)
土 (2) 名	杨香 4	蒲沙 6	葛藤 8	竹叶 10	乌烟豆 12	蕨萁 14	茅草 16	艾草 18	枫树叶 20	笼箕草 22
23 含氮量 (%)	0.58	0.71	0.52	0.72	0.42	0.60	0.33	0.52	0.45	0.53

1. Name 2. Common name 3. Vilex cannabifolia 4. Mao-ching 5. Lespedeza bicolor 6. P'u-sha 7. Pueraria thunbergiana 8. Ko-t'eng 9. Bamboo 10. Bamboo leaves 11. Rhus semi-alata 12. Wu-yen-tou 13. Pteridium aquilinum 14. Chueh-ch'i 15. Hierochloe borealis 16. Mao-ts'ao 17. Artemisia vulgaris var. indica 18. Ai-ts'ao 19. Liquidambar formosana 20. Feng-shu leaves 21. Miscanthus sinensis 22. Lung-ch'i-ts'ao 23. Nitrogen content (%)

The utilization rate of the nitrogen content of green fertilizers is also rather high. An experiment with early rice varieties conducted by Hunan Institute of Agricultural Sciences showed that the nitrogen utilization rate of Astragalus sinicus is 38.2%, that of pig manure is 17%, that of compost is 14.8%, and that of cow manure is 10.6%.

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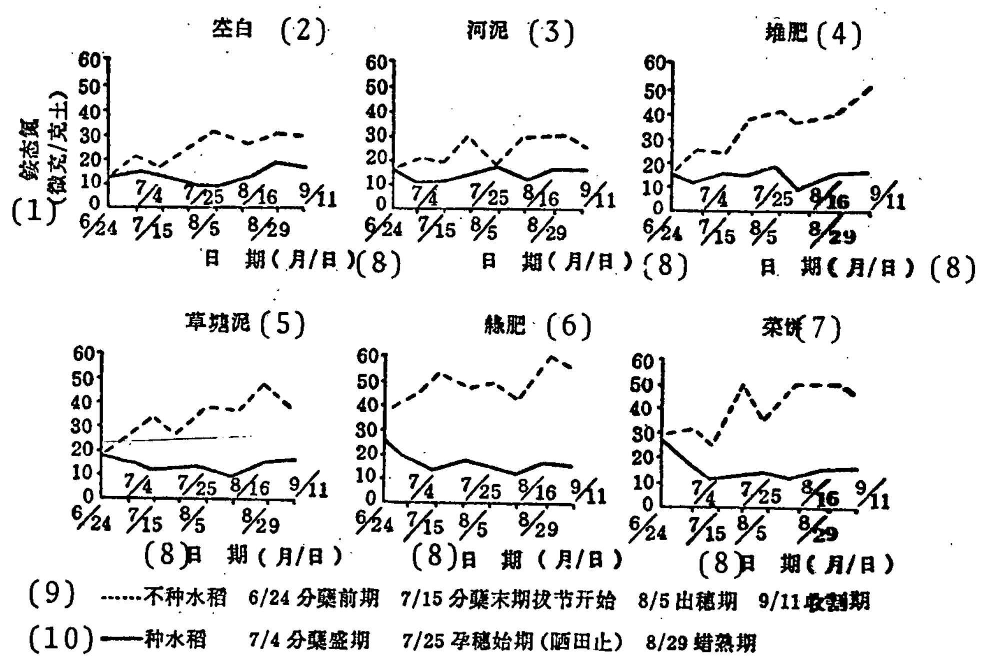
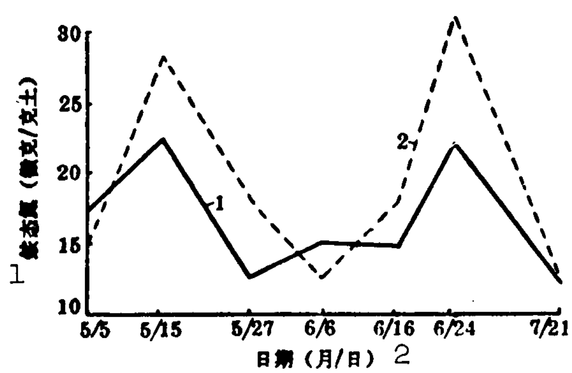
Diagram 14-4 Release of Nitro-ammonium in Paddy Soil by Common Fertilizers (Medium hsien variety, Sheng-li-hsien. 8 chin per mou of nitrogen applied)



1. Nitro-ammonium (0.1 mg/g of soil) 2. Blank
3. River silt 4. Compost 5. Pond silt 6. Green fertilizer
7. Cake of vegetable oil residue 8. Date (month/day)
9. .... Not planted with rice 6/24 early tillering time
   7/15 last of tillering and begining of node growth
   8/5 heading time 9/11 harvest
10. ____ Planted with rice 7/4 peak of tillering time
   7/25 beginning of head growth (end of sunning)
   8/29 wax-ripe stage

The various green fertilizers contain different amounts of nitrogen and the speed of decomposition is different also. According to the studies of Chekiang Provincial Institute of Agricultural Sciences, when 1,000 chin each of Astragalus sinicus and Medicago denticulata are used as initial fertilizer for early rice varieties to compare their effectiveness, it was discovered that at first Astragalus sinicus decomposed faster and supplied more nitro-ammonium, however; during every stage afterwards, its effectiveness was found to be lower than Medicago denticulata. (Diagram 14-5). Astragalus sinicus used as initial fertilizer cannot increase its supply of nutrients as more are needed by the early ripening varieties. Therefore, in the end, the early varieties which had Astragalus sinicus as initial fertilizer were inferior to those which had Medicago denticulata in the height of stalk, number of effectual heads, and yield. The yield of the former was 571 chin per mou, while that of the latter was 619 chin per mou, an increase of 8.4%.

Diagram 14-5 Condition of Nitro-ammonium Release in Soil, when Different Green Fertilizers are Used (Early hsien 503, green fertilizer turned on 19 April, rice transplanted on 30 April, harvested on 21 July.)



1. Nitro-ammonium (0.1 mg/g of soil) 2. Date (month/day)

Green fertilizers are fresh organic matter, and after they are applied to the soil, a certain time must lapse to allow them to decompose before nutrients may be released

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to supply the rice plants. The speed of this process varies with the temperature, soil moisture, and the types of green fertilizer applied. For example, in early spring, the temperature is low, for those paddies where the soil moisture and temperature is inferior, green fertilizer often cannot release sufficient nutrients for the rice plants. When the temperature rises, the decomposition is accelerated, and the soil is suddenly full of nitrogen. This situation may cause the seedlings to grow very fast all of a sudden, while ripening may be delayed. Therefore, for the early crop of the double-crop regions, a small amount of quickly effective fertilizer such as ammonium sulfate or decomposed night soil should be applied just before transplantation. This measure may satisfy the immediate needs of the seedlings, as well as give the necessary nitrogen source for the reproductive activities of the soil microorganisms.

With regard to the late varieties of the single-seasoned crop, green fertilizer is often combined with river silts to stabilize and prolong the effectiveness. For sandy soils, green fertilizer should be turned and plowed deeply, and the paddy should be flooded immediately after plowing. The measure may prevent the fertilizer from decomposing too fast and may also prevent the soil from losing nitrogen through denitrification. If the soil is clay and heavy, then, green fertilizer should be pressed down lightly, and sunning process must be applied to assist its decomposition. However, under normal conditions, since green fertilizer is rather easily decomposed, turning and plowing should be done deeply, and efforts should be exerted to cut it loose so that it will not form concentrated lumps to cause the rice plants to grow unevenly.

The common forage legumes contain a great deal of nitrogen, but very little phosphorus or potassium. In order that the rice plants may grow healty and strong, phosphorus and potassium fertilizers must be combined in the application. In Lien-hsien, Kwangtung, there are large areas of Astragalus sinicus; people plant it with turnip greens, which grow very fast and tall and provide a shade for the neighboring Astragalus sinicus plant which is not drought resistant, and at the same time turnip greens also contain more phosphorus and potassium. When the plants are turned over as fertilizer for the rice paddy, the two may supplement one another.

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(2) Night Soil

Night soil is the most common fertilizer in our country. In the north, the contents of privies are mixed with animal manure and soil, and the mixture is called soil manure. In the cities, it is often dried and used as initial or supplementary fertilizer for rice paddies. In the south, night soil is often used directly; because it is quickly decomposed and becomes effective, it is best to be used as a supplementary application. If a small amount of it is mixed into the initial application, the seedlings may turn green and tiller earlier. It is an organic fertilizer with a small proportion of nitrogen versus carbon, and its organic nitrogen content may easily be converted into ammonia and lost; therefore, it must be stored carefully in order to remain effective as fertilizer.

(3) The Stable Manure

The manure of the domestic animals is often mixed with such stable bedding - as straw, grass, and mud to form stable manure which contains not only nitrogen, phosphorus, and potassium, but also a great deal of organic matter. Therefore, it not only supplements the nutrients of the soil, it may also improve the physical and chemical characteristics of the soil and invigorate the activities of the soil microorganisms.

After the stable manure has be piled up for a while, most of the organic matter has been converted into a more stable compost. However, according to the studies of the Kiangsu Branch of China Academy of Agricultural Sciences, when pig manure is used as an initial fertilizer for early rice varieties, the nitro-ammonium content of the soil before the heading time is found to be less than in the case of applications of green fertilizer, pond silt, or compost. But, from the time the head appears to the time of harvest, the nitro-ammonium content of the soil rises steadily, while in case of other fertilizer, the nitro-ammonium content has a tendency to drop after the heading time. (Diagram 14-6) This study explains the fact that stable manure is best to be used as an initial fertilizer, and is especially good for those varieties of rice, the growth season of which is very long. If it should be used as an initial fertilizer for the early varieties which need more nutrients during the early

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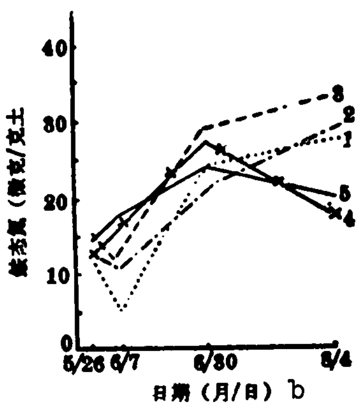
stage of growth, then a quickly effective fertilizer must be applied early to counteract the slowness of the stable manure.

The quality of the stable manure varies with the type of animal, the type of feed, the type of stable bed, and the method of piling it. Its effectiveness also varies with the soil to which it is applied and the season during which it is applied. Generally speaking, among the domestic animals, pig manure is the most effective as a fertilizer. According to the report of Nan-p'ing Special District Institute of Agricultural Sciences of Fukien Province, the manure excreted by a pig in one year roughly equals to 51 chin of ammonium sulfate (Table 14-22), and may be used to fertilize 2 to 3 mou of rice paddies. Therefore, a massive breeding program of pigs is extremely significant for the increase of rice production.

Diagram 14-6 Release of Nitro-ammonium in the Soil When Various Types of Common Fertilizer are applied for the Planting of Early Ripening Varieties of Rice Plants



1. Blank 2. Pig manure 3. Green fertilizer 4. Grass compost 5. Pond silt 5/26 is the tillering time 6/7 is the time for the evolvement of the head 6/30 is the heading time 8/4 is the time of the harvest a. Nitro-ammonium (0.1 mg/ g of soil) b. Date (month/day)

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Table 14-22 Nitrogen Content of Pig Manure

(1) 一头猪饲养一年		(8) 每日出肥量（斤）		(9) 肥料中的全氮含量（%）		(10) 饲养期出肥量（斤）		(13) 折合硫酸铵数量（斤）
(2) 饲养期	7 所需天数	11 粪	12 尿	11 粪	12 尿	11 粪	12 尿	
(3) 小猪期	120	1.5	5	0.607	0.044	180	600	6.81
(4) 中猪期	150	2.0	32	0.866	0.047	300	4,800	24.32
(5) 大猪期	95	2.5	50.5	0.731	0.047	237	4,797	20.00
(6) 合计	365	—	—	—	—	717	10,197	51.13

(14) 注：饲料为菜叶类，出尿量比一般高約一倍。

1. One pig bred for one year 2. Stages of growth 3. The stage of a small piglet 4. The stage of a middle-sized pig 5. The stage of a grown pig 6. Total 7. Days needed 8. Amount of fertilizer produced (chin) 9. Whole nitrogen content of the fertilizer (%) 10. The amount of fertilizer produced during the entire period (chin) 11. Dung 12. Urine 13. The equivalent in ammonium sulfate (chin) 14. Note: Vegetable leaves are used for feed, about double the weight of the excrement.

(4) Compost

There are two kinds of compost, Ou-fei in the south, and Tui-fei in the north. Both of them consist of straw, vegetable stalks, grass, fertile soil, and a little night soil or manure. In the Tui-fei process, these substances are piled up with a suitable amount of moisture, to undergo stages of fermentation with high and low temperatures, under a ventilated condition. With the Ou-fei process, the pile is mixed with a great deal of water to undergo a process of anaerobic decomposition, with a stable temperature. Under the latter condition, the decomposition process is not thorough, and the method is not suitable for areas of low temperature.

The effectiveness of this type of compost depends largely upon the materials used in the pile. At present, the compost made in most areas is very similar to the stable manure just described, and therefore, it is very suitable for

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initial fertilizer.

Ou-fei is the same as pond silt. In the winter, the farmers use river silt and add 2 to 3% straw and pile the mixture up. In the spring, when grass and green fertilizer are at their peak, the farmers put this mixture in the pond, and add a large amount of green grass, green fertilizer, and pig manure, and pound it and tramp it to mix it. Then, it is left to undergo anaerobic decomposition.

Concerning the effectiveness of this type of compost, Hunan Provincial Institute of Agricultural Sciences conducted an an experiment with early rice varieties. The nitrogen applied was 12 chin per mou. The paddy with compost as fertilizer produced 516.6 chin. The paddy with no fertilizer produced 414.6 chin. The increase was 24.6%.

The experiment conducted by the Kiangsu Branch of China Academy of Agricultural Sciences was carried out with medium hsien varieties. The nitrogen applied was 8 chin, in Ou-fei, and the yield was 7.8 to 15.2% more than that of the control group.

The Institute of Pedology of Academia Sinica and Wu-hsi School of Agriculture pointed out that the effectiveness of the compost is related to the materials used. If the amount used is similar, then the compost is better if Astragalus sinicus is used than that of the straw. If lime is added to a compost of straw, then it becomes more effective. (Table 14-23)

Table 14-23 Effect of the Various Pond Silts (Compost) on the Yield of Rice

处 (1) 理	用 (6) 量 (担/亩)	稻谷产量 (斤/亩) 7	(8) 增 产 (%)
稻草草塘泥 (2)	150	697	100.0
稻草草塘泥加贝壳粉 (3)	150	715	102.6
稻草草塘泥加石灰 (4)	150	737	105.6
紫云英草塘泥 (5)	150	758	108.7

1. Treatment 2. Straw pond silt 3. Straw pond silt with sea shell powder added 4. Straw pond silt with lime added

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5. Astragalus sinicus pond silt 6. Amount used (tan/mou)
7. Yield (chin/mou) 8. Increased Yield (%)

Since Ou-fei undergoes a process of anaerobic decomposition, there must be a certain amount of accumulation of effective nutrients. However, anaerobic decomposition is never thorough, and a certain amount of the materials must remain in organic state. Since, there is a great deal of river silt mixed in, some of the nutrients must have been absorbed. Therefore, after the pond silt is applied to the paddy, the release of the nutrients is in a curve. During the early stage of the growth of the rice plants, it is more effective than river silt, Tui-fei, and stable manure, but not as good as green fertilizer, and during the later stage, it is not as good as stable manure. Therefore when it is used for those varieties, the growth season of which is long then, supplementary fertilizer must be applied during the early and the late stages of the plant's growth in order to raise the yield.

(5) Straw

In the continuous rice rop regions south of the Yangtze, the straw of the early rice crop is often used as fertilizer for the late crop. This method is commonly called "returning the straw back to the paddies." It gives back the nutrients the straw has taken from the soil to be absorbed by the late crop, increases the organic matter of the soil, encourages the activities of the microorganisms, and rasies soil fertility. According to the analysis of Hunan Provincial Institute of Agricultural Sciences, straw contains a great deal of potassium, and the ash of straw contains more than 70% of silicon dioxide. Therefore, it is a good fertilizer to use to keep the stalk from falling.

The proportion between carbon and nitrogen is large in straw, and its fiber is highly woody. If it is used directly as fertilizer, its decomposition process is very slow, especially in the areas of low temperature. If the soil moisture and temperature conditions are good, straw may be cut up and mixed with lime before being used directly as fertilizer.

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According to the experiment of 1956, conducted by Chekiang Provincial Institute of Agricultural Sciences, if 820 chin of fresh straw (when dry, straw contains 0.79 % nitrogen), 2.5 chin of ammonium sulfate, and 30 chin of lime are used as initial fertilizer for late rice crops and 8 chin of ammonium sulfate are used as supplements, then the total nitrogen applied is 8.5 chin per mou. When the above method was used , the yield was 491 chin per mou, an increase of 8.9% over another method of using 500 chin of stable manure, and 2.5 chin of ammonium sulfate for initial fertilizer, and 8 chin of ammonium sulfate as supplements, which amounts to 8.8 chin of nitrogen.

This experiment points out that although the carbon and nitrogen proportion in straw is large (about 52), as the temperature is high in July and August, it may release nutrients in time to supply the rice plants, especially when it is used with lime and a small amount of ammonium sulfate.

An experiment in 1959, conducted by Hunan Provincial Institute of Agricultural Sciences points out that if each paddy is applied with 8 tan of pig manure and 50 chin of lime per mou, then, an additional application of 830 chin of fresh straw may increase the yield 10.3%; and if another addition of 100 chin of lime is mixed with the straw, then, there is an additional increase of 12.8% in yield.

These experiments and the productive practice of some regions proved that straw may be used very effectively as a fertilizer if lime and a small amount of quickly effective fertilizer are added to accelerate its decomposition. Therefore, in the continuous rice culture areas south of the Yangtze, it is very suitable for the late crop, when there is a deficiency of materials for initial fertilizer, and an excess of fresh straw from the early crop.

(6) Peat

There is a wide distribution of peat in our country. It absorbs moisture well, and may be used to line pig sties and other animal shelters. It may absorb nutrients from the manure which in turn may cause the nitrogen content of the peat to become utilizable nitrogen. Since peat is very resistant to decomposition, it is not very effective during the season it is applied. In 1958, a test

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conducted by Chekiang Provincial Institute of Agricultural Sciences proved that if ammonia water is mixed with peat before application, its effectiveness as a fertilizer may be greatly improved.

(7) Soils as Fertilizer

The farmers of our country have the habit of using the silts of the ponds, streams, and rivers as fertilizer. The mud of the old walls, hearths and burnt soils are all considered good as fertilizer.

According to the experience of Chekiang and other regions, since such fertilizer as green forage legumes, cakes of vegetable oil residue, and manure contains a small proportion of carbon and nitrogen, and is easily decomposed, if a great deal of soil or mud fertilizer is mixed with it before application, then the mud may absorb the quickly released nutrients and store them for future use. This method is especially important in case of the single-season late varieties with the very long growing season. Burnt soils are good for those paddies with heavy clay soil and a great deal of organic matter. They may improve soil consistency and often improve yield.

The farmers of our country also gather animal hair, bits of leather and skin, scales of fish, horns and bones of animals, and the residue of soy sauce. These substances all contain a certain amount of nitrogen, phosphorus, and potassium. After proper treatment, they may all be used as very effective fertilizer.

2. INORGANIC FERTILIZERS [p 406]

Inorganic fertilizers, especially the chemical ones, are concentrated and effective. They are soluble in water and their content is simple. Applied to the paddies, they may be directly absorbed by the rice plants. They may also improve inferior soils. However, generally speaking, their effectiveness does not last long, and they cannot be used to cultivate soil fertility. Therefore, they must be used only as supplements on the basis of organic fertilizer applications.

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(1) Nitro-fertilizer

The most common nitro-fertilizer used in the rice paddies of our country is ammonium sulfate. Recently, the new products include ammonium nitrate, calcium nitro-ammonium, urea acid, ammonium hydrocarbonate, lime nitrate, and aqua ammonia. The test results of these conducted by the National Fertilizer Testing Agency established in 1958 found all of them to be obviously effective, and they are currently being used in the rice paddies of the various regions. However, if the amount of nitrogen content is the same, nitro -ammonium is more effective than nitrates, this is the difference between rice plants and other dry field crop plants. The studies conducted by Wu Hsiang-yu (0702 4161 6877) show the tissue of rice seedlings does not contain nitrate reductive enzymes. However, if nitrates are added into the cultivating broth, then the rice seedlings in the broth begin to contain nitrate reductive enzymes, the activity of which may be detected an hour after the nitrates are added. (Table 14-7) Thus, although rice plants absorb primarily nitro-ammonium, they do not actually reject nitrates. However, when the paddy is flooded, nitrates cannot be absorbed by soil granules very easily, and the nitrogen may be lost through denitrification.

In 1958, the Northeast Institute of Agricultural Sciences made fertilizer out of peat and ammonium nitrate, and deposited this soil fertilizer near the root system of the rice plants. It was discovered that this solid fertilizer is more effective than ammonium sulfate in powdered form. When powdered ammonium nitrate was tested, it was found to be almost as effective as ammonium sulfate if it is given in separate applications.

In 1957, Hua-tung Institute of Agricultural Sciences conducted a test with medium hsien varieties, and discovered that when any of the chemical fertilizers are applied 15 cm to 18 cm deep in the soil, the result is better than applying it closer to the surface. By comparison, if ammonium sulfate is used, deep application increases the yield 8.9%, if ammonium hydrocarbonate is used, the increase is 22.8%, and when ammonium nitrate is used, the increase is 7.1%. This is to say that when nitro-fertilizers are applied deeper in the soil, there is less chance of losing them. Therefore, it is

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best to apply them before plowing.

Experiments prove that urea acid as a fertilizer is not as effective for rice paddies as ammonium sulfate. If lime nitrate is directly added to the soil without treatments, it will cause the leaves to burn or the plant to die. According to Chekiang Institute of Agricultural Sciences, if lime nitrate is mixed with damp soil equal to 10 times the weight of the lime nitrate, and the mixture is piled up for 15 to 20 days, with the pile kept constantly damp, it may be used as a very effective fertilizer. The result of this method proves to be better for the Huang-ni-t'u soil (the paddy soil with the red soil as its parent material) of the regions south of the Yangtze.

Table 14-24 The Formation of Nitrate Reductive Enzymes in Rice Seedlings (Wu Hsiang-yu (0702 4161 6877), 1957)

实验 1	对照 (在磷酸缓冲液中萌发) 3	在铵盐中萌发 4	在硝酸盐中萌发 5	在硝酸盐中萌发蒸煮过 6	空白 7
亚硝酸盐试验 2	-	-	+	-	-

注：+号表示有硝酸还原酶，－号表示没有。8

1. Test 2. Nitrite salt test 3. Control group (sprouts in diluted phosphate broth) 4. Sprouts in ammonium salt broth 5. Sprouts in nitrate salt broth 6. Sprouts in distilled nitrate salt 7. Blank
8. Note: + indicates a positive detection of nitrate reductive enzymes; - indicates a negative detection

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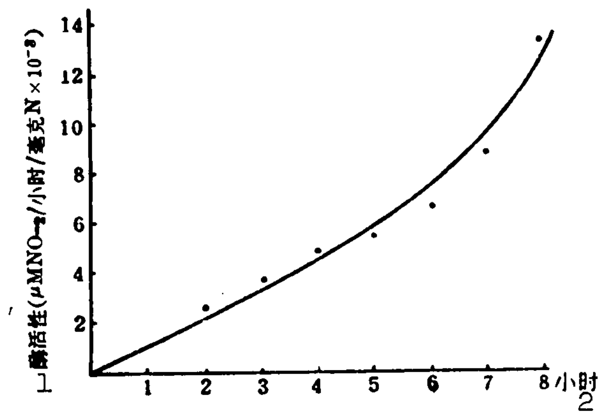
Diagram 14-7   Time Factor in the Formation of Nitrate Reductive Enzymes in Rice Seedlings



1. Active enzymes (uMNO-$_2$/hour/mg N x 10^{-3})   2. Hour

(2) Phosphorus Fertilizer

The most common inorganic phosphorus fertilizer used in our country is calcium perphosphate; then, there are also bone powder, phosphorus mineral powder, and calcium magnesium phosphate, which are being used only recently.

Phosphorus is found in lecithin, syrupus codeinae phosphatis, protein, certain enzymes, and the vitamins. In the form of lecithin, phosphorus also participates in the process of transpiration and fermentation. It is closely related to carbon and nitrogen metabolism. Therefore, phosphorus is just as important to rice plants as it is important to other crop plants.

Rice plants absorb phosphorus with different speeds in different amounts during the various stages of their growth. Yu Te-min (1429 1795 2404) tested with Chung-nung No.4 (a medium hsien variety) and discovered that the greatest amount of phosphorus is absorbed during the tillering stage, and the speed of absorption is the highest during the period after tillering to the beginning of head development.

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Hua-nan College of Agriculture tested with phosphorus in 1959, and discovered that rice seedlings begin to absorb phosphorus fertilizer the second day after transplantation, the absorption is the fastest from tillering to node growth, and during this period, the amount of absorption is the highest also. The speed of absorption remains basically the same until the head begins to develop.

Pao Wen-k'uei (7637 2429 1145) planted Ch'uang-nung 422 (a medium hsien variety) to study the effect of phosphorus fertilizer. He discovered that the rice plants have the largest number of tillers and the weight of 1,000 grains is the heaviest when phosphorus fertilizer is used as an initial fertilizer. (Table 14-25) We may concude that the rice plants demand phosphorus more during the early stages of growth, and if an organic fertilizer with a high phosphorus content is used as an initial fertilizer, with a suitable supplement of quickly effective phosphorus fertilizer, the phosphorus requirement may be best satisfied.

Table 14-25 Application of Phosphorus Fertilizer at Different Times

施用时期 (1)	株高 (厘米) 6	分蘖数 7	有效分蘖(%) 8	插秧至出穗天数 9	产量 (克) 10	每穗粒数 11	谷千粒重 (克) 12	米千粒重 (克) 13	穗数 14	空壳 (%) 15
(2)基肥 (5/21)	158.2	28.6	72.3	70.7	34.31	91.8	24.0	19.03	20.3	15.25
(3)分蘖盛期 (6/12)	153.7	25.8	77.9	69.3	28.78	82.2	22.7	19.11	20.2	19.83
(4)分化期 (7/4)	157.8	25.9	71.1	69.0	27.07	93.8	22.6	18.66	18.2	20.59
(5)出穗期 (8/4)	158.6	24.9	70.2	70.4	20.65	74.0	22.3	18.93	17.1	18.52

(16)注：1. 此品种一般从插秧到出穗需73—76天。
2. 基肥中均施有氮素肥料。

1. Application time 2. Initial fertilizer (5/21)
3. Peak of tillering (6/12) 4. Evolvement (7/4)
5. Heading time (8/4) 6. Height of stalk (cm)
7. Number of tillers 8. Effectual tillers (%)
9. Number of days from transplantation to heading
10. Yield (g) 11. Number of grains per head
12. Weight of 1,000 rough grains in the hull (g)
13. Weight of 1,000 grains without the hull (g)
14. Number of heads 15. Empty hulls (%)

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16. Note: 1. Ordinarily this variety takes 73-76 days to grow from transplantation to heading 2. The initial fertilizer contains nitrogen also.

When the soil is flooded, the effective rate of phosphorus is higher. This is why unless the paddy soil is very low in its phosphorus content, application of phosphorus fertilizer will not show obvious results. In 1954, a test was conducted in Kweichow. When calcium perphosphate was applied in 12 different paddies of yellow soil, an average of 1.3 chin per mou increase in yield was obtained. Tests in the areas of East China also proved that this fertilizer is effective in Huang-ni-t'u (a type of paddy soil with yellow soil as a parent material). When applied to alluvial soil, the effect was not obvious. This is due to the fact that unlike alluvial soil.

Hopei Provincial Institute of Agricultural Sciences reported that if an initial fertilizer is used, a supplement of phosphorus fertilizer brings 13% increase in yield compared with no supplements. If an initial fertilizer is not used, a supplement of phosphorus fertilizer brings an increase of 39.7%. If the supplement of phosphorus fertilizer is applied in the later period of the growth of the rice plants, the yield is still 12.1% higher compared with no supplement. This is to say that phosphorus fertilizer is very effective when applied to the newly cultivated saline soils. However, if it is to be used in the coastal alluvial soils, the effect still depends upon whether these soils are low in phosphorus content.

When direct application of phosphorus fertilizer brings no effective result, we may try to mix some of it in the green fertilizer used for such soil. This is a more economical method.

The effect of calcium magnesium phosphate fertilizer is similar, but since this fertilizer is alkali, it is more suitable for the acid soils such as Huang-ni-t'u. Phosphorus mineral powder is a slow inorganic fertilizer, and is also suitable for acid soils. However, when crystalline phosphorus mineral powder is tested directly as a fertilizer for rice paddies, the effect is found to be not obvious.

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(3) Potassium Fertilizer

The main inorganic potassium fertilizer is grass and wood ashes, which contain not only potassium, but also calcium, phosphorus, and small amounts of borax and manganese, while 90% of its potassium content is soluble. Other potassium fertilizers, such as potassium sulfate and potassium chloride, have also been tested in many regions, but are not currently used very much. During the great leap forward of 1958, potassium feldspar, talc, and lye were made into potassium fertilizer or potassium magnesium fertilizer.

Potassium in the rice plants is free from other chemical compounds, and is therefore, easily transferred. The potassium of an old leaf is easily transferred to a new leaf. When a potassium fertilizer is applied, it may encourage photosynthesis, the manufacturing of carbohydrates, and their transfer. It is also a necessary for protein synthesis, and the division of cells. It is beneficial for the formation of fibers, and causes the mechanical tissue of the stem to be stronger and hence better to resist falling. Pao Wen-k'uei (7637 2429 1145) pointed out that an application of potassium fertilizer at the time of head evolvement may increase the number of seeds per head. In 1959, Hunan Provincial Institute of Agricultural Sciences conducted a test of the absorption of potassium with early and late keng varieties and discovered that it is the highest from the beginning of tillering to the time of head evolvement, and drops thenceforth. If the supply of potassium fertilizer is sufficient in the soil, then the absorption of the plant occurs during the early stages of its life.

In 1958, the National Fertilizer Testing Program conducted tests on the effect of potassium fertilizer, and discovered that it is generally higher in the red and yellow soils. In 1957, Kiangsi Provincial Institute of Agricultural Sciences conducted a test in the paddy soil of the quaternary red soil. It was discovered that if 8 chin of potassium sulfate is applied per mou, the yield of early varieties increases 10.7%, and the yield of the late varieties increases 16.6%. In some areas, the application of potassium fertilizer brought on obvious results, because the soil or the organic fertilizer

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applied to the soil contains potassium in sufficient quantity. However, the analysis of rice plants shows that the potassium content of the plants is higher than that of nitrogen or phosphorus, therefore, a sufficient amount of potassium should be applied if the amount of nitro and phosphorus fertilizers is increased.

(4) Lime and Gypsum

Quicklime [calcium oxide] is generally the type of lime that is applied in the rice paddies. It is more widely used in the acid and "cold" soils of the mountainous regions south of the Yangtze. Its application has had many long years of history.

Lime not only supplies calcium to the rice plants, it also neutralizes the acidity of the soil, improves the activities of the soil microorganisms, and the mineralization of nitrogen. It also converts the originally ineffective phosphates into the effective calcium phosphate, so that it may be absorbed by the rice plants. At time same time, lime also reduces the free iron, alüminium, and manganese content of the soil, and keeps it from harming the rice plants. Besides, calcium is the major alkali radical of the soil. When the soil is saturated with calcium and forms exchangeable calcium, the soil becomes neutral or slightly alkali paddy soil, which is high in the capacity of absorbing nutrients. This is the reason why in productive practice, the application of calcium fertilizer often brings effective results.

In 1959, Hunan Provincial Institute of Agricultural Sciences tested a medium ripening keng and pointed out that the absorption of calcium by the rice plants reaches its peak from the time of head evolvement to the completion of heading, and the presence of sufficient potassium fertilizer may make the amount of calcium absorption especially high.

The farmers of Chin-hua and Chu-hsien of Chekiang apply lime in small amounts with the initial fertilizer, then with large amounts during the second and third plowing, and they emphasize the method of mixing lime with grass and wood ashes. They also insist that the application of lime must be accomplanied by the applications of organic fertilizers, otherwise, it may bring bad effects to the soil. (This is an

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area of Huang-ni-t'u, i.e. paddy soils formed from red or yellow soils). Repeated applications of lime without the accompaniment of organic fertilizer may cause the settling of such elements as phosphorus, copper, zinc, and borax, and bring bad effects to the rice plants.

At present, the amount of lime generally used in the rice paddies of our country is 30 to 50 chin per mous, to as much as 200 to 300 chin or more, and the amount used often varies with the availability of lime, and the nature of the soil.

The paddies of the mountain regions south of the Yangtze have low pH value, with cold water and pastry characteristics. There is a lack of nutrients, and the root system is difficult to become established. The farmers often apply a few chin to tens of chin of gypsum, green cooperas (ferrous sulphate), talc, or Glauber's salt, before transplantation. Such sodium sulfates are very effective for improving this type of soil, because sulfur is one of the elements needed by the rice plants, and gypsum and talc improve soil granules, so that the roots may adhere to the soil. In 1952, Chekiang Provincial Institute of Agricultural Sciences applied green fertilizer to the mountain rice paddies for growing early and medium varieties. In addition to the green fertilizer, the initial application included 10 chin of gypsum, and a 9.2% increase in yield was obtained. The soda soils of the North contain sodium carbonate which is not favorable for rice plants. Aside from applications of organic fertilizer, gypsum is usually added to improve the soil and the yield.

(5) Salt

The farmers of the mountains of Chekiang, Fukien, Kwangtung, and Kwangsi have the habit of using salt as a fertilizer for the rice paddies, in amounts of 2, 3, to several tens of chin, and it proves to be effective for the acid soils. At present, the reason for the effectiveness of salt as a fertilizer is still not fully understood. Perhaps, with the increase of sodium ions (the chlorine ions cannot be absorbed by soil granules, and are consequently washed away from the paddy.) the pH value of the soil rises, and the rise of the pH value improves the nutritional environment of the soil. On the other hand sodium ions are exchangeable with ammonium,

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Potassium, calcium, and magnesium and cause them to be easily absorbed by the rice plants. However, it is important that salt must be applied with organic fertilizers, otherwise, if applied alone, salt may cause the soil to deteriorate.

(6) Other Elements

Same as other crop plants, the rice plants need nitrogen, phosphorus, calcium, potassium, magnesium, and sulfur, and they also need iron, manganese, copper, borax, zinc, and molybdenum. It is known that iron is an element of the cell chromatin system and the enzyme peroxides; copper is an element for phenol oxide enzymes; manganese is for phosphate enzymes and enzyme peroxides, and acts as a catayst for perhydrozide enzymes. In his study of 1942, Lo Tsung-lo (5021 1350 3157) pointed out that manganese may accelerate the desolution of starch and its transfer when the rice seeds are sprouting. Ts'ui Cheng (1508 1794) and Ch'ien Ch'u-kuo (6929 2806 0948) treated rice seeds with iron, zinc, molybdenum, and borax, and discovered that all of these elements have a certain degree of effectiveness in promoting growth, and the effect of magnesium and zinc is the best.

Research studies proved that if 0.003% boric acid is used as a supplementary fertilizer near the root system, when the pollen cells are dividing (when the head is about 7 to 8 cm long), it hardens the stem and improves the yield.

Wu Chao-ming (0702 0340 2494) experimented with borax and manganese as fertilizer in 1958 in the State-operated Ch'ing-ho Farm, and improved yield was obtained. Borax fertilizer caused the head to appear three days ahead of schedule. At present, these fertilizers are still being tested and studied; many problems and techniques remain to be solved, before they can be recommended for general use.

3. BACTERIAL FERTILIZERS [p 411]

Bacteria fertilizer is one of the economical and effective methods of improving plant nutrition and increasing yield with microorganisms. The bacteria fertilizers which may be used in rice paddies are nitrogen-fixing bacteria, phosphorus bacteria, and Benzyl bacteria.

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Based upon the results of direct applications of nitrogen-fixing bacteria in the various regions, the effectiveness varies from place to place. In 1959, Hunan Institute of Agricultural Sciences conducted an experiment with the use of bacteria fertilizer for cultivating single-seasoned late varieties, and discovered that organic phosphorus bacteria, silicate bacteria, nitrogen-fixing bacteria, and inorganic phosphorus bacteria may all improve the yield of the rice plants. (table 14-26) However, the subject of using bacteria fertilizer in the rice paddies has only begun to be studied in our country; further research is needed to understand many aspects of this subject.

Table 14-26 The Effect of the Various Bacteria Fertilizers on the Yield of the Single-seasoned Late Keng Variety

处 (1) 理	产 (7) 量(斤/亩)	产 (8) 量(%)
未施菌剂 (对照)(2)	716.0	100.0
施有机磷菌剂 (3)	758.5	105.9
施硅酸盐菌剂 (4)	742.1	103.6
施自生固氮菌剂 (5)	755.5	105.5
施无机磷菌剂 (6)	770.5	107.6

1. Treatment 2. Bacteria not applied (control group)
3. Organic phosphorus bacteria applied 4. Silicate bacteria applied 5. Nitrogen-fixing bacteria applied 6. Inorganic phosphorus bacteria applied 7. Yield (chin/mou) 8. Yield (%)

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CHAPTER 15. IRRIGATION AND DRAINAGE

[p 415]

The farmers of our country are very experienced in matters of irrigating the rice paddies. This precious experience has been summarized and improved since the liberation. An experimental network for irrigation has been established all over the country to study the amount of water needed by the rice plants, and the various irrigation systems; and the results of these studies are to be used as bases for designing water conservation structures. For example, in 1958, during the great leap forward, and new irrigation method of "water level, dampness, and sunning of the paddies" was found as a result of summarizing the experience of the farmers. This method is devised on the basis of the close relationship between water and fertilizer, and is presented as a combination of irrigation systems for high yield and a drainage system for improving the saline and soda soils. The application of this method has had a certain effect in productive practice. In this chapter, we shall discuss irrigation and drainage of the paddies, planned water consumption, and the arrangement of an irrigation channel system.

SECTION 1. THE AMOUNT OF WATER NEEDED BY THE PADDY RICE FIELD [p 415]

The amount of water needed by rice plants far exeeds ordinary crop plants. In order to devise an irrigation plan for enlarging rice acreage and improve unit yield, we must understand the rules of water requirements of the rice plants. With such measures as deep plowing, dense planting, increased fertilizer application, the growth environment of the rice plants has changed a great deal, and this change necessarily changes the water needs of the rice plants. As we are now

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implementing the"eight-word constitution" in agriculture, the study of the problem of how to coordinate a reasonable irrigation system with the other measures is obviously more significant than ever.

The amount of water needed by a rice plant is calculated by the transpiration of the leaf-area, the evaporation between the groups, and the leakage of the paddy. The transpiration of the leaf-area is the amount of moisture transpired into the atmosphere by the rice plant during its process of growth. The evaporation of the space between the groups is the amount of moisture evaporated by the water suface or soil. Soil leakage is the amount of water seeping through the soil downward and sideward from the rice paddy. Judging from the various tests and experiemnts conducted during the last few years, the amount of transpiration, evaporation, and leakage varies with the area, and the stage of growth of the rice plants, and rules of such variations are definitely discernible.

1. THE AMOUNT OF WATER NEEDED BY CHINA'S PADDY RICE FIELDS [p 416]

Although our country has a vast rice acreage, and an extreme regional difference in the water needs of the rice paddies, within a given region, the water needs of the local rice paddies reflect the the regional characteristics. Generally speaking, the rice growing regions of the country may be divided into three large zones: the regions south of The Yangtze and Ch'ien-t'ang-chiang in which the water requirement of a rice plant during its life of one growing season is between 300 and 700 mm (about 200 to 466 c.m per mou); the regions north of the Yangtze and south of Ch'in-ling and Huai-ho, in which the water requirement of a rice plant is generally between 500 and 1,000 mm (about 333 to 666 c.m per mou); the regions north of Ch'in-ling and Huai-ho, in which the water requirement of a rice plant is generally between 800 and 2300 mm (about 533 to 1,533 c.m per mou.) These facts show that the water requirement is smaller in the south. This difference is related to the rice plant itself, the climatic condition, the soil, the terrain, the ground water, and the agricultural techniques. Table 15-1 shows that the three aspects of transpiration, evaporation, and

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leakage also vary from zone to zone. In the regions north of Ch'in-ling and Huai-ho, there are many newly cultivated rice paddies, the leakage of which amounts to 40 to 63% of the total water requirement. The regions south of the Yangtze and Ch'ien-t'ang-chiang are full of old rice paddies, the leakage of which is relatively negligible. However, the absolute value of transpiration and evaporation is still smaller in the south. This regional difference provides a basis for the study of irrigation systems for rice paddies.

Table 15-1 The Water Requirements of Rice Plants of the Various Regions

地 (1) 区	季别 (5)	蒸腾量 (毫米) (10)	蒸发量 (毫米) (11)	12 腾发量		渗漏量 14		总需水量 (毫米) (15)
				毫米 (13)	%	毫 13 米	%	
长江錢塘江以南 (2)	连作早稻 (6)	160—260	110—210	270—470	67—82.6	30—100	17.4—33	300—570
	连作晚稻 (7)	210—300	140—240	350—540	77—92	30—160	8—23	380—700
长江錢塘江以北秦岭淮河以南	单季中稻 (8)	330—400	180—290	510—690	71—93	40—280	7—29	550—970
秦岭淮河以北 (4)	单季稻 (9)	240—500	240—340	480—840	37—57	360—1,440	43—63	840—2,280

1. Zones 2. South of Yangtze and Ch'ien-t'ang-chiang 3. North of Yangtze and Ch'ien-t'ang-chiang and south of Ch'in-ling and Huai-ho 4. North of Ch'in-ling and Huai-ho 5. Season 6. Early crop of continuous seasons 7. Late crop of continuous seasons 8. Medium ripening rice of a single-seasoned crop 9. Single-seasoned rice 10. Amount of transpiration (mm) 11. Amount of evaporation (mm) 12. Total transpiration and evaporation 13. mm 14. Leakage 15. Total water requirement (mm)

2. AMOUNT OF EVAPORATION [p 417]

(1) Regional Variations

The amount of transpiration and evaporation

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varies with the moisture requirements of the rice plant itself and the environmental conditions. Nationally, the variation is between 300 to 840 mm (Table 15-2). The general tendency is that it is smaller in the south and larger in the north, with the latter about 2.6 times the former.

Table 15-2 The Amount of Transpiration and Evaporation in the Major Rice Growing Regions of the Country

地 (1) 区	季(20) 别	年 (25) 份	生长日数 (26)	腾发量(毫米) (27)
黑龙江 齐齐哈尔 (2)	(21) 单季中稻	1956	100	739.6
河北 天津 (3)	(21) 单季中稻	1958	110	840.0
河南 新乡 (4)	(22) 单季晚稻	—	132	655.3
宁夏 银川 (5)	(21) 单季中稻	—	87	474.7
陕西 汉中 (6)	(22) 单季晚稻	1956	109	652.0
江苏 常熟 (7)	(22) 单季晚稻	1958	105	451.2
湖北 宜都 (8)	(22) 单季晚稻	1957	130	629.3
湖北 鄂城 (9)	(23) 连作早稻	1960	86	419.0
四川 纳溪 (10)	(21) 单季中稻	1959	101	307.8
四川 什邡 (11)	(22) 单季晚稻	1957	101	570.4
湖南 长沙 (12)	(24) 连作晚稻	1956	86	449.6
湖南 永兴 (13)	(23) 连作早稻	1959	88	335.0
江西 泰和 (14)	(24) 连作晚稻	1957	91	373.8
浙江 杭州 (15)	(23) 连作早稻	1957	70	309.8
广东 汕头 (16)	(23) 连作早稻	1960	95	369.8
广西 南宁 (17)	(23) 连作早稻	1959	73	445.0
广西 南宁 (18)	(24) 连作晚稻	1957	110	547.0
福建 莆田 (19)	(23) 连作早稻	1960	82	350.0

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1. Area 2. Ch'a-ha-yang, Heilungkiang 3. Tientsin, Hopei 4. Hsin-hsiang, Honan 5. Yin-ch'uan, Ninghsia 6. Han-chung, Shensi 7. Ch'ang-shu, Kiangsu 8. I-tu, Hupei 9. O-ch'eng, Hupei 10. Na-ch'i, Szechwan 11. Shih-ch'i, Szechwan 12. Ch'ang-sha, Hunan 13. Yung-t'ai, Hunan 14. T'ai-ho, Kiangsi 15. Hangchou, Chekiang 16. Shan-t'ou, Kwangtung, 17. Nan-ning, Kwangsi 18. Nan-ning, Kwangsi 19. P'u-t'ien, Fukien 20. Season 21. Single-seasoned medium ripening varieties 22. Single-seasoned late ripening varieties 23. Early crop of continuous rice culture 24. Late crop of continuous rice culture 25. Year 26. Number of days in the growth period 27. Amount of evaporation and transpiration (mm)

Research studies point out that the major factors affecting the amount of transpiration and evaporation is climate and cultivating measures, and the variations among the regions are the result of a combination of the following factors:

a. Climatic conditions

Under certain conditions, the amount of transpiration and the amount of evaporation are both directly proportional to the difference between the saturation point and the humidity. For example, the growth period of the early crop of the continuous rice culture of the regions south of the Yangtze and Ch'ien-t'ang-chiang is rather short, but it is in the rainy season, with a relative humidity of about 80%. Thus, the amount of transpiration and evaporation is small. During the growth period of the late crop, there is less rain, the relative humidity is low, and the temperature is high during the first part of it; therefore, the amount of transpiration and evaporation is generally higher than that of the early crop. The rain is scanty in the regions north of Ch'in-ling and Huai-ho, and the air is dry. The relative humidity is from 40 to 70%, and the growth season of the single crop is long. Therefore, the amount of transpiration and evaporation is distinctly larger than that of the southern regions. (Table 15-3)

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Table 15-3 Climatic Conditions and the Amount of Transpiration and Evaporation

地 (1) 区	季别 (5)	插秧期 (10)	收获期 (15)	生长期 20 (天数)	降雨量 21 (毫米)	相对湿度 22 (%)	平均温度 23 (°C)	腾发量 24 (毫米)
长江錢塘江以南 (2)	连作早稻 (6)	3—4月 (11)	6—7月 (16)	70—90	400—900	75—85	22—27	270—470
	连作晚稻 (7)	7月前后 (12)	10月以后 (17)	90—110	300—700	70—80	24—27	350—540
长江錢塘江以北秦岭淮河以南 (3)	单季中稻 (8)	5—6月 (13)	8—9月 (18)	90—110	350—650	70—80	22—25	510—690
秦岭淮河以北 (4)	单季稻 (9)	6月前后 (14)	9—10月 (19)	100—130	100—400	40—70	18—21	480—840

1. Zone 2. South of Yangtze and Ch'ien-t'ang-chiang 3. North of Yangtze and Ch'ien-t'ang-chiang and south of Ch'in-ling and Huai-ho 4. North of Ch'in-ling and Huai-ho 5. Season 6. Early crop of a continuous rice culture 7. Late crop of a continuous rice culture 8. Single-seasoned medium ripening varieties 9. Single-seasoned rice culture 10. Transplanting time 11. March-April 12. Around July 13. May-June 14. Around June 15. Harvest time 16. June-July 17. Around October 18. August-September 19. September-October 20. Growth period (number of days) 21. Rainfall (mm) 22. Relative humidity (%) 23. Average temperature (°C) 24. Amount of transpiration and evaporation (mm)

b. Cultivating Measures

Among the various cultivating techniques, dense planting and fertilizer application affect the amount of transpiration and evaporation directly. With dense planting, the total number of plants in a unit area is increased, and the leaf-area is larger; therefore, the total amount of transpiration is larger too. Although the space between groups is small, the total amount of transpiration and evaporation still has the tendency to rise. (Table 15-4)

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Table 15-4 The Effect of the Varied Space between the Groups on the Amount of Transpiration and Evaporation

地 (1) 点	行 (6)距	叶面蒸腾量 (7)(毫米)	科间蒸发量 (8)(毫米)	腾发量 (9)(毫米)	备 (10) 注
(2)浙江杭州	5 × 3	264.9	106.4	371.3	1959年资料 (11)
(3)浙江杭州	5 × 6	219.5	137.0	356.5	
(4)江西泰和	4 ×4.6	228.1	268.3	496.4	1958年资料 (12)
(5)江西泰和	6 × 7	192.7	255.5	448.2	

1. Place 2. Hangchou, Chekiang 3. Hangchou, Chekiang 4. T'ai-ho, Kiangsi 5. T'ai-ho, Kiangsi 6. Space between the groups 7. Transpiration of the leaf-area (mm) 8. Evaporation between the groups (mm) 9. Total amount of transpiration and evaporation (mm) 10. Note 11. Information obtained in 1959 12. Information obtained in 1958

Application of fertilizer affects the growth and the yield of the rice plants; thus, it also affects the amount of transpiration and evaporation (Table 15-5). The latter rises as more fertilizer is applied.

Cultivating measures vary from place to place, hence the factors which affect the amount of transpiration and evaporation vary from place to place also.

Table 15-5 Effect of Fertilizer Application on the Amount of Transpiration and Evaporation

地 1 点	季 3 别	处 6 理	叶面蒸腾量 9 (毫米)	科間蒸发量 10 (毫米)	腾发量 11 (毫米)
2 浙江杭州	連作早稻 4	7 多肥区	236.2	108.7	344.9
		8 一般区	222.5	107.4	329.9
	5 連作晚稻	7 多肥区	244.6	132.1	376.7
		8 一般区	212.7	121.3	334.0

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1. Place 2. Hangchou, Chekiang 3. Season 4. Early crop of a continuous rice culture 5. Late crop of a continuous rice culture 6. Treatment 7. High fertilization area 8. common area 9. Transpiration of the leaf-area (mm) 10. Evaporation of the space between the groups (mm) 11. The total amount of transpiration and evaporation (mm)

(2) Variations of the amount of transpiration and evaporation during the growth period

There are common rules of variations during the growth season of any variety, regardless of area or cultivatting technique.

The amount of transpiration increases with the increase of the leaf-area, and decreases when the ripened leaves gradually turn yellow and wither. The peak of transpiration is reached generally during the stages of head evolvement and heading. The variation of evaporation during the growth season is a physical variation, and is affected by the shading action of the plants. Therefore, it decreases as the plants and the leaves grow. It is large at first, until the later part of the tillering stage. Under the shade of the grown plants, evaporation remains as little as 2 mm a day to the end. (Diagram 15-1)

The temperature at the time of transplantation is low for the early crop; therefore, transpiration increases rather slowly as the plants grow bigger, and the peak is reached at the time of heading and blooming. During that stage of growth, the temperature is high; therefore, the peak is maintained for a long time, and the drop after the peak is slow. For the late crop, the temperature at the time of transplantation is high, and the peak,therefore, appears rather early, around the time of node growth and head evolvement. Around that time, the temperature begins to drop, and the peak is not maintained for very long. After the peak, the drop is rather fast. The stalk of the medium varieties is tall, with large leaf-area; therefore, its transpiration is larger than thatcof the early and the late varieties. It rises fast, and the peak is reached at the time of head evolvement, then, it drops faster than that of the early varieties. The behavior of the late varieties of the single-seasoned crop is similar to that of the medium varieties. (Diagram 15-1)

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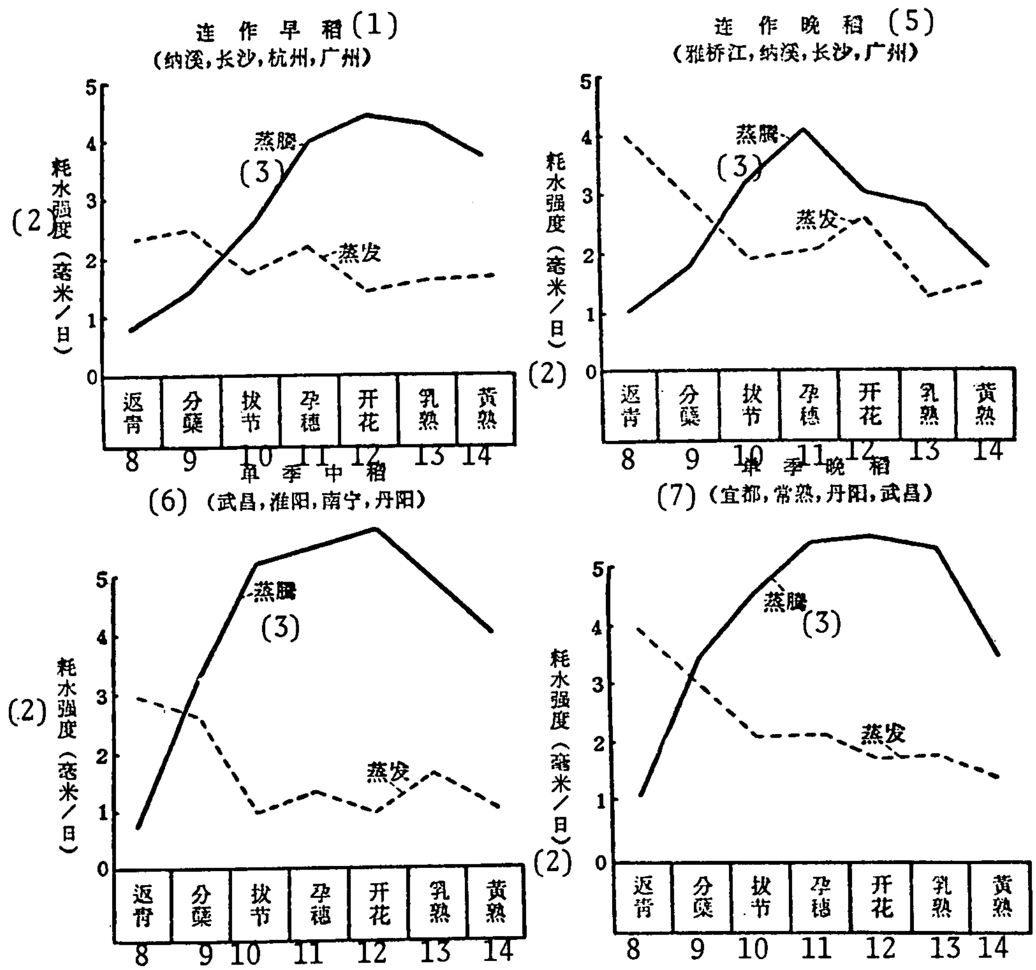
In the areas of rich water resources, a sufficient water supply should be guaranteed to meet the special needs of the variety. In areas where water supply is difficult, then the available water must be used to guarantee the peak stages first, so that the rice plants may still maintain normal growth inspite of the water shortage. This is why in productive practice, a water level is often maintained after the stage of the node growth.

Diagram 15-1 Variations of Transpiration and Evaporation of the Various Early, Medium, and Late Varieties



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1. Early crop of continuous rice culture (Na-ch'i, Ch'ang-sha, Hangchou, Kwangtung) 2. Amount of water consumed (mm/day) 3. Transpiration 4. Evaporation 5. Late crop of continuous rice culture (Ya-ch'ia-chiang, Na-ch'i, Ch'ang-sha, Canton) 6. Single-seasoned medium varieties (Wu-ch'ang, Huai-yang, Nan-ning, Tan-yang) 7. Single-seasoned late varieties (I-tu, Ch'ang-shu, Tan-yang, Wu-ch'ang) 8. Turning green 9. Tillering 10. Node growth 11. Head evolvement 12. Blooming 13. Milk-ripe 14. Yellow-ripe

(3) Water Consumption and Yield

Transpiration is a necessary physiological process of the rice plants, while evaporation adjusts the temperature of the surrounding environment in order to guarantee normal growth. Therefore, the total amount of transpiration and evaporation is closely related to the yield, and a study of its variation and its relationship to agricultural technique and production forms a basis for a reasonable irrigation system. After the practice of dense planting, the increased number of individual plants and the shading condition, the amount of transpiration and evaporation changes also.

According to the test of Huai-yin Irrigation Experimental Station, of Kiangsu (the variety tested was medium keng Kuei-hua-ch'iu), when the space between the groups was changed from 5 x 6 to 3 x 5 , the proportion between transpiration and evaporation changes from 1.1 : 1 to 1.8 : 1, while the total amount did not increase much. With the increased unit production, the amount of water consumption per kg of rice actually dropped. That is to say, the rate of water utilization has been raised.

Kwangtung Provincial K'an-chiang Special District Institute of Irrigation conducted several tests in 1959 on the water consumption rates of the early crop of the continuous rice culture (Table 15-6) and the result of their studies also verified the fact that increased production does raise the amount of water consumed, but the relationship between the two is not directly proportional. We must conclude that the increased application of fertilizer improves not only the yield but also the rate of water utilization.

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Table 15-6 Fertilizer Application and the Amount of Transpiration and Evaporation

施肥水平 (1)	腾 (5) 发 量		产 量	(8) 每斤稻谷需水量	
	毫 (6) 米	%	(7) (斤/亩)	(9) 斤	%
(2) 一般水平	642.9	100	650.9	1,314	100
(3) 增加半倍	656.7	102	886.6	988	75
(4) 增加一倍	687.2	107	1,131.7	850	65

(10) 注：品种为万利籼。

1. Fertilizer application 2. Ordinary level 3. One and half times 4. doubled 5. The amount of transpiration and evaporation 6. mm 7. Yield (chin/mou) 8. Water consumed per chin of rice 9. chin 10. The variety, Wan-li-hsien, was used for the test

According to information of experiments conducted in Kiangsu, when medium keng is planted in the density of 40,000 per mou, the yield was 15.1% above the density of 20,000 per mou, but the increase in water consumption was only 2.4%. Forty-six experiments were conducted in Szechwan (Diagram 15-2) and the result confirmed the fact that improved agricultural technique raises the utilization of the irrigation water. When the production was 450 chin per mou, the amount of transpiration and evaporation was 1,700 chin per chin of rice; when the production was 850 chin per mou, the amount of transpiration and evaporation was only 760 chin per chin of rice. These and similar results of experiments conducted in other regions provide scientific basis for planned production and water consumption, and point out the significance of raising unit production for the economical use of water resources.

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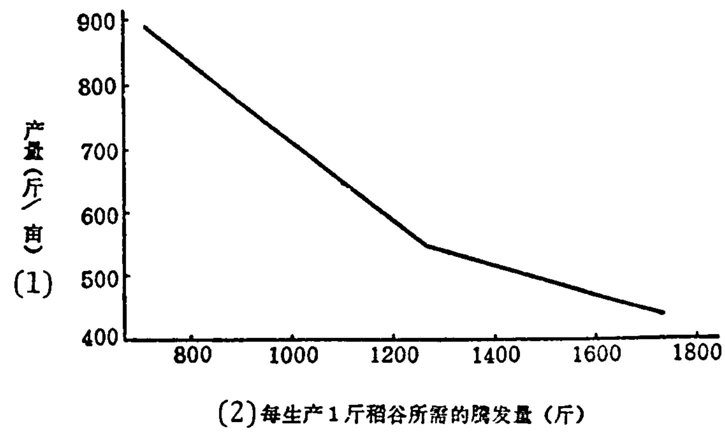
Diagram 15-2 Production and the Amount of Transpiration and Evaporation



1. Yield (chin/mou) 2. The amount of transpiration and evaporation for the production of one chin of rice (chin)

3. AMOUNT OF LEAKAGE [p 421]

(1) Regional Variations

Soil conditions are very complicated in the vast regions of rice culture of our country, and the cultivating system is by no means unified. The amount of leakage of the rice paddies varies a great deal (Table 15-7). In the Ch'a-ha-yang Irrigation District of Heilungkiang, the leakage amounts to 1,279 mm during the rice growing season, while in Yung-shing of Hunan, it is only 60.1 mm, a difference of twenty fold. The general tendency is that it is larger toward the north, and the reason is as follows:

a. The old paddies of the south have a tight plow sole, which has been mechanically pressed down with the finer soil granules seeped through from the plowing layer. This plow sole is largely responsible for preventing the paddy from leaking. In the north, the paddies are new, plow sole is negligible, and the soil is thus more permeable.

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b. In the south, the paddies are plowed many times while in a flooded state; in the north dry plowing is the practice. This cultivating habit directly affects soil structure and its porosity, and therefore, is directly related to soil permeability. In Yung-ch'eng-hsien of Honan, if the paddy is dry plowed once, then wet plowed, the leakage at the transplantation time is as much as 60 mm a day. If it is dry plowed once, and wet plowed twice, then raked carefully over and over again, the leakage is only 2 to 4 mm a day. In Huai-pei of Anhwei, the newly converted paddies were dry plowed once, wet plowed once, and then wet raked 6 times, and the leakage was 2.36 mm an hour. When a paddy was dry plowed twice, wet plowed three times, and wet raked eight times, the leakage was down to 1.9 mm per hour, a reduction of 62.5%. Tests conducted by Hupei Provincial Institute of Agricultural Sciences in Kuang-hua-hsien Hupei brought basically the same results.

Table 15-7 Leakage of the Rice Paddies of China

地 (1) 区	19 水稻类别	年 24 份	生长日数 25	26 渗漏量(毫米)
黑龙江 查哈阳 2	单季中稻 20	1956	100	1,279.8
河北 天津 3	单季中稻 20	1958	110	1,534.9
宁夏 银川 4	单季中稻 20	—	87	360.3
陕西 汉中 5	单季晚稻 21	1956	109	1,590.0
河南 新乡 6	单季晚稻 21	—	132	602.7
湖北 宜都 7	单季晚稻 21	1957	130	197.9
四川 纳溪 8	单季中稻 20	1959	101	281.4
四川 什邡 9	单季晚稻 21	1957	101	186.5
湖南 长沙 10	连作晚稻 22	1956	86	419.8
湖南 永兴 11	连作早稻 23	1959	88	61.1
广东 广州 12	连作早稻 23	1958	91	86.2
广西 南宁 13	连作早稻 23	1959	73	65.3
广西 南宁 14	连作晚稻 22	1957	110	62.0
福建 福州 15	连作早稻 23	1957	80	131.3
江西 泰和 16	连作晚稻 22	1957	91	103.4
江苏 常熟 17	单季晚稻 21	1958	105	135.5
浙江 杭州 18	连作早稻 23	1957	70	86.3

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1. Place 2. Ch'a-ha-yang 3. Tientsin, Hopei 4. Yin-ch'uan, Ninghsia 5. Han-chung, Shensi 6. Hsin-hsiang, Honan 7. I-tu, Hupei 8. Na-ch'i, Szechwan 9. Shih-ch'i, Szechwan 10. Ch'ang-sha, Hunan 11. Yung-hsing, Hunan 12. Canton, Kwangtung 13. Nan-ning, Kwangsi 14. Nan-ning, Kwangsi 15. Fuchou, Fukien 16. T'ai-ho, Kiangsi 17. Ch'ang-shu, Kiangsu 18. Hangchou, Chekiang 19. Type of paddy rice 20. Single-seasoned medium ripening varieties 21. Single-seasoned late ripening varieties 22. Late crop of the continuous rice culture 23. Early crop of the continuous rice culture 24. Year 25. Number of days in the growing season 26. Leakage (mm)

c. In the north, the soil is very permeable and the climate is arid; therefore, a large amount of water is needed for every irrigation application. In some areas, the water is kept deep in order to wash out the saline content of the soil. In the South, water level is usually shallow, and in some areas, the soil is only kept damp. This difference in practice also affects the amount of leakage. According to the studies of Hupei Provincial Institute of Water Conservation, if leakage in shallow water is 100, then, when the depth is 2 to 4 cm, the leakage is 111 and when the depth is 6 to 8 cm, the leakage is as much as 128. In Ch'ang-shu, Kiangsu, it was discovered that when all other conditions remained constant, 710 c.m. of water was needed for deep water irrigation per mou, while only 495 c.m. was needed if the paddy was irrigated intermittently, and only 292 c.m. was needed to keep a shallow water level in the paddy.

d. In the north the rice paddies are mixed with dry fields, and leakage through the sides is considerable This is another reason why leakage is more a problem in the north.

Besides, within a given area, due to the difference in terrain, soil, and ground water conditions, leakage of the rice paddies may vary a great deal.

Permeability of the soil is the major factor which determines the leakage of the paddy. When the soil structure is well granuled, the porosity is small, and the organic content is high; then, the paddy leaks less. (Table 15-8)

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Table 15-8 Leakage and the Various Soils

(1) 地点 / (2) 土质 / (3) 项目	石 (8) 牌		仙 (11) 河		潽 14 芦 陂
	粘 9 土	10 重 壤 土	粘 12 土	13 重 壤 土	重 15 壤 土
(4) >0.005毫米物理颗粒 (%)	59.5	30.0	51.0	20.0	22.5
(5) 平均每昼夜渗漏量 早稻 (6)	0.78—2.33	2.82—3.51	1.42—1.86	2.92—3.36	7.05—8.75
(5) 平均每昼夜渗漏量 晚稻 (7)	1.48—3.40	4.45—6.13	—	—	—

1. Place 2. Soil 3. Item 4. Larger than 0.005 mm physical granules (%) 5. Average leakage each day and night (24 hours) 6. Early varieties 7. Late varieties 8. Shih-pei 9. Clay 10. Heavy soil 11. Hsien-ho 12. Clay 13. Heavy soil 14. P'o-lu-p'o 15. Heavy soil

Soil permeability is also related to the ground water table. As the ground water table rises, the soil is less permeable. Due to the variation of terrain and ground water table, leakage of the paddies may vary within a small area.

(2) Measures to control Leakage

If the leakage is too great, the soil is washed so much that the nutrients are lost. The water is lost for nothing, and the labor and the investment in the irrigation equipment become wasteful. However, if the soil leakage is too small, then, the soil becomes poorly ventilated. The soil temperature is low, and there is an oxygen shortage , and occurrence of poisonous substances. Therefore, the control of a proper level of leakage is a very important problem. In the hilly regions, ditches are often dug to drain the water out of the area so as to prevent the rise of the ground water table; in low areas, aside from the ditches, drainage dikes are often built for the same reason.

For those paddies, the leakage of which is excessive, the measures to be taken to correct this condition are as follows:

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a. To plow and rake more intensively so as to change the permeability of the soil. The farmers say:"Level the paddy when it is dry, rake it wet to prevent leakage," and "Plow and rake three times to hold the water, and mend the dikes for a good harvest." When the paddy is flooded, it should be plowed and raked over and over so that the lumps of soil are completely and finely separately, with the very fine granules well settled to cover the larger cleavages and cracks. After the edges are plowed and raked, the dikes should be repaired . These procedures will bring down the amount of leakage. According to the experiments of 1957, conducted by Szechwan Provincial Institute of Agricultural Sciences, plowing, raking, and other procedures of land preparation may reduce leakage from 6.77 mm per night and day to 1.94 mm.

b. To fill up the drainage ditches in the paddies, and raise the ground water table are also effective means of reducing leakage. According to Chun-lang-ch'eng Experimental Station of Hopei, after the ditches were filled, the ground water table was 20 to 30 cm below the surface of the paddy, a rise of about 40 cm, and the leakage was apparently lower.

c. A change from deep water irrigation to damp or shallow water is another way of checking leakage, since the leakage of the paddy is related directly to the still water pressure; therefore, a reduction in the level of water will bring down water pressure, and thus bring down leakage. According to the experience of Tientsin Institute of Rice, when the paddy is irrigated with the damp method during the entire growing season, the water needed for that season is 1,577 mm per mou, while if a deep water level is maintained, the amount needed is 2,103 mm.

Besides, an increase of green fertilizer, and a careful sunning process to avoid large cracks are also good methods. In some cases, muddy water proved better for irrigation purposes.

4. IRRIGATION QUOTAS [p 424]

During the rice growing season, our major rice

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growing areas all have a definite amount of rainfall; however, a certain amount of artificial irrigation water is also needed in all the areas. Therefore, an understanding of the amount of natural rainfall and the water requirements of the rice paddy is necessary for the planning of the amount of water used for irrigation. According to the information of certain tests, the amount of irrigation water needed for a double seasoned rice culture is between 600 to 860 mm. For the single-seasoned rice culture in the south, it is 300 to 420 mm. In the newly converted rice paddy areas of the North, (mainly the saline and soda soils) it is 400 to 1,500 mm. The variation is greater in the North.

The factors which determine the difference are mainly as follows:

(1) Rainfall and its Distribution

In the north the rainfall is smaller. The rainy season generally appears during the later part of the tillering stage, and at that time, the rice plants are already being kept in a level of deep water. Therefore, rain water should be utilized fully so as to reduce the need of repeated irrigation. According to the experience in Hupei, by utilizing rain water, there may be a saving of 15 to 42% of water. If the rain distribution during the growing season is relatively even, its utilization may be as high as 90%.

(2) Amount of Leakage

In some rice paddies, such as the regions north of Ch'in-ling and Huai-ho, the leakage is almost as high as the amount used for irrigation. Thus, a control of leakage is a major water saving measure in these areas. Aside from intensive land preparation and improved irrigation methods to fill up the ditches and raise the ground water level are also very effective means of checking leakage.

Efficient field management of the water supply is also important for conserving water resources and establishing the amount needed for irrigation. There should be a special team responsible for filling up cracks, and other chores. Rules concerning draining and irrigating measures

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should be strictly implemented to improve the rate of water utilization and to check waste.

Table 15-9. The Amount of Irrigation Water Used in the Major Rice Growing Areas

地 (1) 区	(5) 试验地点	稻 (20) 别	生长期利用雨量 (25)	灌溉定额 (26)
(2) 长江钱塘江以南	广东海口 (6)	连作早稻 21	271.6	346.2
		连作晚稻 22	280.2	513.3
	广西兴安 (7)	连作早稻 21	224.1	224.1
		连作晚稻 22	87.1	405.0
	湖南长沙 (8)	连作早稻 21	201.3	313.5
		连作晚稻 22	125.9	353.7
	江西南昌 (9)	连作早稻 21	348.5	375.0
		连作晚稻 22	259.8	227.0
	福建福州 (10)	连作早稻	175.5	322.6
		(21) —	—	—
	浙江金华 (11)	连作早稻 21	120.1	363.0
		连作晚稻 22	166.5	630.0
长江钱塘江以北 秦岭淮河以南 (3)	12 江苏丹阳	单季晚稻 23	469.1	411.6
	13 湖北随县	单季中稻 24	272.2	287.0
	14 四川郫县	单季中稻 24	263.0	375.0
秦岭淮河以北 (4)	15 安徽蚌埠	单季中稻 24	157.0	435.0
	16 河南新乡	单季中稻 24	399.2	425.0
	17 河北天津	单季中稻 24	320.0	1,000—1,500
	18 内蒙古 呼和浩特	单季中稻 24	201.9	1,066.5
	19 黑龙江 齐齐哈尔	单季中稻 24	186.1	1,440.0

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1. Zone 2. South of Yangtze and Ch'ien-t'ang-chiang 3. North of Yangtze and Ch'ien-t'ang-chiang and south of Ch'in-ling and Huai-ho 4. North of Ch'in-ling and Huai-ho 5. Place tested 6. Hai-k'ou, Kwangtung 7. Hsing-an, Kwangsi 8. Ch'ang-sha, Hunan 9. Nan-ch'ang 10. Fuchou, Fukien 11. Chin-hua, Chekiang 12. Tan-yang, Kiangsu 13. Sui-hsien, Hupei 14. Pi-hsien, Szechwan 15. Pang-pu 16. Hsin-hsiang, Honan 17. Tientsin, Hopei 18. Hu-ho-hao-t'e, Inner Mongolia 19. Ch'a-ha-yang, Heilungkiang 20. Rice season 21. Early crop of a continuous rice culture 22. Late crop of a continuous rice culture 23. Single-seasoned late ripening varieties 24. Single-seasoned medium ripening varieties 25. Rain water utilized during the growing season 26. Fixed amount of irrigation water to be used

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SECTION 2. TECHNIQUES OF IRRIGATION AND DRAINAGE [p 426]

1. PROPER AMOUNT OF MOISTURE IN THE PADDY FIELD DURING EACH GROWTH STAGE [p 426]

There are many old sayings in our country remembered by the farmers which in essence summarize the long years of experience regarding the moisture requirements of the rice plants at the various stages of growth as well as irrigation measures to meet these requirements. The farmers are very careful in managing the water during the tillering stage so that the labor of fertilizing, weeding, and cultivating may bring better effects. The water is often shallow after an application of fertilizer, becaude they say "fertilizer supplements should have tiny water," so that the nutrients will not be washed away. During the stages of head evolvement, heading and seeding, there is a need of more water. The masses say: "Three ts'un of water for the evolving heads and blooming flowers." During the stage from heading to ripening, the water is no longer needed very much by the rice plants. The farmers say: "The grain is yellow and ripe, the paddy is barely covered." Since the liberation, experience such as this has been gradually summarized and developed. The following is a brief description of the irrigation and drainage techniques in productive practice and as a result of scientific study.

(1) The Stage when the Seedlings are Turning Green Again

In order to be able to transplant the seedlings shallow, straight, and firm, we require that the water in the paddy should be shallow. The newly transplanted seedlings have just suffered some injury in the root system, and are to weak to absorb water efficiently; therefore, they cannot withstand either drought or flood. The farmers say: "A bit of tardiness with the yellow seedlings, they will never grow up." They are trying to say how important is the water management during the transplanting time. A water level may provide a warm and stable environment for the seedlings, so that the

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their root system becomes established. The temperature of the transplanting time varies with the varieties. It is low for early varieties; warm for the medium and late varieties; for the late varieties of the continuous crops, it is hot. Therefore, different water levels are required to adjust the various temperature conditions for the benefit of the seedlings.

When the early varieties are planted early, the paddy is shallow during the day and deep during the night to protect the seedlings from the cold waves. If the temperature drops suddenly, more water is added to give added protection.

For the medium and the late varieties, the temperature is rather high when the seedlings are transplanted. According to a two year experiment conducted in Kiangsu, if the water level is maintained at 5 to 7 cm, more of the original green leaves are kept alive. If the water level is maintained at 7 to 9 cm, the leaves at the base will turn yellow, and fewer green leaves will be alive. In the latter case, new leaves have to appear first before the seedling can grow normally again. If the water level is kept at 2 to 4 cm, the leaves will seriously wither, new leaves will appear very slowly, and a longer time will be needed for the entire seedling to turn green again. When the seedlings turn green early and tiller early, there will be more effectual tillers.

Table 15-10 The Effect of Irrigation Methods on the Seedlings of the Late Varieties of the Single-seasoned Crop

灌溉处理 (1)	返青期实际灌水深度（毫米）4	株高 (5)	单株叶片数 (6)	单株叶面积（平方厘米）7	单株干重（毫克）8	单株粗根数 9	粗根直径（毫米）10	分蘖增加*（%）11	植株中 12		
									碳水化合物（%）13	氮（%）14	碳/氮 15
(2) 浅水	10—22	35.50	5.30	43.20	252	25.5	0.84	78	21.9	2.52	8.68
(3) 湿润	0—18	37.28	4.15	34.82	201	18.5	0.72	29	18.5	2.10	8.80

* 分蘖增加（%）系根据7月7日检查结果。(16)

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1. Irrigation treatment 2. Shallow water 3. Damp soil
4. Actual water level during the period when the seedlings are turning green(mm) 5. Height of stalk
6. Number of leaves for a single stalk 7. Total leaf-area of a single stalk (cm^2) 8. Dry weight of a single stalk (mg) 9. Number of large roots for a single stalk
10. Diameter of the large root (mm) 11. Increased number of tillers (%) 12. Contents of the stalk 13. carbohydrates (%) 14. Nitrogen (%) 15. carbon/nitrogen 16.* the result of the examination conducted on the 7th of July

In case of the late crop of the continuous rice culture, when the seedlings are transplanted, the temperature is high and evaporation is great. In order to prevent the hot water from burning the seedlings, the paddy is flooded with shallow water, or flowing water. In the areas of sufficient water resources and adequate irrigation systems the paddy is often flooded with deep water during the day, and drained at night. The method may vary from place to place, but the purpose is always to reduce the temperature of the water and the soil so that the seedlings may turn green again faster.

In a word, such factors as the quality of the seedlings and the temperature determine the water level to be kept during the stage immediately after transplantation. Generally speaking, the water level should not be so high as to cover the leaves of the young seedlings.

(3) Tillering Stage

During the tillering stage, the rice plant undergoes the nourishing period of growth. At its peak, shallow water is more suitable. The farmers say: "Leaving the seedlings in shallow water is like giving them night soil; being left in deep water, the seedlings will act as if they were sick." In Szechwan, for the early and medium varieties the water is best kept below 5 cm. In Kiangsu, Kwangtung, and Hupei, experiments proved that the best water level is 3 to 5 cm. If the water is above 5 cm, tillering will be inhibited to a certain extent. Since the adoption of such measures as deep plowing, dense planting, and more fertilizer application in 1958, many areas adopted the damp method of irrigation during the tillering stage. (The paddy is flooded with a shallow

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level of water twice, and between the applications, the soil remains highly moist.) With this method, tillering occurs in the same manner as if the shallow water irrigation method (1 to 4 cm) is adopted. The following factors cause the damp soil method or the shallow water method to be beneficial for the seedlings during the tillering stage.

a. Encourage tillering

With damp soil or shallow water, the sunlight can shine directly on the base of the plant and the soil. The temperature is thus warmer and oxygen sufficient to encourage early tillering near the base of the plant.

b. Decomposition and Absorption of Organic Fertilizer

If the water level is kept deep for a prolonged period of time, oxygen is lacking in the plowing layer and the temperature of that layer is lower too. The activities of the aerobic microorganisms are thus inhibited, while those of the anaerobic microorganisms become stronger. This condition affects the decomposition of the fertilizer as well as the absorption capacity of the roots. Damp and shallow water methods of irrigation are beneficial for the decomposition of fibers also.
Pedology with the aid of electric conductance measurements proved that soil nutrient content is higher when the damp or shallow water irrigation methods are adopted.

c. The Development of the Root System

During the tillering stage, photosynthesis products are used mostly for the growth of the tillers and the roots, while the proportion relationship between the growth of the roots and that of the tillers is determined largely by the depth of the water. When the soil moisture is low, or when the soil is sometimes damp, then dry, the photosynthesis products are distributed more to the roots than to the tillers. According to a survey conducted in P'ing-nan-hsien, Kwangsi, when the damp soil method of irrigation is adopted the root system is distributed to a depth of 7.4 to 8.4 ts'un, and to a width of 3 to 4.2 ts'un. If the deep water method is used, the roots reach only 6.2 to 6.8 ts'un in depth and 4.4 to 5.2 in width. According the test results conducted in Tientsin, there are more roots in the soil

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between 15 and 30 cm, if the paddy is irrigated with the damp soil method. If the soil is kept with a layer of water, then, the root system stays in the layer between 5 to 15 cm.

However, we must also point out that with the irrigation methods we described above, the soil remains in a state of high saturation. If the soil moisture is down to 70 to 80% of saturation, the tillers will suffer serious damage. According to the studies of Hua-tung Institute of Agriculture Sciences, if water is drained off 7 days before the peak of the tillering stage, the soil moisture drops to 60% of saturation;then, the lower tillers begin to degrade, and the yield is 10% lower than the control group.

Toward the later part of the tillering stage, two measures are taken to control ineffectual tillering. The first is to flood the paddy with deep water so as to reduce the temperature of the water and the soil and to weaken the light exposure of the base of the plant. However, the deep water level should not be kept over 7 to 10 days, otherwise there may be an excessive growth in the first and the second spaces between the nodes to cause the plant to fall. Accordin to Erh-ling Experimental Station of Kiangsu, a deep water level about four days after the tillering has reached its peak is most effective for controlling excessive tillering. The second method is to drain the paddy and to sun the soil. The the plowing layer is deficient in moisture; tillering will naturally stop. But this method is only used in paddies of fertile soil which holds moisture well.

Irrigation and draining measures during the tillering stage should be applied in close coordination with fertilizer application, cultivating, and weeding. When quickly effective fertilizers are applied, the water level should be kept shallow, and if slowly effective fertilizers are applied then the water level should be kept deep. When the soil is cultivated, attention should be given to the consistency of the soil in order to adjust the water level.

(3) From Node Growth to Heading

With the early and the medium varieties, the stage of node growth comes about the same time as the head evolvement; therefore, node growth is a turning point of the plant from the nourishing stage to the reproductive stage.

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With the late varieties of the single-seasoned rice culture, there are usually 10 to 12 days from the stage of node growth to head evolvement, and control over the moisture supply during these days is beneficial to plants about to develop heads as well as for the growth of the stem and the root system.

During the stage of head evolvement, the leaf-area is large, the transpiration is intense, and it is the critical point of water supply for the rice plants. The amount of transpiration of all the varieties amounts to 25 to 30% of the total amount of transpiration during the entire growth period. During this time, the temperature is high. Skillful adjustment of the irrigation system can protect the rice plants from the high temperature, improve soil condition, and invigorate the root system. While the actual water level varies with the local conditions, a constant water cover is the common principle. A water shortage at the beginning of the head evolvement time may inhibit the growth of the stem and the inflorescence and reduce the number of heads. A water shortage during the middle part of the head evolvement stage may cause abnormal inflorescence and failure to bloom. A water shortage during the time when the sexual organs begin to develop may cause the pollen and the egg cells to fail to develop and fertilization may not occur. The farmers say: "Wet flowers and dry heads make half of the rice; dry flowers and dry heads make no rice." According to the experiments of Hua-tung Institute of Agricultural Sciences, if during the first stage of head evolvement, the paddy becomes dry for 7 to 10 days, and the moisture of the surface soil drops to about 54% of the maxium moisture content of the paddy, then, even though the paddy may be flooded at this point, the heading time will be delayed 5 to 7 days. The heads will be small, and the yield will be down 20%.

A survey of Kiangsu Irrigation Station during the August drought of 1959, when the medium and the late varieties need water very urgently, showed that the yield of all the paddies which ran out of water dropped considerably. Wang-chuang Team of Hsin-pei production brigade ran out of water on the 6th of August, and the rate of empty hulls was 50.4%, and the yield was down 57%. All the paddies of Ch'eng-yen Commune of Kao-yu had a rate of empty hulls of 45%, and the yield was down 27%.

During this stage, if there is not a layer of water

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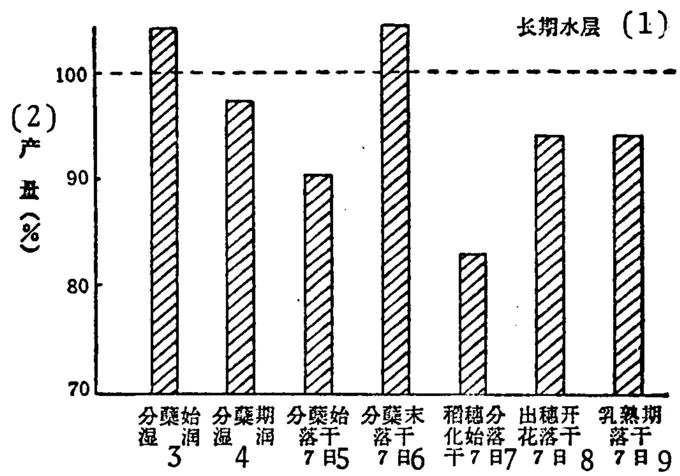
in the paddy, even though the soil moisture is at saturation point, the yield will be less than the paddy which has a layer of water cover. According to experiments in Hupei Province for the early variety of continuous crops (Nan-t'e-hao) when a paddy without a water cover is compared with that of a 11 cm water level during the stage of node growth and head evolvement, the rate of effectual heads of the latter was 6.4% higher, the number of grains was 6% higher, and the yield of each group was 1 g heavier.

According to the test result of Szechwan Province, when damp soil method is used between the stage of node growth and head evolvement (Ta-yeh-tzu Variety) the condition of the heads was very much inferior. (Table 15-11)

Diagram 15-3 The Effect of Draining On the Yield of Late Variety No.853



1. Normal water level 2. Yield 3. Damp soil method begining at the onset of tillering 4. Damp soil method adopted during the tillering stage 5. The paddy is left dry for 7 days at the onset of tillering 6. The paddy is left dry for 7 days at the end of tillering 7. The paddy is left dry for 7 days after the onset of the head evolvement 8. The paddy is left dry for 7 days after the plants have come to a head and bloomed 9. The paddy is left dry for 7 days during the milk-ripe stage

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Table 15-11 Soil Moisture Conditions and the Development of the Head

(Szechwan Provincial Institute of Agricultural Sciences 1959)

处 (1) 理	穗长 (4(厘米)	每穗粒数 (5)	退化枝数 (6)	空壳率 (7) (%)	千粒重 (8) (克)
(2)土壤湿润	19.44	50.3	1.83	31.0	26.38
(3)水层 5 厘米	22.24	74.4	1.32	30.8	27.08

1. Irrigation treatment 2. Damp soil 3. A water level of 5 cm
4. Length of the head (cm) 5. Number of seeds per head
6. Number of degraded stalks 7. Rate of empty hulls (%)
8. Weight of 1,000 seeds (g)

During the period from node growth to heading, a water level is maintained to satisfy the physiological needs of the rice plants as well as for the following reasons:

a. To guarantee the supply of nutrients

During this period, the plant abosrob a great deal of nutrients and the growth is at its peak. When there is a level of water, the supply of nitro-ammonium is stable. Under normal conditions, during the period after the node growth, the nitro-ammonium content of the soil has a tendency to drop; therefore, at the onset of head evolvement, an application of ammonium sulfate is generally the practice; then a water level is kept to preserve the nitro-ammonium.

b. To adjust temperature

When the head is developing, especially during the division of the pollen cells, the plant is very sensitive to environmental conditions. A change of temperature may inhibit the development. Therefore, it is necessary to maintain a suitable level of water for protection.

In the south, the stage of node growth and head evolvement of the medium varieties is in the summer, when the

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temperature at noon may reach above 35°C, while the same development stage of the early varieties is in the spring when a low temperature is quite possible.

Deep water is generally the practice during the stage of head evolvement. According to the test results of Ta-i, Szechwan (Table 15-12) a deep level of water is beneficial to the development of the heads.

Table 15-12 The Effect of the Various Levels of Water during Node Growth and Head Evolvement on Yield

年份 (1)	地点 (2)	品种 (6)	水层深度 (厘米) (10)	穗长 (厘米) (11)	每穗粒数 (12)	空壳率 (%) (13)	千粒重 (克) (14)	产量 (斤/亩) (15)	产量对比 (%) 16
1955	(3) 大邑站	(7) 中农4号	5—7	23.50	121.9	5.00	26.20	726.9	107.5
			2—4	22.60	105.4	8.35	26.00	675.7	100.0
1955	(4) 温江站	(8) 中农4号	7—10	24.90	132.4	7.90	25.34	588.9	108.3
			2—6	23.40	118.6	6.30	25.32	543.7	100.0
1956	(5) 岳池站	(9) 胜利籼	4—6	21.80	76.3	5.74	25.54	699.2	110.8
			2—4	21.00	71.4	4.86	25.20	630.9	100.0

1. Year 2. Place 3. Ta-i Station 4. Wen-chinga Station 5. Yueh-ch'ih Station 6. Varieties 7. Chung-nung No.4 8. Chung-nung No. 4 9. Sheng-li-hsien 10. Depth of water (cm) 11. Length of head (cm) 12. Number of seed per head 13. Rate of empty hulls (%) 14. Weight of 1,000 seeds (g) 15. Yield (chin/mou) 16. Yield compared (%)

According to the test result of Tientsin Institute of Rice Culture, a deep level of water may prevent the young head from degrading. However, if the temperature is high and the air is humid, and if the soil is fertile and cultivation is intensive (such as the deltas of Pearl River and Han-chiang of Kwangtung, and Min-nan and Ping-hai of Fukien), or if the terrain is low and the ground water table is high, or if the fertilizer is applied improperly and the plants

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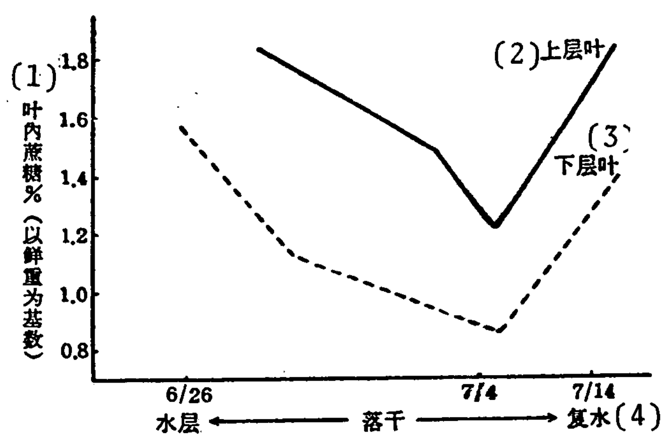
grow extremely fast in the wrong places, or if the soil reductive process is extremely high, then, damp soil method of irrigation may be adopted for this stage also.

c. From heading to ripening

From the stage of heading and blooming to the beginning of pollination, the rice plant is also very sensitive to moisture, and it is still necessary to maintain a water level in the paddy. Under normal soil conditions, a drop of the water level may weaken photosynthesis and reduce the carbohydrate content of the plant. Even though the water may be refilled, the formation of the seeds may be damaged by the temporary lack of moisture. (Diagram 15-4)

During the heading time, there should not only be a level of water; the air should also be moist. If the paddy lacks water, and at the same time, the relative humidity of tha air is around 50%, heading will be difficult. The farmers call this the "mouth locking drought." From July to August 1957, there was a drought in T'ai-chou-shih and Ching-chiang-hsien of Kiangsu, just when the medium varieties were coming to a head. The masses used sprayers to add moisture to the air, and the plants came to a head 2 to 3 days earlier. In Ch'ung-ch'ing-hsien, Szechwan a three-year test was conducted, and the result proved that if the paddy is allowed to become dry during the heading and blooming stage, the rate of empty hulls is increased 2 to 8%, and the yield is reduced 3.7 to 10.5%.

Diagram 15-4 Drought during the Heading Time and the Sugar Content of the Leaves



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1. Sugar content of the leaves (%) (based upon fresh weight)
2. Leaves of the upper level 3. Leaves of the lower level
4. Water level ------- dry -------- water recovered

Table 15-13   Drought during Heading and Blooming Time and the Yield

(Ch'ung-ch'ing Irrigation Experimental Station of Szechwan, 1958)

年份 1	处理 2	穗长 (厘米) 5	每穗粒数 6	秕粒数 7	空壳率 (%) 8	千粒重 (克) 9	产量 (斤/亩) 10
1956	落干 3	24.1	108.2	—	13.27	25.78	520.7
	深水层 (4)	24.6	112.6	—	12.17	25.64	548.8
1957	落干 3	20.1	97.6	8.9	9.14	25.52	537.2
	浅水层 4	20.1	95.6	7.1	7.40	25.70	594.0
1958	落干 3	19.9	73.9	15.2	2.05	23.79	479.8
	浅水层 4	19.9	79.5	9.0	1.13	24.26	497.6

注：1. 品种为川农422中籼稻。 (11)
2. 浅水层为2—5厘米，深水层5—8厘米。

1. Year 2. Treatment 3. Dry 4. Deep water level
5. Length of head (cm) 6. Number of seeds per head
7. Number of ineffectual seeds 8. Rate of empty hulls (%)
9. Weight of 1,000 seeds (g) 10. Yield (chin/mou)
11. 1. Chung-nung No.422, a medium hsien variety was used.
    2. Shallow water level means 2 to 5 cm deep; deep water level means 5 to 8 cm deep.

If the ground water table is high, the soil holds water well, and the soil fertility is high, then, if the water is drained 3 to 5 days before heading time it may help prevent the plants from falling and even encourage the heads to develop better.

In the middle and the lower reaches of the Yangtze, during the heading time of the late varieties of the single

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or double seasoned culture, the temperature has begun to drop. In this case, a deep water level may also serve to keep the plants warm. The weight of the seeds is supplied to the extent of 2/3 by photosynthesis products after heading time. A shortage of moisture supply may weaken photosynthesis; then the weight of 1,000 seeds will drop and the yield will be less. According to Mien-chu Irrigation Experimental Station of Scechwan, a drought at the onset of the heading time may cause the yield to suffer 4 to 11.7%. A drought at the milk-ripe stage may cause the yield to suffer 4.6 to 8.5%. When the rice plant reaches the stage of wax-ripe, its physiological need of moisture drops. From then on, the soil should be kept in a saturated state, or dryer. The problem is the timing of the draining process. If the paddy is drained too early, the seeds may not be very full; if it is drained too late, the ripening process may be delayed and the plant may fall prematurely. According to ordinary experience, the draining should be done at the time of wax-ripe stage. However, in the areas where there is a winter crop (such as green fertilizer and wheat), in order to plow the field or plant the dry crop, the paddy is often drained one week after the wax-ripe stage has begun. This timing has been proved to be beneficial for the yield. If the soil does not hold water well and cracks appear easily on the soil surface after draining, then, **the paddy** may be filled and drained a couple of times afterwards.

Table 15-14 Draining and Yield

品 (1) 种	7 出穗始期断水产量	8 乳熟始期断水产量	9 蜡熟期断水		备 11 注
	%	%	10 斤/亩	%	
新 2 繁谷	89.3	95.4	626.1	100	1954
中农4号 3	—	94.6	726.9	100	1955
谷儿子 4	96.0	—	694.5	100	
新繁谷 5	—	91.5	774.5	100	
川农 422 6	92.7	98.6	636.8	100	1957

1. Variety 2. Hsin-fan-ku 3. Chung-nung No.4 4. Ku-erh-tzu 5. Hsin-fan-ku 6. Ch'uan-nung No.422 7. Yield when the paddy is drained at the onset of heading

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8. Yield when the paddy is drained at the onset of milk-ripe stage 9. When the paddy is drained during the wax-ripe stage 10. chin/mou 11. Note

For the early crop of a continuous rice culture, the paddy is usually not drained unless the plants begin to fall during the ripening stage so as to make it easier to prepare the paddy for the late rice crop.

2. TECHNIQUES OF DRYING THE FIELD [p 434]

The technique of draining and sunning the paddy at the end of the tillering stage and before the evolvement of the head is a unique measure of our country. This measure was described as early as the 17th centuiy in Ch'en-shih Nung-shu, in which it says: "Around the beginning of fall, the paddy is dried or dry raked until the soil begins to have cracks." It also says: "If the draining is done before the autumn, the paddy may be left dry for a few days; if it is done after the beginning of autumn, then, the paddy should be flooded again as soon as cracks appear on the surface." "The draining is to cause the roots to reach for and make the stalks sturdy and robust."

The following is a discussion regarding the technique of sunning and its effects.

(1) The Effect of Sunning

When the paddy is drained, the soil moisture condition changes may trigger a series of physical changes in the soil and affect the physiology of the plants. When the paddy is covered with water, aside from the 1 cm surface, the remaining portion of the plowing layer is in an anaerobic condition, and a reduction layer may be formed. When the paddy is drained, air enters the soil, and its oxygen content increases. (Table 15-15). Thus, such harmful substances as methane and hydrosulfide may become oxided. The activities of the aerobic microorganisms may be renewed so as to promote the mineralization of the organic matter.

Table 15-15 Changes in Soil Condition Before and After Sunning

(1)测定日期		水分状况 8	10 渗漏水中气体含量		电位
2 月/日	3 前后天数		11 二氧化碳（毫克/升）	12 氧气（毫克/升）	13 （毫伏）
7/29	晒田前 5 天4	水9层	74.5	1.54	190
8/7	晒田后 5 天5	42.0 %	53.2	1.74	170
8/15	复水后 1 天6	水9层	18.6	3.40	365
8/17	复水后 3 天7	水9层	41.6	1.71	280

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1. Date of survey 2. month/day 3. Number of days
4. Five days before sunning 5. Five days after sunning
6. One day after the water level is recovered
7. Three days after the water level is recovered
8. Moisture condition 9. Water level 10. Gas content of the drainage water 11. Carbon dioxide (mg/l)
12. Oxygen (mg/l) 13. Electric potential (mv)

When the paddy is being sunned, the moisture content of the plowing layer drops, but the moisture condition of the lower layers does not change much. When the water level is recovered, the leakage will increase. All these changes improve the nutritional environment of the soil and deeply affect the growth of the root system. According to observation, the number of black roots are reduced during the sunning process. The lack of moisture inhibits the growth of the root system, but most of the roots are white (Table 15-16), and more roots grow after the water level is recovered.

Table 15-16 Number of Yellow, White, and Black Roots if the Paddy is Sunned or Not Sunned (the Institute of Plant Physiology Academia Sinica, 1959)

测定日期 (1)(月/日)	处 (2) 理	总(5)根数	白 (6) 根		黄 (8) 根		黑 (10) 根	
			根(7)数	%	根(9)数	%	根(11)数	%
8/6	晒 (3) 田	786	—	—	689	87.66	97	12.34
	不 晒4田	648	—	—	452	69.75	196	30.25
8/8	晒 (3) 田	866	—	—	843	97.33	23	2.67
	不 晒 4田	981	—	—	817	83.28	164	16.72
8/16	晒 (3) 田	970	81	8.35	806	83.00	83	8.65
	不 晒4 田	938	20	2.13	583	61.50	335	36.37
8/18	晒 (3) 田	431	120	27.84	180	41.77	131	30.39
	不 晒 4田	922	26	2.82	422	45.77	474	51.41

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1. Date of survey (month/day) 2. Treatment 3. Sunning process is adopted 4. The sunning process is not adopted 5. Total number of roots 6. White roots 7. Number of white roots 8. Yellow roots 9. Number of yellow roots 10. Black roots 11. Number of roots 12. Note: The paddy is recovered with water on the 16th of August and the 18 th of August

Table 15-17 The Distribution of Assimilation Substances(Carbon^{14})in the Plant Body During the Sunning and Water Restoration Periods

(1) 测定时期		(8) 晒田初期			(12) 复灌初期		
处 2 理	(5) 植物部位	(9) 总重（克）	(10) 脉冲数 cpm	(11) cpm/克	(9) 总重（克）	(10) 脉冲数 cpm	(11) cpm/克
浅水晒田 (3)	茎	0.81	28,050	34,600	1.42	47,200	33,200
	叶	3.22	58,700	18,200	3.87	88,300	22,800
	(6) 稍	4.64	89,000	19,200	7.43	22,800	30,700
浅水不晒田 (4)	茎	1.23	15,100	12,300	0.84	15,950	19,000
	叶	4.15	124,000	29,900	4.21	85,000	20,200
	(7) 稍	6.12	74,000	12,100	6.46	142,000	22,000

1. Testing time 2. Treatment 3. Shallow water and sunning 4. Shallow water without sunning 5. Parts of the plant 6. Stem, leaf, tip 7. Stem, leaf, tip 8. When the paddy is first sunned 9. Total weight (g) 10. Radioactive carbon measurement cpm 11. cpm/g 12. When the water is first restored.

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Table 15-18 Content of Assimilation Substance Compared (Kiangsu Branch, China Academy of Agricultural Sciences 1959)

日 (1) 期	处 5 理	8 蔗糖(%)			9 还原糖(%)		10 淀粉(%)		半纤维(%) 11
		叶片 12	叶鞘 13	14 茎	叶片 15	16 茎	叶鞘 17	18 茎	19 茎
8月4日 (晒田前) 2	晒 6 田	0.58	0.58	0.81	0.21	0.28	—	3.33*	
	7 不晒田	0.66	0.54	0.74	0.16	0.23	—	3.51	
8月11日 3 (晒田后)	晒 6 田	0.91	0.82	1.25	0.22	0.22	0.68	3.16	3.55
	7 不晒田	0.84	0.71	1.19	0.22	0.32	0.39	1.54	3.27
8月18日 4 (复水后)	晒 6 田	0.66	0.63	1.30	0.25	0.36	0.33	3.21	5.15
	7 不晒田	0.65	0.71	1.24	0.25	0.39	0.35	3.48	4.26

注：品种为老来青。晒田日期在8月4日到8月11日生育时期。(20)

* 8月4日分析茎中淀粉和半纤维素的总合。

1. Date 2. 4 August (before sunning) 3. 11 August (after sunning) 4. 18 August (after water is restored)
5. Treatment 6. Sunning the paddy 7. Not sunning the paddy
8. Sugar (%) 9. Reduction sugar (%) 10. Starch (%)
11. Semi-cellulose (%) 12. Leaves 13. Petiole 14. Stem
15. Leaves 16. Stem 17. Petiole 18. Stem 19. Stem
20. Note: The variety is Lao-lai-ch'ing The paddy was sunned from 4 August to 11 August.
*The amount of starch and semi-cellulose found on the 4th of August.

The effect of sunning is also manifested in the root system. Sunning may raise transpiration (Table 15-19), and when the paddy is restored with water, the plant may absorb more potassium. Potassium has the effect of causing the cell wall to be thicker and of improving photosynthesis. As a result, sunning also helps the plant to resist falling.

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Table 15-19 Transpiration of the root system during the Sunning Period and after the Water is Restored

测定日期 (月/日) 1	处 理 (2)	呼吸强度（微升/1克鲜重小时）(5)	%	测定日期 6 (月/日)	处 理 7	8 呼吸强度（微升/1克鲜重小时）	%
8/6	晒 3 田	20.85	110.6	8/16	3 晒 田	23.95	114.6
	4 不晒田	18.83	100.0		4 不晒田	20.89	100.0
8/8	晒 3 田	18.36	115.2	8/19	3 晒 田	23.04	117.1
	4 不晒田	15.93	100.0		4 不晒田	19.67	100.0
8/11	晒 3 田	25.25	111.9	8/29	晒 3 田	16.17	131.5
	4 不晒田	20.00	100.0		4 不晒田	12.29	100.0

注：8月6日至11日是晒田期间，8月16日至29日是复水后。(9)

1. Testing time (month/day) 2. Treatment 3. Sunning process 4. without sunning process 5. Transpiration (ml/1 g of fresh weight per hour) 6. Testing time (month/day) 7. Treatment 8. Transpiration (ml/1 g of fresh weight per hour) 9. Note: The sunning period was from 6 to 11 in August. The period from 16 to 29 of August was after the water had been restored

Another function of the sunning process is to accelerate the elimination of ineffectual tillers so that nutrients may be quickly converted to the main stem. Before the head evolvement, the carbohydrates in the plant body are low, while the sunning process often improves the situation. After the water is restored, these carbohydrates are quickly transferred to the normal growing stem, and thus, during the stage of head evolvement, the plant may have more organic nutrients for the head.

About 7 to 10 days after the water has been restored, the activities of the root system are improved and photosynthesis becomes more intense. These changes prepare a better material basis for the development of bigger heads.

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In conclusion, through inhibiting the ineffectual tillers, promoting the root system, and adjusting the nutrients, the sunning process becomes one of the factors of securing a higher yield.

Table 15-20 Photosynthesis of the Leaves During The Sunning Period and After the Water is Restored (Unit: CO_2 mg/100 cm^2/100 cm^2/hour)

(1) 测定日期 (月/日)	(2) 测定时间	(5) 光合作用强度		(8) 差数 (晒田—不晒田)
		(6) 晒田	不(7)晒田	
8/4	上午 3	8.31	6.74	+1.57
	下午 4	—	—	—
8/7	上午 3	12.39	8.65	+3.74
	下午 4	3.62	3.07	+0.55
8/9	上午 3	5.88	8.03	−2.15
	下午 4	3.97	7.25	−3.28
8/12	上午 3	5.01	6.20	−1.19
	下午 4	6.09	4.64	+1.45
8/17	上午 3	2.48	6.37	−3.89
	下午 4	—	—	—
8/23	上午 3	8.95	11.57	−2.62
	下午 4	6.43	7.35	−0.92
8/25	上午 3	7.37	9.18	−1.81
	下午 4	8.00	7.40	+0.60
9/2	上午 3	8.25	7.38	+0.87
	下午 4	—	—	—
9/8	上午 3	8.82	7.94	+0.88
	下午 4	9.92	8.74	+1.18

注：1. 测定时间：上午在9—10时，下午在14时30分至15时30分。 (9)
2. 8月4日至8月12日是晒田期间，8月17日至9月8日是复水后。

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1. Testing date (month/day) 2. Testing time. 3. A.M. 4. P.M. 5. Photosynthesis 6. With the sunning process 7. Without the sunning process 8. The difference (sunning-no sunning) 9. Note: 1. Testing time: From 9 to 10 o'clock A.M., and from 14:30 to 15:30 P.M. 2. The sunning period was from 4 to 12 in August, and the period from 17 August to 8 September was after the water had been restored.

(2) The Technique of Sunning the Paddy

With regard to pedology, soil sunning is a measure for renewing the nutritional condition of the soil, and its function varies with the characteristics of the soil and its fertility. With regard to plant physiology, the sunning process has the function of both inhibiting and promoting growth. Therefore, the sunning process must be adopted in coordination with the condition of the seedlings and other agricultural techniques.

According to surveys and experiments, the method of sunning the paddy often brings obviously higher yield under the following conditions:

a. In the paddy with fertile soil or in which a great deal of organic fertilizer has been applied

The paddy with green fertilizer plowed in, or with a great deal of not yet completely decomposed organic fertilizer has a tendency of containing highly poisonous reductive products which weaken the nutritional function of the root system. The sunning process oxides these poisonous substances and as a result, promotes the growth of the root system

b. The paddy with a high ground water table and inefficient draining system

The sunning method has always been used to correct badly drained low paddies. It helps the roots to be strong and also improves the yield.

c. When the seedlings grow wild and there is a possibility that they may fall.

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If inproper fertilizer application has caused the seedlings to grow too tall, the sunning process may be used to reduce the nitrogen supply of the soil, limit the nutrient absorption of the root system, and control the growth of the leaves and the stems. But if the paddy is sunned for this reason, the water should be restored before cracks appear on the soil surface.

d. Sunning may check the spread of diseases and insects

In 1959, the survey of the high yield paddies in Chekiang proved that when the paddy has been sunned the relative humidity between the groups was 6.9 to49.6% lower, and the leaf smut disease rate was 27.6 to 49.6% lower. After the treatment of the sunning process, the rate of occurrence of this disease was down 21.2%, and the damage of those paddies which still had this disease was made lighter by the sunning process.

According to a survey of the newly converted rice growing area of Huai-pei, Anhwei, in 1958, the rice plants of the area were attacked by borers. Those of the paddies that had been sunned had stronger stems and leaves, and the borer damage was much lighter. Those paddies are easier to treat with insecticide also. According to surveys of the various regions, the sunning process is also effective against the stinkbugs.

The sunning process is normally carried out during a period when the rice plants are not very sensitive to moisture. The most suitable time is at the end of the tillering stage and before the head evolvement. While the head is developing, sunning is generally not wise. With any given variety, the timing for the sunning process must always be determined according to the stage of growth and the size of the seedling. If the seedlings are large and strong, then, the sunning process should be carried out early. If they are small and weak, then the paddy should be sunned late or not at all.

For some late varieties, the growth season is long, and after the stage of node growth, there are more than 10 days before the evolvement of the head; therefore,

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Ch'en Yung-k'ang (7115 3057 1660) has the experience of sunning the paddy three times. He suns it lightly at the end of the tillering stage to keep the leaves from growing too fast. He suns it thoroughly after the node growth and before the head evolvement in order to make the space between the nodes stronger and the roots deeper. These results will keep the plant from falling and help the head to grow bigger. He suns it again lightly about 3 to 5 days before the plants come to a head to prevent rotten roots and to help the roots develop better ability to absorb nutrients so as to fill the seeds.

How much a paddy should be sunned depends primarily upon the condition of the paddy. High ones should be sunned only lightly; low ones should be sunned thoroughly; fertile ones should be sunned thoroughly; and thin ones should be sunned only slightly. The pasty ones should be sunned thoroughly, the hard soil ones should be sunned only lightly. The clay and poorly drained paddies should be sunned early, thoroughly, and frequently; while the sandy soil paddies should be sunned only lightly. The paddies which leak badly should not be sunned at all. According to the experience of the masses, when a paddy is sunned lightly, the water is restored when your feet no long sink into the soil when you walk in the paddy. When a paddy is sunned thoroughly, the water is not restored until the edge of the paddy has turned white, or there are fine cracks on the surface.

3. METHODS OF IRRIGATION AND DRAINAGE OF THE PADDY RICE FIELD [p 439]

(1) The Basic Types of Irrigation Methods

We have discussed the suitable moisture conditions for the various growth stages of the rice plants; now, we are going to discuss a reasonable combination of moisture conditions for a high yield paddy. According to surveys, there are two basic types:

a. A Constant Water Level Method

This method may again be divided into several types according to the depth of the water level.

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(a) Shallow Water Type

Before the milk-ripe stage, the paddy is regularly kept in a shallow water cover. The depth of the water level does not vary very much during the various growth stages. For example, in the mountain regions of Kwangtung and in the new rice area of Yung-ch'eng, Honan, the early crop is covered with a shallow water level of 4 cm, with the paddy sunned before the head evolvement time. This method is often adopted when the soil hold moisture well, the cultivation is intensive, and the yield is high.

(b) Shallow - Deep Type

With this method the paddy is kept in a shallow water cover until just before the node growth. After that time, the water level is kept deeper. This method is adopted in the lightly or heavily saline soil of Kiangsu. The water level changes from the 3 cm before the node growth to 6 to 9 cm afterwards. This method is adopted more in the north, for the saline soils. In the south, it is adopted sometimes for the hilly regions during the late crop so as to protect the plants from low temperature. Or, it may be adopted because the water resource of the area is poor, and the rice paddy is a good place to store water.

(c) Shallow-Deep-Shallow Type

A shallow level is kept between the time the seedlings turn green to the tillering time. The water level is made deeper from the node growth (head evolvement) time to heading or milk-ripe stage, at which time, it is made shallow again. This method is generally adopted in the Northeast, the North, the Szechwan Plain, and the hills, the Han-chung Plain of Shensi, the hills of Hunan, the areas of Ma-ch'eng and Mien-yang of Hupei, the Hsu-huai new rice areas of Kiangsu, and the southern parts of that province, and in many places of Chekiang and Kwangsi.

b. A Combination of Water Level, Damp Soil, and Sunning

In rice paddy irrigation, the terms intermittent or damp soil method are special concepts of our country's productive practice. The two terms are similar

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but a great deal of difference still exist between the two. With the intermittent method, the soil is left damp and moist between floodings; with the damp soil method, there is no water level at all, and the soil is kept constantly damp in a satuarated state. At present, each time the paddy is flooded, there is always a very shallow water level, but this level is not maintained, and lasts only a short while. In other words, with the intermittent method, the paddy is basically kept under a shallow water cover, while the period when the soil has no water cover and is only damp is very short and temporary; on the other hand, with the damp soil method, the soil is basically kept damp without a water level, and the water level at each flooding is only temporary.

With the methods of a water level and damp soil, combined with sunning, many forms of irrigation methods may be devised.

In the area of Hsia-li-ho and the low paddies of T'ai-hu, Kiangsu, intermittent irrigation is practiced between the tillering time and the milk-ripe time. The masses call this method "three wet days and two dry days," while during the rest of the time, a water level is kept in the paddy. The paddy is also sunned once before the head evolvement time.

In the hills of Hunan, for the early varieties, the paddy is kept with a shallow level of water from transplantation to tillering; then, the soil is only barely covered for the remaining stages of the plant's growth. For the late crop of the low areas of Kwangtung, a shallow level is kept from transplantation to tillering; then the damp soil method is adopted for the remaining stages. In Chekiang and Kiangsi, for the early varieties, only a shallow level is kept from transplantation to tillering; for the remaining time, the damp soil method is adopted.

Apparently, the irrigation method of our country is determined by the two rules of the physiological requirement of the plant and the morphological requirement of the plant.

The physiological requirement of moisture is for transpiration and organic synthesis. It reflects the hereditary reaction toward moisture. This special characteristic is manifested by the different moisture requirements during the various stages of growth. Research studies have already proved that the best moisture condition for paddy rice during

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sprouting time and wax-ripe time is 70 to 80% of the maxium water holding capacity of the soil; for the remaining stages of its growth, the requirement is highly damp soil, or with a water level. For example, during the tillering stage, the photosynthesis and carbohydrate metabolism are very similar whether the paddy is kept with 4 to 6 cm of water or the soil is close to saturation. This extremely adaptable nature of the moisture requirement of the rice plants is one of the reasons why there are so many methods of irrigating the paddies.

Water is also one of the environmental factors, the most obvious of which is its use for adjusting soil temperature. In our country, from the low coastal regions to the highlands of the Southwest, the climate and soil conditions are extremely complicated, and there are also the variations of water resources, technical level, and labor conditions. These conplications constitute another reason for the varied methods of irrigation. Although the arrangement of the irrigation system varies a great deal, a careful analysis reveals the basic similarity, that is the various irrigation systems rely mainly on a water level. Rice is originally a marsh plant, and the flooded paddy is its native home. The goal of the varied system of irrigation is only to adjust the local conditions to make them suitable for a high yield rice culture.

(2) The Basic Irrigation Systems of the Major Rice Growing Areas

Since the irrigation system is formulated in accordance with the moisture requirement of the rice plant and the local environmental conditions, it is difficult to find one system suitable for all the places. Our farmers insist upon "looking at the sky (climate), looking at the ground (soil and ground water), looking at the seedlings (the growth condition), and looking at the water (water resource and construction), and they, in fact, explain fully the principle of irrigation systems. Therefore, the most effective way of establishing an irrigation system for each locality is to summarize the experience of the high yield paddies of that locality. Based upon currently available materials, the irrigation systems of our country may be described basically as follows:

a. The New Rice Areas North of Ch'in-ling and Huai-ho

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This is an arid region. The year's rainfall is between 200 and 750 mm. The soil is mostly calcarious alluvium, desert soil, and some saline soils. These newly con verted paddies leak a great deal, and the problem of water source is not completely solved yet. Therefore, in these areas, the irrigation system is formulated primarily in accordance with water resource, terrain, and soil. It is generally the method of shallow-deep-shallow, with no sunning process. The water level is 3 to 5 cm when shallow, 7 to 10 cm when deep. Water applications are best in 3 to 5 days intervals. The sunning process may be adopted in the older paddies of these areas, if the soil has a higher organic content and is more fertile. The originally slightly saline soils may be sunned if the paddies are basically desalinized. If the soil was once moderately or heavily saline, it should not be sunned because sunning encourages salinization.

b. The Old Rice Paddies South of Ch'in-ling and Huai-ho

In these areas, the air is moist and the rainfall is plentiful, about 750 to 2,700 mm. The paddies soils are formed from red soil, yellow soil, brown soil, purple soil, and alluvium, and they hold water well. They are mostly fertile, and the water resources are sufficient. The masses are very skilled in rice culture. The method of shallow-deep=shallow may be adopted here in coordination with the sunning process. (Shallow water should be 1 to 5 cm in depth, and deep water should be 5 to 9 cm in depth.) The measures of wet plowing in deep water, and wet raking in shallow water should also be adopted. When organic fertilizer has been applied, the water level should be deep, and when chemical fertilizer has been applied, then the water level should be shallow. If the paddy is low, then the short periods of damp soil and the sunning process should be applied for soil improvement. In the mountainous regions, the irrigation system should be based upon the effective use of rain water, and the paddies may be irrigated lightly and at the same time may be used to hold deep levels of rain water for storage.

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4. SETTING UP A SYSTEM OF IRRIGATION AND DRAINAGE DITCHES IN THE PADDY RICE FIELD [p 442]

A reasonable and planned irrigation system can be guaranteed only by a good quality engineering structure of the paddies. A complete irrigation arrangement controls the moisture shifting and storage of the irrigation district, and water may be poured or drained as the condition required. This type of arrangement includes the network of channels, roads, and field dikes, which are designed in accordance with the local hydrography and agricultural production. The following is a description of the arrangements of the various areas:

(1) The Plains

When the land is flat and large, the irrigation system should be arranged for the convenience of machine cultivation. There are generally the five grades of Kan-chu [main channel], Chih-chu [Branch channel], Tou-chu [Small channel], Nung-chu [Subdivided channel], and Mao-chu [Fine channel]. If the irrigation district is small, three or four graded systems may also be used. All these channels are connected with one another, and Tou-chu is generally the unit for flooding and draining, and usually controls about 200 to 800 mou of paddies. The Tou-chu in Tientsin is generally 1,000 to 1,500 m long, and the space between two Tou-chu should be 200 m, so as to facilitate machines, transportation, and irrigation management.

There are two ways of arranging Tou-chu. The irrigating channel and the draining channel may be arranged alternately (Diagram 15-5) or they may be arranged next to one another (Diagram 15-6). With the first method, one person may look after the paddies on both sides of the irrigation channel and can easily take care of 180 mou. The distances between two irrigation channels are shorter, and the distance between the irrigation and drainage channels keep the water from seeping into the latter. But, the dikes of the irrigation channel are thus in the center of the paddy, and leveling of the paddy is thus very difficult, and this fact also makes this method unsuitable for any large area with a surface slope. With the method of arranging the irrigation and drainage channels next to one another, one person can only take care of 140 mou, but it is easily built and surface leveling is no problem. This method may be adopted on a sloped ground surface.

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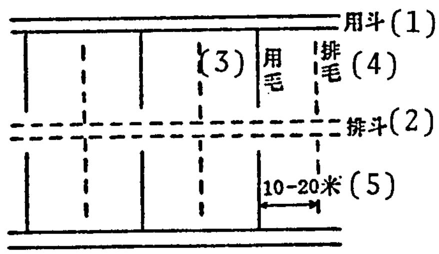
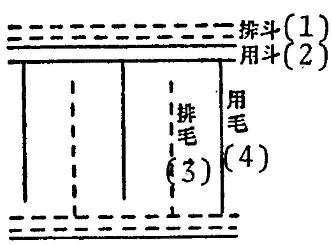
Diagram 15-5 Surface View of Tou-chu, with the Irrigation and Drainage Channels Arranged Alternately



1. Irrigation tou /channel/ 2. Drainage tou
3. Irrigation mao /fine channel/ 4. Drainage mao
5. 10-20 m

Diagram 15-6 Surface View of Tou-chu, with the Irrigation and Drainage channels Arranged Next to One Another



1. Drainage tou 2. Irrigation tou 3. Drainage mao
4. Irrigation mao

The road, the channel, and the ditch are arranged parallel to one another in either method as shown in Diagram 15-7, and Diagram 15-8.

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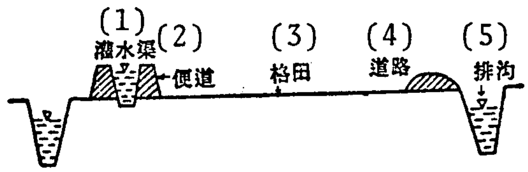
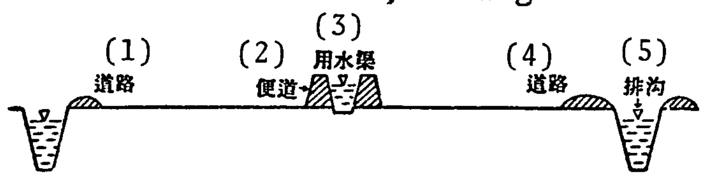
Diagram 15-7 A Cross Section View of the Irrigation Channel and the Drainage Ditches, Arranged next to One Another



1. Irrigation channel 2. Small walk 3. Dividing dike
4. Road 5. Drainage ditch

Diagram 15-8 A Cross Section View of the Irrigation Channel and the Drainage Ditches, Arranged Alternately



1. Road 2. Small walk 3. Irrigation channel 4. Road
5. Drainage ditch

The small channels in the paddies for direct irrigation and drainage are generally called mao. These fine channels are the last in the grades of channels, and they are very numerous. The are arranged perpendicular to Tou-chu or Nung-chu, and they are as long as the distance between the two Tou-chu. The irrigation mao and the draining mao are always arranged alternately, generally about 20 to 40 m apart. If the distance is too wide, it is not easy to drain the paddy thoroughly. Each mao controls about 10 to 25 mou of rice paddies.

The paddies are divided by temporary dikes. The larger each of the paddies, the less area these dikes take up. However, if the paddies are large, considerable labor is needed to level the surface. Generally each paddy is about 1 mou, depending upon the location, but never larger than 5 mou. The best shape is a rectangle of 1.5 : 2. The dike is usually 0.3 m high, with the bottom about 0.9 m wide, and

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the top about 0.3 m wide. The tractor road is about 8 m wide.

(2) A Water Network Style

It is adopted mostly in the low areas. There are two ways of arranging the network:

a. The main channel is built on the higher grounds of the surrounding areas, and the existing streams are used as much as possible. The drainage ditches are built in the center of the area to be drained so as to drain more efficiently.

b. Both the irrigation channel and the drainage ditch may be built in the center part of the area. This arrangement is more suitable for areas with the center higher than the surroundings.

When either method of arrangement is used, the smaller channels are generally arranged in the shape of + or ++ . All these ditches or furrows are linked together to form a network; the areas covered are determined by the conditions of terrain and water resources.

(3) The Hilly Mountain Regions

When the slope is large, irrigation depends mainly upon conserving the water resources. The irrigation network is designed mainly to store water. There are usually the following two arrangements.

a. The Channel System for the Area with Plenty of Water Resources

With this method, channels are built to connect the existing streams, ponds, and reservoirs to enlarge the water resources. This method is also called"a long melon vine." The river or stream are the roots, the artificial channels are the vines, and the ponds and reservoirs are the melons. The purpose of this method is to store water all year long for the use of a given short period. The rivers, streams, and ponds, surround the mountains and the hills, to check the flow of the water to be used to irrigate the paddies.

b. The Channel System for the Area with a Single Water Supply

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In this case, the normal arrangement is to place the pond or reservoir at the foot of the mountain, with paddies below it. The irrigation and drainage channels are built at the foot of the two mountains, and the paddies are in the middle of the two.

The method of digging irrigation channels all around the mountain has the advantage of storing all the water that flows off the mountain, and thus enlarges the source of water and reduces erosion. It may also prevent the mountain flood water or the cold spring water from damaging the rice plants.

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SECTION 3. TECHNIQUES OF IRRIGATION AND DRAINAGE IN PADDY FIELDS IN SALINE AND ALKALI SOIL [p 445]

As early as 2,300 years ago, saline soils were utilized in our country for rice paddies, however, the technique was never developed further until after the liberation. Since then, following the development of water conservation projects, the experience of the masses regarding the use of saline soils for rice paddies has also been summarized and popularized. For example, the state-operated Huai-hai Farm converted the meadow saline soils of the coastal region into rice paddies. These soils originally contained about .15 to .4% of chlorine salts, and after one year's use as rice paddies the saline content has been down to 0.1%. After two year's use, the top desalinized layer is as thick as 60 cm, and it is 1 to 1.2 m thick after three years. The saline soils of T'uan-p'o-yu, Tientsin contained an average of 1.75% of salts in the top 0 to 30 cm layer, and after being converted into rice paddies, for one year, the saline content is down to .21%; after 2 to 5 years, it becomes stabilized to .1 to .3. At present, these barren lands of the past are being used for rotated paddy and dry crops.

To convert saline soils into rice paddies, we must have water to improve the soil. To irrigate these paddies, the technique is different from that of the ordinary paddies. The following is a description of the major aspects of this problem:

1. TECHNIQUES OF WASHING AWAY THE SALT BEFORE PLANTING RICE [p 445]

(1) Leveling the Paddies

The paddies of the saline soils must be more carefully leveled than those of other soils. There should not be a difference of 3 to 5 cm in height within a given paddy; otherwise, not only is more water needed, the effect of desalinization will suffer also. If the moisture condition

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is good (including precipitation), the higher areas may be desalinized better, and the seedlings will grow better. If the moisture condition is not good, the higher areas may become exposed above the water, and the capillary movement of the soil will cause the saline content to rise to the surface. In this manner, the higher areas will not be desalinized at all. Therefore, land leveling is an important measure before the rice plants are planted.

As a first step, the area within the space between two fine channels (irrigation mao) is considered as one unit (about 10 to 20 mou) is to be leveled. The soil of the higher places are taken to fill the lower places. Then contour dikes are built around each of the units. Then, the paddies are plowed and raked, and wet plowed and wet raked so that the surface is truly leveled. A complete irrigation system must then be built, before the paddies are ready for the rice plants.

(2) Soak and Wash the Salts

In order to make certain that the saline content of the soil is less than the critical margin required by the rice plants, the paddies are soaked first to drain off some of the salts. Generally speaking, in the chlorine salt regions, the salt content must be lower than .15% in the top 30 cm of soil; in the areas of sodium salts, the saline content must be lower than .2 to .3%.

If the soil is permeable, and the ground water table is more than 1 m, then the vertical washing method may be used, i.e. fill the paddy with irrigation water, and wait till the water drains down naturally. In areas such as Ta-yu-chang of Shantung, 200 c.m of water per mou is needed to soak and wash the paddy twice, and afterwards, the saline content of the surface soil may be reduced from 1.1% to below .3%. (Diagram 15-9) From then on, as long as a water level is maintained in the paddy, the rice plants may grow normally.

If the soil is not very permeable, or if the ground water table is less than 1 m, and then, the saline content of the soil is more concentrated in the surface layer, and the surface washing method should be adopted. According to the experiment in Honan (Diagram 15-10) if 90 c.m of water is used for surface washing the saline content of the 20 cm layer may be reduced from .25 to 0.05%. With the same amount

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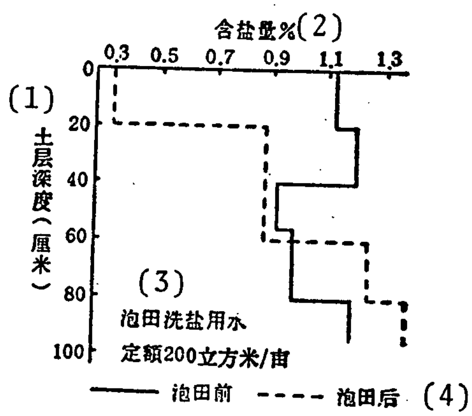
of water, the effect is less, if the vertical method is used.

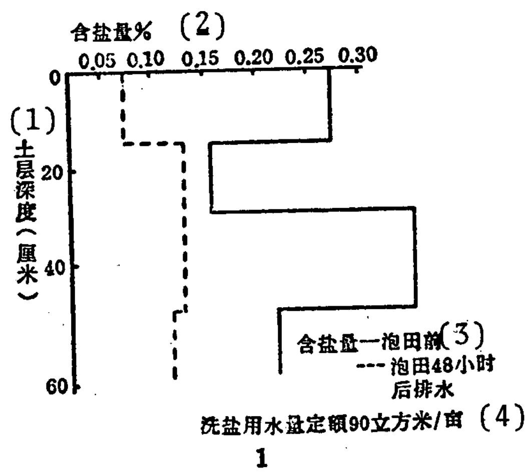
Diagram 15-9 The Variation of Saline Content in the Coastal Saline Soil Before and After Soaking and Washing



1. Depth of soil (cm) 2. Saline content (%)
3. Water used for Soaking and Washing : 200 c.m/mou
4. ______ before soaking and washing ---- after soaking and washing.

Diagram 15-10 The Effect of Soaking and Washing on Soda Soils

1. Surface Washing



1. Depth of soil (cm) 2. Saline content (%)

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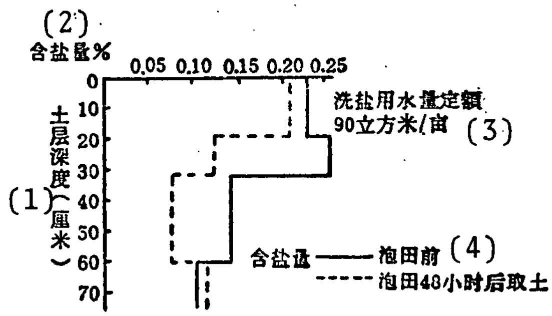
3. Saline content ___before soaking ---- soak 48 hours then, drain
4. Water used for soaking and washing:90 c.m/mou

2. Vertical Washing



2

1. Depth of soil (cm)   2. Saline content (%)
3. Water used for soaking and washing : 90 c.m/mou
4. Saline content ____ before washing and soaking
   ---- tested the soil after beging soaked for 48 hours

The Amount of water needed for soaking the saline soil is determined mainly by the saline content, the type of salts, the soil condition, the ground water table, the drainage condition, and the cultivating method. According to the test results, the amount needed is as follows:

Table 15-21   The Soaking Times and the Amount of Water needed for Different Saline Contents

(1) 盐碱强度	轻 (5) 度	中 (6) 度	重 (7) 度	强 (8) 度
(2) 土壤含盐量(%)	0.3以下	0.3—0.6	0.6—1.2	1.5以上
(3) 洗盐定额(立方米/亩)	70—100	100—200	200—250	250—300
(4) 洗盐次数	1	1—2	2—5	3—4

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1. Saline content 2. Saline content of soil (%)
3. Water used for washing (c.m/mou)
4. Number of soaking and washing
5. Light 6. Medium 7. Heavy 8. Extremely heavy

The desalinization effect is related to the irrigation method adopted. The lower paddies must be washed first; then, there must be a water level on the lower paddies when the saline content of the soil has been washed down to below the critical level. The pressure of the water level on the lower paddies may prevent the saline content of the higher paddies from seeping down when they are being washed. When the paddies are being leveled, the drainage ditches must be closed before the paddies are filled to 4 to 5 ts'un. After the soil is completely covered for a certain period of time, the drains should be opened to let out the salt water. When the water is down very low just above the soil surface, the second filling should begin. This time, the water level should be only 2 to 3 ts'un. If only two washing actions are planned, the dikes should be mended this time, and the drainage ditches should also be closed so that the paddy is ready to be wet raked for transplantation. If the saline content of the soil is more than 1%, continuous washing is necessary to make the soil suitable for the rice plants, and the dikes are mended after the last washing. If the soil contains very little salts, then, the paddy may be prepared while the soil is being washed.

We must point out that cultivation is also important to desalinization. The soil may be improved by autumn plowing and sunning. Because, this measure cuts the capillaries of the soil, so that less salt may rise from the lower layers. Sunning and freezing processes make the soil loose and dry, so that washing action may become more effective. Experiments proved that the less is the moisture content of the soil, the dryer are the soil granules before washing, the more water the soil will absorb, the faster will the salts dissolve, and therefore, the better is the desalinization effect of the washing process. (Table 15-22)

Besides, the higher is the water temperature and the atmospheric temperature, the better the desalinization effect. Therefore, if the water temperature may be raised, or the process may be conducted on clear and warm days, better results

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may be obtained.

Table 15-22 The Moisture Content of the Soil before Washing Time, and the Desalinization Effect

(1) 处理 (2) 项目 (3) 取土深度 (厘米)	1			2		
	4 含水量 (%)	5 冲洗前 NaCl %	6 冲洗二次后 NaCl%	7 含水量 (%)	8 冲洗前 NaCl %	9 冲洗二次后 NaCl %
0—10	21.66	1.84	0.46	16.00	1.39	0.25
10—20	22.14	1.30	1.02	20.75	2.50	0.95
20—30		1.10	1.47		1.47	1.44

1. Treatment 2. Item 3. Depth from which the soil sample was taken (cm) 4. Moisture Content (%) 5. Before washing 6. After two washings 7. Moisture content (%) 8. Before washing 9. After two washings

2. TECHNIQUES OF IRRIGATION DURING THE GROWTH PERIOD [p 448]

The important aspects of irrigating the saline soils are as follows:

(1) The paddy should be constantly covered.

The water level is maintained not only to satisfy the moisture requirements of the rice plants; it also provides pressure to keep the salt down so that the saline content will continuously drop during the growing season. The method of "shallow-deep-shallow" may be adopted through out the growing season. With the clay soil, the water level should be shallow during transplantation; it should be deeper for the sandy soils, about 2 to 5 cm. According to the two-year observation at T'uan-p'o-yu of Tientsin, if a water level is kept at 4 to 6 cm, and the water is periodically

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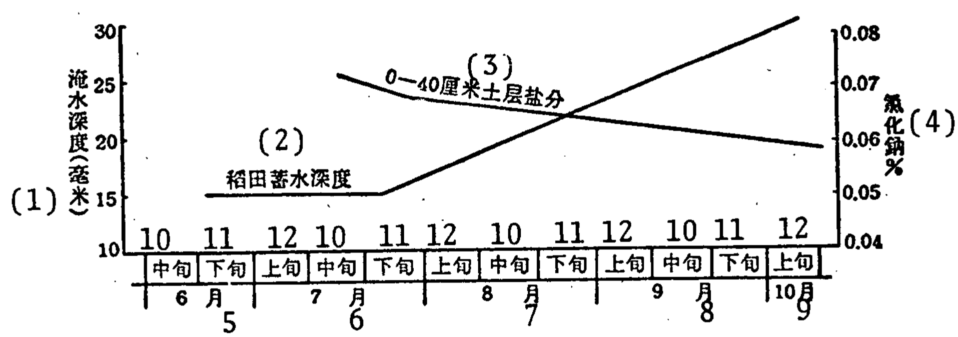
replaced, the survival rate of the seedlings may be higher than 95%. If damp soil and a water level are used as alternate practices, only about 60 to 80% will survive. If the water level is as deep as 10 to 12 cm, then, the survival rate will drop to 60 -75%. This is due to the fact that before the seedlings turn green again, they can withstand neither salts nor drought. (Diagram 15-11)

If the saline content of the soil is very light, then the irrigation method may be the same as ordinary paddies. Aside from the tillering stage, the damp soil method should not be used, and unless there are signs of falling, the paddy should not be sunned. If the saline content of the soil is high (more than 0.6%), then a water level should still be kept at all times, and should be gradually deeper toward the later stages of the growth of the rice plants.

Diagram 15-11 Depth of Water during the Growing Season and the Variation of the Saline Content
(Special Bureau of Water Conservation, Yen-ch'eng, Kiangsu)



1. Depth of the water (cm) 2. Depth of water in the paddy
3. Saline content of 0-40 cm lay of soil
4. Sodium chloride % 5. June 6. July 7. August
8. September 9. October 10. Middle 10 days
11. the Last 10 days 12. The first 10 days

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(2) Fresh Water Irrigation and Periodical Changes of Water

Periodical changes of water may reduce the saline content of the soil and the water in the paddy. This measure is especially important for the saline soils which are not very permeable.

Experiments conducted in Li-shu Irrigation District of Kirin (Table 15-23) proved that if the water is not periodically changed, the saline content of the water may increase from the original .127% at the beginning to .47%. This condition may cause the plants to grow poorly and the yield suffers. The experiment in 1958, conducted in Hsin-hsiang Hsiao-ho proved that when the water of the paddies of soda soil is changed every two to three days, the saline content of the water is 0.548 g/l, and most of the rice plants grow very well. In the paddies where the water is changed every 6 to 7 days, the saline content of the water reaches 228 g/l, and most of the plants are stunted. However, if the water is changed too often, more water is used, more nutrients are washed away, and the yield does not increase. Therefore, the frequency of the water changes depends upon the conditions of the soil and the water, and must be determined by tests.

Table 15-23 The Growth of the Plants and the Various Methods of Irrigation (Li-shu Irrigation District Kirin)

处 (1) 理	(5) 田间水含盐量(%)较泡田时增减情况				株 高 (厘米) (10)	穗 长 (厘米) (11)	千粒重 (克) (12)	灌 水 定 额 (立方米/亩) (13)	排 水 定 额 (立方米/亩) (14)
	5月16日 (6)	8月16日 (7)	增减量 (8)	增 减 (%) (9)					
(2) 活水灌溉(勤灌勤排)	0.408	0.114	−0.294	−72	66.8	13.6	24.97	1,613	1,428
(3) 死 水 灌 溉	0.127	0.465	+0.338	+266	63.5	13.7	24.2	577	156
(4) 定 期 换 水 灌 溉	0.324	0.163	−0.161	−49.7	67.7	14.2	24.93	670	374

1. Treatment 2. Fresh water irrigation (frequent irrigating and frequent draining) 3. Still water irrigation

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4. Periodical changes of water 5. Saline content of the water in the paddy (%) compared with the washing time
6. 16 May 7. 16 August 8. Increase or decrease
9. Increase or decrease (%) 10. Height of stalk (cm)
11. Length of head (cm) 12. Weight of 1,000 seeds (g)
13. Water used for irrigation (c.m/mou)
14. Water drained (c.m/mou)

The rice plants react to salts differently during different stages of growth. In the sodium chloride soils, the salt content should not be more than .15% during the period when the seedlings are turning green, not more than .3% during the tillering stage, and not more than .4 to .5 % during the later stages. In the carbonate soils, the saline content (CO_3) should not be above .1% during the early stage. The frequency of water changes should be determined by the saline content of the water in the paddy and the stage of growth of the rice plants.

When the water is being changed, the best way is to drain the salty water out first before filling the paddy with fresh water again. However, in some areas there may be a labor shortage; then, the drainage channel may be adjusted to drain the water slowly while fresh water is being filled in, so that a constant water level may be maintained. In the paddies of permeable soil or the coastal saline soil the water needs not be changed at all.

(3) Single Irrigating System

Each group of paddies should be irrigated separately, instead of making the lower paddies take the water from the higher paddies. According to tests conducted in the new rice areas of Kiangsu, when each row of rice paddies is irrigated separately, the water of the paddies contains o.264 g/l of chlorine ions, while if the lower paddies take the water from the upper paddies, then, the water contains 0.4 g/l of chlorine ions. The difference is almost 51.6%. When the latter method is practiced in Li-shu Irrigation District of Kirin, the growth of the rice plants is poor, and the yield is 22% less than with paddies that are irrigated separately (Table 15-24).

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Table 15-24 The Effect of Single-Row Irrigation System on Yield

项 (1) 目	(4) 株高（厘米）	(5) 穗长（厘米）	(6) 每穗粒数	(7) 产量（斤/亩）
(2) 单灌单排	87.2	15.1	61.7	770.0
(3) 串灌串排	80.3	11.3	57.0	634.7

1. Item 2. SeparateLy irrigated single row of paddies
3. Many rows irrigated together 4. Height of stalk (cm)
5. Length of head (cm) 6. Number of seeds per head
7. Yield (chin/mou)

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SECTION 4. TECHNIQUES OF IRRIGATION USING COLD WATER, DIRTY WATER, SALT WATER AND MUDDY WATER [p 450]

To use cold water, dirty water, salt water, or muddy water for irrigation is a unique technique. It has been tried in our country during recent years, and good results have been obtained. The following is a description of our experience in this subject.

1. COLD WATER IRRIGATION [p 450]

The use of water of low temperature for irrigation often brings bad effects to the nutrient absorption capacity of the root system and the growth of the above ground portion of the plant. Therefore, when high mountain snow, mountain springs and well water are used for irrigating the rice paddies, measures to adjust the temperature of the water must be taken. The water source of Tu-chiang-yen Szechwan is snow. The melted snow flows two to three hundred li through dense forests and mountain valleys to reach the irrigation district. The water flows fast all the way, and is not exposed to sunlight to any great extent. Therefore, during the growth season of the early and the medium varieties, the water is too cold for irrigation. Tests showed that the temperature of the water in the irrgation channel is 2 to 3°C lower than the water in the paddy. This condition is not good for the rice plants. In Hou-ho-hsiang, Wang-ch'ing-hsien, Kirin, the mountain spring water is used for irrigation, the average water temperature in July is 13 to 14°. A survey in Kuang-hua-hsien of Hupei shows that when temperature is 28°C, the temperature of the spring water is about 18°C. This type of cold water will cause the rice plant to delay the ripening stage, and increase the rate of empty hulls. Generally the following methods must be adopted to raise the temperature of the water in these areas:

(1) Make the water flow a longer distance before reaching the irrigation channels

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When the water is made to flow a longer distance before it reaches the irrigation channels, it may have a better chance of being warmed up by the sunlight. Surveys in Ho-p'u-hsien of Kwangtung showed that a distance of 257 m may raise the temperature of the water 1°C. If the flowing distance is 820 m, then the water may be 3°C higher in temperature. In Tu-chiang-yen Irrigation District of Szechwan an irrigation system is so designed that the water flows around many times before it reaches the paddy. Thus, in March, April, and May, the average water temperature is raised 1.6, 1.3, to 2.7°C, and an increased yield of 8.5% is obtained. (Table 15-25)

Table 15-25 The Effect of the Round-about Irrigation Method on the Yield (Szechwan Institute of Agricultural Sciences, 1959)

项 (1) 目	(4) 最高分蘖数	有效分蘖率 (5) (%)	每穗粒数 (6)	千粒重 (7) (克)	产量 (8) (%)
(2) 宽沟迂回灌水	28.2	71.2	44.6	26.08	108.5
(3) 对照	25.6	60.5	49.8	25.52	100.0

1. Item 2. Wide channel, round-about irrigation system
3. Control group 4. Highest number of tillers
5. Rate of effectual tillers (%) 6. Number of seeds per head
7. Weight of 1,000 seeds (g) 8. Yield (%)

(2) Store the Water until It is Warm

The reservoirs and the irrigation channels may be used to store water until it is warmed up. According to the surveys conducted in Lo-t'u-hsiang, Wang-ch'ing-hsien, Kirin, in May, the temperature of the water in the reservoir was 5 to 6°C higher than that of the irrigation channel. In Mo-ho, Heilungkiang, when rice was tested in 1959, the water of the reservoir was found to be more than 4°C warmer

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than the water in the paddy at 7 o'clock in the morning. With the result of this survey, it was decided to irrigate lightly in the morning, deeply at noon, and still deeper at night. The yield was improved obviously.

(3) Adjust the Water Level

Shallow water absorbs heat faster, and deep water disperses heat slower. Therefore, the paddy may be filled lightly in the morning so that the shallow water may absorb the heat from the sun. At night, before the temperature drops, the water level may be made deep to reduce the drop of the temperature.

2. DIRTY WATER IRRIGATION [p 452]

With the development of industries and cities, there is a great amount of dirty water. For example, Fushen alone drains 300,000 tons of industrial waste water a day. After certain treatment, this waste water may be made a source of water and fertilizer for the rice paddies. So--called dirty water includes sewage water of the people and the waste water of the industrial plants. Sometimes, the water contains such poisonous substance as the chlorides, phenols, and oils; therefore, it must be analyzed first before using.

At present, the waste water of the coal mines, the petroleum refineries, wool plants, and leather plants are being successfully used as irrigation water.

When such waste water is used, the yield of the rice paddy obviously increased. In 1956, Wan-yen-ch'ing Agricultural Cooperative of western suburb of Tientsin used waste water to irrigate its 130 mou of rice paddies. It was originally estimated that the yield should be 500 chin per mou. Since the water was rich and fertile, the yield was finally 800 to 900 chin per mou. Shanghai People's Commune of Wushen, Liaoning used the waste water of a petroleum refinery as its irrigation water to irrigate its 11,300 mou of rice paddies. Compared with its 255 mou of rice paddies which were irrigated by fresh water (with 20 to 50 chin per mou of ammonium sulfate added), the yield of the paddies irrigated with the waste water produced 30% more. This type of waste

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water contains a great deal of nitrogen, and therefore, is a good fertilizer as well. The results in Chu-chou, Hunan, Peking, and Chi-nan-shih, Shantung were similar.

To use the sewage water or the industrial waste water for irrigation is actually a combination of irrigation and fertilizer application. Therefore, with each application of water, the amount of fertilizer brought by the water must be calculated, and the possible poisonous substance the water may contain must be considered also.

Table 15-26 The Nutritional Content of the Waste Water

取样地点 (1)	污水种类 (7)	(10)养分含量（每升毫克）		
		氮 (11)	(12) 磷	(13) 钾
上海市长征人民公社 (2)	生活污水 8	209.00	19.13	16.30
北京市右安门(3)	生活污水 8	26—50	7.00	19.00
北京清河制呢厂洗毛车间 4	工业废水 9	584—897	35—57	86.30
南京紫金山人民公社 (5)	生活污水 8	30.00	10.50	99.50
南昌市青云谱人民公社 6	工业废水 9	25.20	—	13.49

1. Place where the sample was taken 2. Ch'ang-cheng People's Commune, Shanghai 3. Yu-an-men, Peking 4. Wool washing machine shop, Ch'ing-ho Wool Plant, Peking 5. Tzu-chin-shan People's Commune, Nanking 6. Ch'ing-yu-p'u People-s Commune, Nanking 7. Type of waste water 8. Sewage 9. Industrial waste water 10. Nutritional content (mg/l) 11. Nitrogen 12. Phosphorus 13. Potassium

(1) To Mix Waste Water with Fresh Water

In Wu-shen, when the waste water was used to irrigate the rice paddies, the nitrogen content of the soil reached 0.3%, and as a result, the rice plants lost balance, and grew so fast that they fell and they suffered from the blight disease. Therefore, it is safer to use the waste water with the fresh water, in the proportion of 1 to 4. The two kinds of water may be mixed first before irrigation, or the paddy may be irrigated alternately with the two kinds

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of water. According to the experience of Tientsin, when the waste water is used for irrigation, the nitrogen content may be limited to 20 chin per mou, and it should not be higher than 24 chin per mou. If used too much, the plants will tiller ineffectually, the weight of 1,000 seeds will be less, and the yield will be smaller.

Table 15-27 Effect of Irrigation with Waste Water on the Yield

灌溉次数 (1)	土壤 (2)	出穗期 (月/日) (4)	分 (5) 蘖		每穗粒数 (8)	千粒重 (9)(克)	每穗秕粒数 10	产量 (斤/亩) 11
			有效 6	无效 7				
3	3 黑粘土	8/20	17.9	2	99.5	23.0	14.3	700.6
6	3 黑粘土	8/20	15.45	0	95.5	18.7	23.6	688.0
7	3 黑粘土	8/20	13.5	4	93.2	15.4	48.2	504.0

注：品种为银坊。12

1. Number of times the paddy was irrigated
2. Soil 3. Black clay soil 4. Heading time (month/cay)
5. Tillers 6. Effectual 7. Ineffectual 8. Number of seeds per head 9. Weight of 1,000 seeds (g) 10. Number of empty hulls per head 11. Yield (chin/mou) 12. The variety Yin-fang was used for the experiment.

(2) To Irrigate according to the Condition of the Seedlings

Just after transplantation, the young seedlings cannot resist any harmful substance, and requires a soil environment with plenty of oxygen. The waste water itself consumes a good deal of oxygen, and contains other foreign substance which may suffocate the young seedlings. Therefore, the waste water must not be used before the seedlings are at least 1 ts'un high. Before transplantation, waste water is not normally used for soaking the paddies. If waste water is used to irrigate sandy soil, the paddy must be plowed and raked while being filled so that less water may be needed, to

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avoid excessive nitrogen.

(3) The Temperature of the waste water

The waste water of the industry is often very warm. It may be used early in the morning or late at night so that the temperature of the water in the paddy, especially in the summer, will not be too high for the rice plants.

(4) Settling and Oxidization of the Waste Water

To use waste water for irrigation, it is necessary to have a pond near the paddies for the special purpose of settling and oxidizing the waste water before it enters the paddy.

3. SALT WATER IRRIGATION [p 453]

This is part of the precious experience of our farmers. Since the liberation, many areas of the saline and soda soils have been converted into rice paddies, after being soaked and washed. About 40 to 70% of the irrigation water for these paddies seeps through to the ground water, and another portion flows through the drainage ditches. This type of drainage water contains 1 to 10 times more salts than the fresh water. In order to solve the problem of water sources for irrigation, the masses discovered the method of using the salt water of the drainage ditches. This method is, in essence, to use the same water over and over again until the saline content of the water is such it is harmful for the rice plants. According to surveys in Tientsin, in 1958, during the drought season, many rice paddies were irrigated with the drainage water over and over again. In areas of Kirin, Liaoning, and Heilungkiang, there is also such a practice, which may save as much as 1/3 to 2/3 of the amount of water used for irrigation. According to information from Tientsin, the rice plants may withstand the following degrees of saline content in the irrigation water. (See Table 15-28)

When the saline content of the water is not such that it may harm the rice plants, it may be used to irrigate, but the water level should be kept shallow, and gradually be made deeper. When the water contains too much salt, then

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fresh water may be added to dilute it.

When saline water is used, the water level should be constantly kept so that the soil may not be salinized again. If the soil is not very permeable, it is also necessary that the water should be periodically changed.

The various varieties can withstand salts differently. Ta-hung-fang is more saline resistant than Yin-fang and Shui-yuan. The seeds of the plants which were irrigated with saline water will grow plants more saline resistant than the parents. The old seedlings are more saline resistant than the tender ones.

Table 15-28 Saline Resistant Characteristic Throughout the Growth Stages

盐土类型 (1)	灌溉水主要成分 (3)	(5) 生育期	(10) 灌溉水盐分含量(%)		
			11 可用浓度	12 受抑制	13 受盐害
(2) 氯化物盐土	(4) 氯化钠为主	6 返青期	0.1—0.12	0.12—0.2	>0.3
		7 分蘖期	0.1—0.2	0.3—0.4	>0.4
		8 拔节、孕穗期	0.2—0.3	0.4—0.5	>0.5
		9 灌浆期	0.3—0.4	0.5—0.6	>0.6

注：品种为银坊。(14)

1. Type of saline soil 2. Chloride saline soil
3. Major content of the irrigation water 4. Mainly sodium chloride 5. Growth stages 6. The seedlings turn green
7. Tillering 8. Head evolvement , **node** growth
9. Ripening 10. Saline content of the irrigation water
11. Utilizable density 12. the density when the growth of the plant is stunted 13. The density when the plants are damaged by the salts 14. The variety Yin-fang was used for testing.

4. MUDDY WATER IRRIGATION [p 455]

The irrigation water of the areas of the North often contains a great deal of mud and sand. The water is not clear. Huang-sheng-li Channel of Honan contains 1 to 2% of mud and sand in its water, sometimes, as high as 6%. Ma-ch'ang-ho of Hopei contains 0.4 to 0.8% of mud and sand in its water, and during the flood season, as much as 2 to 4%.

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The muddy water contains more nutrients. Analysis shows that the water of Ma-ch'ang-ho contains 0.103% of nitrogen and 2.7% of potassium. The 1958 analysis of the water of Hsin-hsiang-hsiao-ho of Honan shows that it contains 0.87% of organic matter, 0.075% of nitrogen, 0.0014% of quickly effective phosphorus, and 0.0034% of quickly effective potassium. Therefore, muddy water may improve soil fertility. The mud it contains is mostly powdered sand (81% of it has a diameter of 0.01 to 0.05 cm) and sticky particles (with 1.25 to 1.5% of the particles less than 0.01 in diameter.) These particles are brought to the paddies and they act to improve the soil. They are particularly good for the saline soils. (Table 15-29)

Table 15-29 The Effect of Muddy Water Irrigation on the Saline Content of the Soil

(1) 盐类 / (2) 含盐(%) / 土层 (3) (厘米)	(4) 氯		(5) 硫酸		(6) 重碳酸	
	淤 7 前	淤 8 后	淤 7 前	淤 8 后	淤 7 前	淤 8 后
0— 35	0.17	0.10	0.26	0.18	0.05	0.05
35— 75	0.55	0.06	0.08	0.06	0.06	0.04
75—105	0.55	0.07	0.07	0.08	0.07	0.03

1. Type of salts 2. Saline content (%) 3. Layer of soil (cm) 4. Chlorides 5. Sulfats 6. Heavy carbonates 7. Before silting /before irrigation with muddy water/ 8. After silting /after irrigation with muddy water/

The Following factors must be considered when muddy water is used for irrigation:

(1) Irrigate the large seedlings not the little ones

If muddy water is used to irrigate the seed bed or the very young seedlings, the seeds or the seedlings may suffocate from lack of oxygen. If the water in the

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irrigation channel is muddy, most of the mud and sand must be settled before the water may be used for the seeds or the seedlings. If muddy water should accidentally be spilled on the leaves, it should immediately be rinsed off. When the seedlings are 20 cm high, they may no longer be suffocated by muddy water as long as the water level is not too high.

(2) Change the entrance and do more work to level the paddy

The mud or silt content of the water is by no means even, neither is it distributed evenly in the paddy. At the entrance, a fan is often formed; therefore, it is necessary to change the entrance often. Every year, more work should be done to level the paddy, otherwise, some plants will have accumulated more silts than others, and the surface of the paddy will no longer be even.

(3) A Water level must be kept to prevent soil cracking

The silt or mud content of the water is always very fine and shrinks a great deal when dried. If the paddy is allowed to drain, the large cracks may cause the roots to break. Therefore, generally speaking, when silt water is used for irrigation, the paddy is not sunned.

(4) There should be measures to stop the accumulation of silts in the channels

There should be plans to distribute more silt to the lower areas. In Tientsin, the experience is to use the small drainage ditches to bring more silt to the lower areas. Then, the work of dredging the channels must be emphasized to keep them from clogging.

(5) Muddy water must be used in accordance with the soil structure

If the soil of the paddy is heavy with clay, then water containing too much sticky particles should not be used for irrigation. Such water should be diverted to the soil of light and sandy structure; it may improve the leakage of the such soils. Thus, the muddy water may be utilized properly for the benefit of the soil.

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CHAPTER 16. FIELD CONTROL

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The field management of a rice paddy is chiefly to take timely and proper measures to promote or to control growth during the various stages of the life of the plant in accordance with the needs of the particular variety so as to adjust the environmental conditions for the proper development of the plant to achieve high yield.

In order to obtain high yield, it is necessary to bring the rice plants safely through the five stages of sprouting, transplantation, tillering, head evolvement, and seeding, for more heads, larger heads, and fuller seeds. In this chapter, we shall emphasize the key measures and the essential responsibilities of field management during the various stages of the plant's life. Then, we shall concentrate on the three problems of fall prevention, weeding, and flood and drought protection.

SECTION 1. CONTROL OF GREENING AND TILLERING PERIODS [p 459]

The entire growth process of the rice plant may be divided into the early stage (nutritional stage) and the late stage (reproductive stage.) During the early stage, the center of growth is the tillering stage; during the late stage, the center is the formation of the head and the growth of the seeds. The two stages are of course a continuous development. For the purpose of high yield, that is to obtain large heads and full seeds, we must not only emphasize the late stage of the plant's life, but also should emphasize the nutritional stage of its growth. The tillering time is the time when the number of heads is determined, and is also the time the foundation for high yield is established. Therefore, field management during tillering time is especially important.

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It takes the seedlings a week's time after being transplanted to become green again, and the growth continues afterwards. As the temperature is rising, the root system gradually develops, and new leaves and tillers begin to come. The tillering reaches its peak at about 3 to 4 weeks after transplantation. From then on, tillering has basically stopped, and some of the tillers degrade and die. The number of tillers per group has a tendency to drop. Under normal conditions, for the early and medium varieties it is about 30 to 40 days and for the late varieties it is about 50 days after transplantation when the rice plant enters the head evolvement stage of life.

Under the condition of dense plant, a high yield depends upon the main head and a definite number of the heads of the tillers. The appearance of the early tillers and the late tillers may have a difference of three weeks, but all of them come to a head within about one week, but the heads of the early and therefore larger tillers have more seeds, and the late tillers often contain nothing but empty heads or they may wither and die prematurely. Thus, the problem of how to obtain the maximum number of effectual tillers is one of the chief jobs of field management.

Due to the difference in varieties, the planting time of the rice plants varies, as do the temperature conditions. During the tillering stage of the late varieties, the temperature is very high, while during the tillering time of the early and medium varieties, the temperature is rather low at first. Field management is therefore different for these different varieties.

For the early and medium varieties, the goal is to encourage the plants to turn green, to tiller, and to ripen as early as possible. The plants should not remain green too long. The same may be said of the late varieties of the Yangtze Valley, because the cold temperature may come before the seeds are ripe. Therefore, it is necessary to select the proper technique of field management for a given variety in order to guarantee healthy growth and increase the number of effectual tillers.

1. FIELD INSPECTION AND REPLACING MISSING SPROUTS TO ASSURE FULL NUMBER OF SPROUTS [p 460]

"Only when there is a seedling, may there be a

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plant; only when there is a plant, may there be a head; only when there is a head, may there be rice." Ordinarily after transplantation, some seedlings may have floated away, others may have fallen into the water, and there are always some spots where there are not seedlings. If these spots are not filled, the yield will suffer. First of all the transplanting must be done right. The seedlings must be transplanted shallowly, straight, or firmly. This is the first step for high yield. After transplantation, the paddy should be checked to see if there are spots where there are no seedlings. New ones must be planted in these spots to make up the loss.

2. ADJUSTMENT OF THE WATER LEVEL TO PROTECT SPROUTS AND FACILITATE GREENING [p 460]

After transplantation, the seedlings need a certain period of time to recover before new leaves and roots will grow and the color of the leaves will turn green again. This period of time is called turning green stage. The duration of this stage depends upon the health of the seedlings, the fertility of the soil, the quality of the transplanting work, and the weather of the days immediately after the transplantation. Besides, the management of the water is also directly related to the growth of the seedlings during this stage. Generally speaking, the paddy during this stage is kept in a shallow level of not more than half of a ts'un of water. If the water is deeper than that, the seedlings may easily float. If it is not as deep, the roots cannot be firmly established. After the transplantation is finished, in clay soil, one ts'un of water is maintained; in sandy soil, one and a half ts'un. For the early crop of the continuous rice culture and the rice varieties in the North, the temperature is still very low during this stage; therefore, the water level should be shllow during the day, deep at night. In the Yangtze Valley, the seedlings of the late varieties are also protected with a water level of one to two ts'un, but in the areas of South China, since the temperature is high, one ts'un of water is the general practice.

3. TIMELY CULTIVATION AND WEEDING [p 461]

Cultivation is to get rid of the weeds and to loosen the soil so as to improve soil ventilation, mix the fertilizer with the soil, and to encourage the development of

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the root system. In the north, cultivation during the tillering stage helps to encourage early growth.

Cultivation must be done on time, generally about 7 to 10 days for the early, medium, and the late varieties of the double crops. For the late crop of the single-seasoned varieties, it should be done about half a month after transplantation. If the soil is pasty, there should be 2/10 to 3/10 of a ts'un of water when the paddy is being cultivated. The water should be deeper if the soil is hard. During cultivation, the weeds are turned under the soil, and after cultivation, the paddy is filled with deep water again, and the weeds generally float on the surface and die. Five or six days later, a second cultivation should be done. During cultivation, only a very thin layer of water is kept in the paddy. The second cultivation should not be as deep, but the soil around the roots of the plant should be loosened; then, the water level should be added to over one ts'un.

A third cultivation is done one week after the second. At this time, the seedlings have grown, and the paddy is full of greens. Cultivation is generally completed around the end of the tillering stage and before the node growth. The paddy is then sunned when the cultivation is done, and any weeds or bad tillers are poured out as soon as discovered.

4. OBSERVE THE SPROUTS TO DETERMINE SIDE DRESSINGS AND PROMOTE EVEN GROWTH [p 461]

After the transplantation is done, we must watch for the spots where the seedlings are missing, and on the other hand, we must also have a sufficient amount of quick-acting fertilizer on hand and watch how the seedlings grow. This application should be coordinated with cultivation and weeding with the purpose of encouraging the growth of new roots and early tillering.

The growth season of the early varieties is short. Tillering begins about 8 to 10 days after transplantation. In areas such as Kwangtung and Kwangsi, the entire tillering stage lasts only a little more than a week. That is to say that the tillers which appear before the 17th to the 18th day after transplantation are effectual, and those which appear

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after that time are mostly ineffectual. Therefore, it is important to apply fertilizer to encourage the tillers to appear early. In the various areas, the first supplementary application is usually done immediately after the seedlings turn green, and is completed within 20 days after transplantation. If the initial fertilizer is sufficient, and the seedlings grow normally, then nitrogen fertilizer is not needed. Instead, phosphorus and potassium fertilizers may be applied. If the initial fertilizer is too heavy, the tillering stage may be unduly prolonged with the result of an abundant number of ineffectual tillers.

In the north, an early application of supplementary fertilizer is more important, because, the rice growing season is short and the sooner the plants grow from one stage to another the better chance there is for a high yield. The practice of the past of applying fertilizer too late during the tillering stage and causing the plants to delay the next stage of growth has been completely overcome.

In the Yangtze Valley, the medium varieties stay in the paddy about 100 to 120 days. The plants enter the head evolvement stage of life about 40 days after transplantation. Therefore, like the early varieties, fertilizer should be applied early. According to the experience of Ma-cheng People's Commune of Chiang-yin, Kiangsu, if the medium rice is planted in the paddy with a previous crop of green fertilizer or barley, then the transplating is done early and the supplementary fertilizer is applied with the first cultivation. In this case, the rice has a longer time to grow. If the previous crop of the paddy is wheat, the harvest of which is late, then, the rice does not have as long to grow. A supplementary fertilizer is not needed if the initial fertilizer is sufficient; if not then, it should be applied very early after transplantation.

After the transplantation of the late varieties, the temperature is hot and the fertilizer decomposes fast. Supplementary fertilizer may be applied very lightly and only where it is needed.

It is important that supplementary fertilizer is applied during the tillering stage to insure that all the plants of the paddy grow evenly. As a first step, the seeds and the seedlings should be carefully selected; then, if after

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transplantation, some seedlings are found to be slow, weak, or damaged by insects and diseases, spot application of supplementary fertilizer and other effective measures may be taken to give them extra encouragement.

5. COMBINE SHALLOW IRRIGATION AND DRYING THE FIELD TO CULTIVATE STRONG ROOTS AND HEALTHY PLANTS [p 462]

During the tillering stage, the water is managed to supply the needed moisture for the plants, to protect the seedlings from low temperature, and to help the growth of the root system. First of all, there should be no drought in the paddy. A drought may cause an inhibition of the nutrient absorption of the root system, and the number of heads will be reduced. The second rule is to maintain the water level shallow so as to promote tillering. Toward the later part of the tillering stage, a deep water level is maintained to stop ineffectual tillering. Generally speaking, after the seedlings have turned green, a half ts'un water level is the most suitable. If the water level is higher than that, the water temperature is too low during the day, and there may not be enough sunlight at the base of the plant. The growth of the ineffectual tillers may thus be inhibited.

According to the survey of the Hsin-sheng Farm of Tientsin, if the water level is maintained at 3.3 ts'un, the tillering may be delayed five days. The survey of T'uan-p'o-yu People's Commune also proved that when the water measured 1 ts'un, the total number of tillers per group was 16.2 (including the main stem); when the water measured more than 2 ts'un, there were only 11 tillers; when the paddy often ran out of water, there were also only 11.2 tillers.

In the Yangtze Valley and the north, the temperature is low when the early varieties of rice plants are transplanted; therefore, the water level has to be deeper sometimes to protect the plants from a cold wave. Then, the water should be drained to a shallow level as soon as the cold wave is over.

The medium varieties are transplanted early also, and the water management should be similar to that of the early varieties. For the late crop of the continuous rice culture and the late varieties of the single-seasoned crop,

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transplanting is done when the temperature is warm. The water level during the tillering stage should not be more than 1 ts'un. Each time the paddy is cultivated and weeded, the water should be drained to a very shallow level. In most areas south of the Yangtze, the paddy is sunned after the last cultivation which is always at the end of the tillering stage. How many times the paddy should be sunned and for how long depends upon the condition of the soil and the seedlings. In the North, the paddies are always filled with a deep level of water toward the end of the tillering stage to control tillering. The sunning process is not used. If the soil is saline, it cannot be sunned.

For the single-seasoned late varieties in the lower reaches of the Yangtze, the paddy is generally sunned at the end of the tillering stage, and sunned again the second time before the head evolvement, the first time lighter than the second.

Toward the end of the tillering stage before the formation of the head, the leaves may look too dark, which is a sign of over growth. The sunning process may cause the leaves to be lighter in color. A water level is restored when the plants regain some strength. The studies of the Kiangsu Branch of China Academy of Agricultural Sciences showed that the sunning process promoted the accumulation of carbohydrates in the stems, increased growth of the root system, and improved transpiration. Therefore, when the water level is restored, the root system can absorbe more nutrients, the photosynthesis is stronger, and more nutrients are supplied to the head during the evolvement stage to grow larger heads.

Supplementary fertilizer should be arranged in coordination with the irrigation system. Generally, when such organic fertilizer as vegetable oil residues, pig manure, night soil, and green fertilizer are applied, the water level should be maintained above one ts'un for five or six days, so that the soil may slowly absorb the fertilizer. When this one ts'un of water is gradually drying out, the next filling should be shallower, mostly half a ts'un, to let the paddy soak another three or four days. When this filling is again drying out, if more fertilizer is applied, the water level should be still shallower, about less than half a ts'un. If the water is too deep, the fertilizer cannot be easily absorbed by the plants.

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6. PREVENTION OF INSECT PESTS [p 464]

During the tillering stage, the plant organs are at the peak of their development, and they should be protected against the insects. During this stage, the most damaging borer is Chilo simplex (the type in the south reproduces 2-3 times a season, the large ones only once. The ones in the north reproduce twice.) There are also other types of borers, stinkbugs, bettles, and water weevils. They may cause a large area of rice plants to wither and die. The keng varieties are often subject to the leaf blight disease which spreads very fast on healthy and strong plants. Other diseases such as the white tip and leaf smut may also occur.

Based upon predictions and reports, insecticide must be used to spray the plants for protection. A spray of the 666 solution before the borers (Chilo simplex) lay eggs, then, one more spray after 6 to 7 days are often effective for these as well as other insects. If the rice plants are healthy, and the leaves and stems are prevented from growing excessively, the spread of the diseases may be effectively checked, and the insect damage may be lessened also.

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SECTION 2. CONTROL DURING SPIKE DIFFERENTIATION PERIOD [p 464]

Under normal conditions, the head evolvement stage begins about 30 days before heading time. At that time, the tillering has ended, the stem has grown taller, and the number of the roots has reached the maximum. Photosynthesis has obviously become stronger, and dry substance is rapidly accumulated. Every sign points to the fact that the plant has entered the stage when the center of its development is the stem and the head. The number of heads, and the number of seeds per head are being determined. The plant is very sensitive toward its environmental conditions at this time. Judging from practice, at this critical time, there must be a plentiful supply of nitrogen and other minerals, and at the same time, there must be a sufficient accumulation of carbohydrates. Moreover, there must be a smooth transfer of these organic substances to the head. Therefore, the management of fertilizer and moisture must be very careful.

If there are not enough nutrients when the plant is growing nodes and entering the head evolvement stage, the tillers and the stem often wither and die. The number of seeds per head is related to the number of inflorescences. Measures which promote the evolvement and growth of the inflorescences should therefore be taken to prevent their degradation.

Although the number of seeds per head is also related to the previous growth condition of the plant, the environmental conditions at the time of head evolvement exercise a more direct effect. Drought, flood, cold and lack of nutrients can all affect it greatly. A bad environment during the head development time, especially the first 20 days,may cause the number of inflorescences to be reduced, and especially about 12 to 13 days before heading time, a bad environment may increase the number of degraded inflorescences.

During this stage, field management should provide as good an evironment as possible, and prevent the occurrence of natural calamities, so that the plants may grow strong,

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with more heads and more seeds.

1. REASONABLE APPLICATION OF SPIKE FERTILIZERS [p 465]

Under normal conditions, the rice plants are inspected one month before heading time. If the leaves are straight and the stems are strong, but the tip of the leaves are slightly yellow, then, some head fertilizer may be applied. If the initial fertilizer is not sufficient, or if in case of the late varieties, the high temperature has caused the initial fertilizer to decompose too fast, then, an application at this time is necessary. The time for this application should be about 30 days before heading time. If necessary, another application may be given about half a month before heading time. For the early and the medium varieties, the fertilizer is composed mainly of phosphorus and potassium, with some nitrogen. For the late varieties, nitrogen is the primary fertilizer at this time, with some of the other two to make the application more effective. For the early varieties and for the rice plants of the Northeast, fertilizer is applied during the head evolvement time only if the plants show signs of nutritional lack. If not, it is better not to apply any fertilizer so that head evolvement will not be delayed.

2. WATER LAYER IRRIGATION [p 465]

From the beginning of head evolvement to the heading time, photosynthesis is strong and metabolism is high. The atmospheric temperature is high and transpiration is high too. The rice plant needs moisture now more than at any other time of its life. A drought now will weaken the absorption, synthesis, and transfer of organic matter; especially during the later part when the sex cells are dividing, about 10 days to two weeks before the heading time, a drought may cause the inflorescence to become abnormal, degraded, or not to bloom at all. The severe drought in July and August of 1957 in the lower reaches of the Yangtze hit the head evolvement time of the medium and early varieties, and the yield was much higher in those paddies which were irrigated. In such places as Kao-yu, Kiangsu, the heading time was delayed four to five days and the rate of empty

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heads was as much as 45%. The yield was 27% less than in the paddies which were irrigated.

In every rice growing area, the paddies are kept with more than one ts'un of water during this period. This is not only for the moisture requirements of the rice plants; the water level also helps to stabilize the temperature. However, we must also point out that for those paddies with poor drainage, if the sunning process at the end of the tillering stage does not accomplish its purpose, or if the stems and the leaves grow excessively due to faulty fertilizer applications, then the paddy may also be drained temporarily until the carbon metabolism becomes higher so that the head evolvement stage may come more smoothly.

About 3 to 5 days before the heading time, all the parts of the head are developed. In some areas where the ground water table is high, the soil holds moisture well, and the plants are growing prosperously; then, the water may be drained for two or three days for a light sunning, but the soil should not crack, and the leaves should not turn yellow. Normally, if the paddy is high, if the soil is sandy, or if the soil is very permeable, the sunning process should not be practiced during this period.

3. PREVENTION OF INSECT PESTS AND COLD DAMAGE [p 466]

During the head evolvement stage, the blight disease may occur, therefore, the paddies should be inspected thoroughly at this time. If blight of the leaves, the nodes, or the neck is discovered, a spray of slaked lime, once at the end of the head evolvement time and once at the time when the head begins to appear, should be sufficient to prevent it from spreading.

The diseases of leaf smut and white tip often occur during the head evolvement time in the areas south of the Yangtze, especially when the paddy is very densely planted, the drainage is poor, or the growth of the early stages have been excessive. For leaf smut, the basic cure is proper density, irrigation, and fertilizer management. It is also important that there should be sufficient light and ventilation between the groups. If the drainage is poor, then,

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the paddy should be properly sunned to correct this condition.

White tip is a disease carried by the seed, and the basic cure is the use of disease-free seeds, the selection of disease resistant varieties, and disinfecting the seeds. In the paddies where this disease is discovered, the management of irrigation and fertilizer application should be especially emphasized to help the plants to grow strong and more disease resistant.

During the head evolvement stage, the rice plants may also be damaged by borers, stinkbugs, and weevils. A large amount of whiteheads may be the result, and the damage to the yield can be very serious. Whenever, these insects are reported, labor should be arranged to take care of this matter immediately, and a sufficient amount of insecticide should be on hand for such an emergency.

During the head evolvement stage of the early crop in the areas of the Yangtze Valley, the plants may also be damaged by low temperature. For example, in May the temperature of the central parts of Hunan averages above 22°C, but during the past few years, there have been occasions of lower than 20°C temperature. From the 21st to the 23rd of May, 1959, the lowest temperature was 12°C, and this period was just when the pollen cells of the bearded early keng was divided. The damage was so serious that the rate of empty hulls was 70 to 100%. The yield averaged less than 200 chin per mou, and the most seriously damaged areas had no harvest at all.

To prevent low temperature damage during the head evolvement stage, we must first select the varieties that withstand low temperature better. Then, we must adjust the planting and transplanting time so that when the pollen cells are dividing, the temperature is more stable (about two weeks to 10 days before the heading time.). If unexpected low temperature occurs, the water level should be adjusted to give the plants more protection.

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SECTION 3. CONTROL DURING FLOWERING AND MATURITY [p 467]

From blooming to ripening is the most important period of the seed development. During the blooming time, the plants require an average of above 20°C temperature. The fertilization may be damaged if the average temperature is below 20°C, or the lowest temperature is below 15°C. Drought during this period may cause a large amount of empty hulls. When the seeds are being filled, the average temperature should be above 18°C, and they will not be full if the temperature is below 15°C. As the seeds are being filled, their weight rapidly increases, and the plant needs a great deal of nutrients for this process. If organic matter is not supplied sufficiently, the seeds of the late inflorescences may not be properly filled, and a large amount of empty hulls will be the result. If there should be frost damage during the ripening stage, a large amount of green seeds or empty hulls may be the result.

The yield may also suffer from storms, blight, and borers.

Therefore, on the basis of good previous field management, the work in the paddies should be continuously emphasized in order to obtain a high yield.

1. REASONABLE IRRIGATION AND TIMELY DRAINAGE [p 467]

The moisture requirement of the rice plants is no less now, and a certain water level should still be maintain throughout the period from heading to ripening. Under ordinary soil conditions, a drought at this time can still seriously affect the yield. If the water is allowed to fall, the seeds will not be filled properly, and the weight of 1,000 seeds will be lighter.

From the milk-ripe stage to the wax-ripe stage, the moisture requrement of the plant begins to drop. If the soil is kept in a saturation state, the moisture condition

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should be sufficient to satisfy the needs of the plants.

Ordinarily, during the blooming stage, the water level is kept at one to two ts'un. In the low paddies, the soil needs only to be barely covered. If the color of the leaves is too dark during this stage, the water should be immediately drained, and soil is kept damp all through the ripening period. If the soil holds moisture well, then the water should be drained about 10 days before the harvest time. In the high paddies, or highly sandy soil, the water should be filled two to three times after the seeds have been filled.

For the continuous rice culture, after the early crop is harvested, the late varieties must be transplanted in a hurry. Unless the situation requires it, the paddy of the early crop is normally not drained at all. The thin layer of water is left in the paddy after the seeds are filled for transplanting the late crop.

In the areas of the lower reaches of the Yangtze, where a green fertilizer crop is planted after the single-seasoned late rice crop, the paddy is generally drained at the wax-ripe stage. If the soil is pasty, it is generally sunned until small cracks appear on the surface, then, it is filled again with water to soak before the green fertilizer seeds are planted. After planting, the paddy is drained again.

In those areas where the temperature is warm, the water level should not be too deep after the blooming time, otherwise the stalk may grow weak and fall. In the cold temperature regions, the rice plants may suffer from frost during the ripening stage. Sometimes, a layer of four ts'un of water must be kept to keep the soil temperature. On clear and warm days, the water is drained to a lower level. In those regions where the irrigation water is cold, measures must be taken to raise the water temperature before it reaches the paddy.

2. PROPER APPLICATION OF PELLET FERTILIZERS [p 468]

Aside from water, nutrients are also very important for the rice plants during the period from heading, and blooming to seeding. During the two weeks from blooming to

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seeding, the weight of the seed gains very rapidly, and the supply of nutrients largely determines the fullness of the seed. About 1/4 to 1/3 of the dry substance of the seed is stored in the stem and the leaf bract until after heading, and at which time, it is transferred to the seed. The remaining portion must be continuously synthesized by the stem and the leaves. According to experiemnts, if the top leaf is cut off at this time, the rate of the empty hulls is increased 30%. If the second leaf is cut off, then, the rate of empty hulls is increased 25%. If both the top and the second leaves are cut off, the rate of the empty hulls is increased 90%. Thus, it is important to keep enough green leaves after the heading time. Experience also proved that serious white tip disease of the leaves may also increase the rate of empty hulls. In the T'ai-hu region, the masses say: "I'll knock the head of the rice with a night soil ladle, and get another three tou of rice." Therefore, just before heading, if the leaves become too yellow, or otherwise show signs of insufficient nourishment, a small amount of ammonium sulfate should be applied. In Kwangtung, the farmers sometimes apply a little amount of thoroughly decomposed night soil in the afternoon when the blossoms have just closed, and the method often brings a higher yield. In 1959, Hua-nan College of Agriculture conducted an experiment of applying nitrogen and potassium fertilizer when the plants come to a head. Compared with the control group, there was 5.7% less half-grains, and the yield was 5.4% higher.

3. PREVENTION OF INSECT PESTS AND WIND DAMAGE [p 469]

Before the plants come to a head, they may be damaged by blight disease, the borers, the stinkbugs, or the weevils. To prevent these insects and diseases from reducing the yield, an application of insecticide is needed at the end of the head evolvement time, and another at the begining of the heading time. If slaked lime and 666 powder are mixed together, then the insects and diseases may be taken care of with one operation. In the new rice areas of the North, the beetles are the most serious problem during August and September. They may kill a whole paddy of rice in a few days. Two applications of 666 powder may be sufficient to keep them away.

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Along the coast, when the early and medium varieties are ripening during the period from July to September, the plants may also be attacked by the typhoons and storms. For example, the areas of Kwangtung and Kwangsi are often attacked by typhoons between June and September, especially the early and middle parts of June when the early varieties are blooming and ripening. The loss can be very serious. Early maturing varieties which are resistant to low temperatures should be selected for the areas which are attacked frequently. If the rice plants have reached the wax-ripe stage when the storm comes, then, workers should be gathered to push the plants to fall with the direction of the wind to prevent the seeds from falling down. When the storm is over, those paddies should be immediately drained so that the leaves and the head are exposed to prevent the seeds from sprouting or becoming rotten.

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SECTION 4. SEVERAL PROBLEMS IN FIELD CONTROL [p 469]

To prevent the plants from falling is an important problem of field management. If the plants should fall, the harvest is made difficult, and the quality and the qnantity of the harvest will suffer too. The farmers say: "When the wheat falls, you have a just a handful of bran; when rice fall, you have a paddy full of seedlings." This is a true description of the problem.

Falling affects the yield differently at different time and under different weather conditions. The earlier it happens, the more serious it is, because normal fertilization will be affected. At the same time, when the plants fall upon one another, light exposure and ventilation are poor, and the leaves of the plants begin covered by others will turn yellow, even become rotten. After the plant falls, the stem is bent and the tissue is mechanically damaged, and cannot transfer nutrients and moisture efficiently. According to surveys, when the plants fall at the time of heading and blooming, the yield will be reduced 40 to 50%. It they fall at the time of milk-ripe, the loss is about 30%; at the wax-ripe stage, the loss is about 10 to 20%. The result of the study of 1959, conducted by Anhwei Provincial Institute of Agricultural Sciences on this subject is shown in Table 16-1.

Table 16-1 The Effect of Falling at Various Stages of Growth on the Yield

倒伏时期 (1)(月/日)	半实粒 (7) (%)	不实粒 (8)(%)	千粒重 (9)(克)	每亩产量 (10)(斤)	减产 (11)(%)
2 孕穗 (6/24)	20.0	32.1	25.2	500.0	45.0
3 出穗 (7/3)	11.0	26.4	25.7	584.8	34.4
4 灌浆 (7/7)	9.0	25.1	26.0	629.0	29.4
5 乳熟 (7/12)	6.1	23.5	26.4	786.0	11.8
6 蜡熟 (7/23)	4.2	20.1	27.3	891.0	1.0

1. Falling time (month/day) 2. Head evolvement time
3. Heading time 4. Starch filling time 5. Milk-ripe time
6. Wax-ripe time 7. Half-full seeds (%) 8. Not filled seeds
9. Weight of 1,000 seeds (g) 10. Yield per mou (chin)
11. Loss (%)

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(1) An Analysis of the Causes

Rice plants may fall when the base of the stem is bended or broken. This is usually the result of a combination of internal and external factors. The plant may not possess strong resistance against falling, because too much nitrogen fertilizer has been applied, or the application has not been done properly. Or,perhaps the water level has been too deep, and the paddy has not been sunned properly. Or, perhaps the planting has been too dense, and light and ventilation between the groups have not be sufficient. All these factors may cause the plants to suffer from nutritional imbalance, and the plants may fall down as a result. Then, there are also such external factors as storms and hail which may break the stems, and such diseases as blight. leaf smut, and such insects as the borers and stinkbugs, all of which may cause the stems to break or rot, resulting in various degrees of falling.

In most cases, when the plant falls the stem undergoes obvious changes. According to Wu K'ai-chih (0702 7030 4160) and others based upon their observation of the stems of the medium variety Sheng-li-hsien and Chung-nung No.4, the stems of the plants that have fallen grow more nodes, and the space between the nodes at the base becomes longer, and the average unit weight is less. (Table 16-2)

Table 16-2 Dry Substance and Bending Strength (Hua-tung Institute of Agricultural Science, 1955)

品 (1) 种	倒伏与否 4	8 地上部节数	9 下部第二节间长度（厘米）	10 单位折断力	11 单位干物重
2 胜利籼	直 5 立	4.15	13.94	105.10	0.3318
	倒 6 伏	4.55	15.84	98.91	0.3044
	差异（直－倒）7	−0.40	−1.90	+6.19	+0.0274
中农4号	直 5 立	4.06	16.64	86.20	0.2831
	倒 6 伏	4.33	16.96	73.74	0.2696
	差异（直－倒）7	−0.27	−0.32	+12.46	+0.0135

(12)注：1. 单位折断力 $=\frac{\text{折断力（克）}}{\text{直径（毫米）}}$；单位干物重 $=\frac{\text{单位长度干物重（克/厘米）}\times 100}{\text{直径（毫米）}}$。

2. 本表系根据原表节录的。

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1. Variety 2. Sheng-li-hsien 3. Chung-nung No.4
4. Fall or not 5. Standing straight 6. Has fallen
7. Difference (Straight - fallen) 8. Number of nodes above the ground 9. The length of the second space between the nodes from the ground (cm) 10. Unit bending strength
11. Unit weight of dry substance
12. Note: 1.

$$\text{Unit bending strength} = \frac{\text{bending strength}}{\text{Diameter (mm)}};$$

$$\text{Unit weight of dry substance} = \frac{\text{Weight of dry substance in a unti length (g/cm)} \times 100}{\text{Diameter (mm)}}$$

2. This table is a simplified version of the original.

According to the studies of Yang Ho-feng (2799 7729 1496) and co-workers, the stems of the fallen plants contain less cellulose (Table 16-3), the cell wall and the tissue walls are thinner (Table 16-4), the cells are larger, and are not as closely arranged as the cells of the normal stems.

Table 16-3 The Cellulose Content of the Stems and the Fact of Falling
(Yang-chou Special District Institute of Agricultural Sciences, Kiangsu, 1958)

取 1 样 地 点	(4) 倒 伏 情 况	(7) 纤 维 素 (克/厘米)
江苏省农业科学研究所 (2)	不倒 (5)	2.5893
	倒 (6)	0.8750
苏北农学院五星农场 (3)	不倒 (5)	1.6786
	倒 (6)	1.1956

1. Place from which the samples were taken
2. Kiangsu Institute of Agricultural Sciences
3. Wu-hsing Farm of Su-pei College of Agruculture
4. The Condition of falling or not falling
5. Does not fall 6. Has fallen
7. Cellulose content (g/cm)

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Table 16-4 The Thickness of the Tissue Wall and the Fact of Falling (Same source as Table 16-3)

取(1)样 地 点	(3)倒 伏 情 况	节 (6) 间	(9)厚壁组织平均厚度 (微米)
(2) 江苏省农业科学研究所	(4) 不 倒	第2	62.68
	(5) 倒	第2	41.78
	(4) 不 倒	第3	56.61
	(5) 倒	第3	35.04

注：本表系根据原表节录的。(10)

1. Place from which the samples were taken
2. Kiangsu Provincial Institute of Agricultural Sciences
3. The condition of falling or not falling
4. Does not fall 5. Has fallen 6. Space between nodes
7. The second 8. The third 9. Average thickness of the tissue wall (0.001 mm) 10. Note: This table is a simplified version of the original.

(2) Measures for the Prevention of Falling

Although the factors which may cause the plants to fall are complicated, it is a special characteristic of the stem itself to resist falling. The nodes of the stem, for example are more numerous toward the ground, and the space is shorter. The leaf bract covers each node, and the stem has heavey walls around its tissues. If cultivating measures are taken to develop these internal fall resistant factors, the plants may be easily made to resist falling successfully.

It is more important to prevent the plants from falling than to adopt measures after they have fallen. For example, attention should be paid to cultivate strong seedlings, to plant with reasonable density, to apply fertilizer properly, to irrigate with the right amount of water at the right time, to plow deeply, and to take measures to protect the plants from insects and diseases. All these cultivating techniques must be chosen in accordance with the local conditions so that they may bring about the desired effect. The following are the few basic measures to be taken to protect the plants from falling:

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a. Choose the varieties which resist falling

The biological characteristics of some varieties are differnt from the others, therefore, their resistance to falling is different also. Generally speaking, with varieties which have shorter space between the nodes, their stalk is shorter, their leaves are narrower and straighter, their top leaf is shorter, and their roots are stronger and more resistant to falling. In general, those of the hsien subspecies fall easier than those of the keng subspecies. It has been a practice of many areas to solve the problem of falling plants by changing from hsien subspecies to the keng. We must point out that besides choosing from the existing varieties the most fall resistant ones for the vulnerable areas, we must try to cultivate more fall resistant varieties, to suit the new requirements under the new cultivation methods and conditions. This is also an important problem for the implementation of machine cultivation in the rice paddies.

b. Reasonable fertilizer application

In order to apply fertilizer reasonably, we must consider the characteristics of the variety, the climatic and the soil conditions, before we decide how to adjust the proportion between the three elements of nitrogen, phosphorus, and potassium. If too much quickly effective nitrogen fertilizer is applied at one time, a high incidence of falling can easily occur.

In the process of growing, the protein content of the rice plant is closely related to the level of nitrogen fertilizer. The higher is the level of nitrogen fertilizer, the higher is the protein content in the plant body. The accumulation of the non-protein nitrogen follows the same tendency. However, the content of carbohydrates drops as the protein accumulates. During the node growth stage, if the protein content rises quickly and the carbohydrate content drops quickly, the plant is in danger of falling.

Within a given paddy, those plants which have fallen contain as much as double the amount of nitrogen of the plants which do not fall. They also have a tendency to have a higher phosphorus and potassium content.

Protein nitrogen content of the fallen plants is

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obviously higher than that of those which do not fall, and the difference in the non-protein nitrogen content is even more obvious. At the same time, as the content of carbohyradtes drop, the mechanical structure of the stem becomes weaker. The carbohydrate content of the fallen plants is not even quite half of that of the normal plant.

Table 16-5 The Nitrogen, Phosphorus, and Potassium content of the Rice Plant and Its Relationship to Falling (Dry Weight tested at the Wax-ripe Stage %, Tzu-ping-hsien, Kiangsi, 1959)

含 (1) 量	(5)全 氮		(6) 磷		(7) 鉀	
	8 倒	未9 倒	8 倒	未9 倒	8 倒	未9 倒
最 (2) 高	2.94	1.77	1.21	0.87	4.98	4.34
最 (3) 低	1.40	0.66	0.71	0.35	2.57	2.12
平 (4) 均	2.17	1.10	0.88	0.72	3.71	3.42
%	189	100	122	100	108	100

1. Content 2. Highest 3. Lowest 4. Average
5. Whole nitrogen 6. Phosphorus 7. Potassium
8. Has fallen 9. Does not fall

The above facts show that reasonable application of fertilizer is very important with regard to falling. Under normal conditions, the initial fertilizer should be mainly organic fertilizer, which should be semi-decomposed, and should be well mixed with the soil so that the root system may continuously absorb nutrients. Supplementary fertilizer should be used only to meet the nutrient requirements of the various stages of growth, and should be applied only after close inspections of the seedlings. For the early and the medium varieties, the initial fertilizer is the most important. If a supplement is used at all, it should be applied early. For the late varieties which have a longer growth season, the initial fertilizer should be in a proper

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amounts without too much quick-acting fertilizer in it, because the plants should not grow too fast during their early stages of development. Such supplements as the head and seed fertilizer should only be applied if the seedlings show signs of need, i.e. if the leaves show signs of turning yellow just before the head evolvement time and the heading time.

c. Shallow Water Irrigation and the Sunning Process

Paddy rice needs more moisture than ordinary dry land crops, however, if the plants are kept in deep water for a prolonged period, the base of the plant may grow too long, with a hollowed center. This is another reason for the weakness of the stem, which causes the plant to fall. Shallow water and the sunning process may promote the downward extension of the root system as well as control the excessive growth of the stems and the leaves. In this manner, the tissue of the stem becomes stronger and therefore, more resistant to falling.

According to the studies of the four reasearch units of Hunan Provincial Institute of Agricultural Sciences, the plants which are irrigated with shallow water have shorter spaces between the first and second nodes, and the stems are more elastic. The test conducted by the Institute of Plant Physiology of Academia Sinica showed that among the plants which grow in shallow water, the structure of the stems varies depending upon whether the paddy is sunned or not. The experiments of the Kiangsu Branch of China Academy of Agricultural Sciences proved that the sunning process may promote the accumulation of a large amount of carbohydrates, and thus may cause the tissue of the stem to be stronger.

Table 16-6 The Length and the Elasticity of Stems Compared, When Different Irrigation Systems are Adopted

	地 (1) 点	(7) 长期淹水灌溉			(8) 浅水湿润灌溉		
		(9) 第一节间长（厘米）	(10) 第二节间长（厘米）	(11) 茎秆弹力（克）	(9) 第一节间长（厘米）	(10) 第二节间长（厘米）	(11) 茎秆弹力（克）
2	湖南省农业科学研究所	8.9	—	84.0	6.5	—	79.7
3	同上	—	—	118.4	—	—	170.1
4	衡阳专区农业科学研究所	8.7	16.7	—	2.4	11.7	—
5	永兴灌溉试验站	—	—	104.6	—	—	111.3
6	邵东农业科学研究所	3.2	10.0	—	1.2	9.2	—

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1. Place 2. Hunan Provincial Institute of Agricultural Sciences 3. Same as Above 4. Heng-yang Special District Institute of Agricultural Sciences 5. Yung-hsing Irrigation Experimental Station 6. Shao-tung Institute of Agricultural Sciences 7. A prolonged deep water cover
8. Shallow water and damp soil irrigation method
9. the length of the first space between the nodes (cm)
10. The length of the second space between the nodes (cm)
11. Elasticity of the stem (g)

d. Reasonable Density

If the plants are planted too densely, the space between the groups is filled very early, and the ventilation and light exposure suffer. The dry weight of the individual plant and the leaf-area are smaller. There are, therefore, less photosynthesis products. The stems are weaker; there are less vascular bundles; the dry substances weigh less; and the root system does not develop properly. These facts are also the basic reasonsfor the plant to fall.

Therefore, when dense planting is attempted, we must consider the local climate, soil, and the particular characteristics of the varieties, so as to adopt a reasonable standard. At the same time, dense planting must be coordinated with deep plowing, and reasonable fertilizer application, and other cultivation measures. With regard to the arrangement of the plants, we must consider at once the development of the plant colony and the nutritional area of the individual plants, so as to harmonize the relationship between the individual and the colony. There must be sufficient number of plants in a unit area, yet, there must also be sufficient sunlight and ventilation so that each individual plant may develop normally.

e. Deep Plowing

The development of the root system of the rice plants is closely related to the depth of the plowing layer. Productive practice and scientific research agree that deep plowing combined with fertilizer application can create a

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a better environment for the root system, and therefore, is an effective measure to prevent the rice plants from falling.

Table 16-7 The Effect of Draining and Sunning on the Carbohydrate Content of the Stem

日 (1) 期	处(5)理	蔗糖 (8) (%)	还原糖 (9) (%)	淀粉 (10)(%)	半纤维 (11)(%)
2 8月4日（晒田前）	6 晒田	0.81	0.28	3.33	
	7 不晒田	0.74	0.23	3.51	
3 8月11日（晒田后7日）	6 晒田	1.25	0.22	3.16	3.55
	7 不晒田	1.19	0.32	1.54	2.27
4 8月18日（复水后6日）	6 晒田	1.30	0.36	3.21	5.15
	7 不晒田	1.24	0.39	.48	4.26

注：表内数字为鲜样百分数。(12)

1. Date 2. 4th of August (before sunning)
3. 11th of August (seven days after sunning)
4. 18th of August (six days after the water was restored)
5. Treatment 6. Sunning process 7. Without sunning process
8. Sugar (%) 9. Reductive sugar (%) 10. Starch (%)
11. Semi-cellulose (%) 12. Note: The percentage listed in this table was taken from fresh samples.

In a word, the basic problem of fall prevention is also the problem of reasonable implementation of the "eight-word constitution" of agriculture. If the measures regarding water, fertilizer, soil, seeds, density, and management are coordinated and implemented correctly, then, to a great extent, the problem of fall prevention is solved.

We must first, of course, take measures to prevent the plants from falling. For example, if we discover that the plants are growing excessively, which is a serious warning that the plants are about to fall, we must take immediate action to avoid loss. The masses have rich experience in this matter, and it may be described as follows:

a. Sweep the dew

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If the leaves have an appearance of spreading out to make a tent, the farmers immediately get up before dawn, i.e. before the morning dews are dry. Then, two people hold a long rope and stand in the paddy to sweep the dew off the leaves with the rope. At the same time, the paddy is immediately drained and sunned. They keep on sweeping the dew for three to four days, to lessen the load on the leaves. This measure has been proven to be effective to reduce the number of fallen plants.

b. Cut off the tip of the leaves

If it is discovered that the leaves are growing excessively and the tips are pointing downward, the farmers cut off the tips to reduce the load and to let in sunlight. This method is found to be effective, however, the leaf is a nutrient manufacturing organ. If too much of it is cut off, the plant will suffer considerable damage. Therefore, the cutting should be done, if it is necessary, as early and as little as possible. The top leaf should never be cut, and not more than one cutting should be permitted.

If the plants have already fallen, the salvaging measures have to be decided upon according to the conditions. If the plants of a large area have fallen, and if the fall occurs after the seeds have begun to be filled, then, the paddy should be drained immediately, so that the heads and the stalks will not become rotten.

2. PREVENTION AND ERADICATION OF WEEDS [p 475]

Weeds are enemy of rice. They rob the sunlight and the nutrients from the rice plants. If there are seeds of weeds mixed in the harvest then the quality of the rice is poor. In the paddy, the weeds are the host plants of the insects. Therefore, weeding is an important measure of field management.

(1) The Biological Characteristics of the Paddy Weeds

The weeds of the paddy or swamp are stubborn species. For example, the Phragmites and the Polygonaceaes

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have very large roots, reaching as deep as 1 m into the soil. These roots can absorb nutrients much more effectively than the roots of the rice plants. Some of the weeds, such as the mosses, grow roots in the water and compete with the rice plants for the nutrients of the water. Many of the weeds have dense leaves and stems, which may cover the surface of the water to the extent that the rice plants cannot receive sufficient sunlight.

These swamp weeds can sprout when the temperature of the soil is only 5 to 8°C. The perennials sprout even earlier. The rice plants, on the other hand, cannot sprout until the temperature is above 10°C. Thus, the weeds have a head start. Before the transplantation of the rice plants, they are already in the paddy taking up the nutrients from the soil. The various kinds of weeds bloom at different times, and scatter their seeds in the paddy to make it difficult to clear them out.

The weeds are also very adaptable. They resist low temperature, drought, or any other kind of environment. Sometimes, they can live in 15° below 0 C. The swamp weeds can usually live when the soil is dry. They may prefer damp soil, they are also very adaptable to dry and thin sandy soils.

The weeds produce a tremendous number of seeds, and most of them rest through the winter and do not sprout until next year. This characteristic makes the winter weeding method ineffective.

The seeds of the weeds may be buried deep in the soil for many years and sprout once they have been turned to the surface. Sometimes, if they are eaten by an animal, and if they are still not broken in the manure, they can still sprout. If the weeds are cut with the seeds still green, they may beomce ripe on the dead stalk, and sprout someday. The perennial weeds often possess asexual reproductive organs. If any parts of these weeds are destroyed, the remaining portion may still live.

(2) The Technique of Weeding Rice Paddies

Although the weeds are stubborn, there are some weak links in their life cycle which we may take advantage of. The following is a description of the rich experience of our farmers in the technique of weeding the rice paddies.

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a. The Correct Land Leveling Technique

Fall plowing is effective for killing the perennial weeds. When the underground nutritional structure is exposed, they die. This method is more effective if it is done early in the fall before the weeds become dormant.

Before a piece of wasteland is converted to a paddy, the vegetative cover, such as Scirpus, Phragmites, and Cyperaceaes, should be turned and covered before they become very properous in the summer. Then, dikes should be built and the paddy be filled with water to soak for a week. Then the soil should be wet plowed and wet raked when the water is about one ts'un deep, and afterwards, drained completely and sunned five or six days. After the sunning process, the paddy is again filled with water to one or two ts'un, so that all the roots of the weeds will become rotten and die.

b. Prevent the Seeds of Weeds from Being Brought to the Paddies

The paddy which is reserved for collecting rice seeds should be cultivated very intensively to eliminate all weeds, especially those which habitually accompany rice plants, such as Penicum crus galli. Everyone of them must be pulled out, so that their seeds will not be brought with the rice seeds.

Before the rice seeds are planted, they should be carefully selected . They may be selected by the sieve, wind, salt water, or machine, so that they contain as few weed seeds as possible.

Before the paddy is filled, the channels must be cleared and inspected so that the water does not bring any weeds or weed seeds to the paddy. The dikes should be cleared of weeds too. In some state-operated farms, crop plants or perennial pasture grass are planted on the dikes. They discourage the growth of weeds.

Compose piles and stable manure contain a fair amount of weeds and seeds of weeds. They should be thoroughly decomposed before being applied to the paddies.

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c. Timely Cultivation to Get Rid of the Weeds

When the cultivating machine is used to loosen the soil between the groups, the weeds can be effectively killed also. Cultivation must be done early while the weeds are still small. Once they grow up, they are very difficult to get rid of.

Cultivation may be needed twice or three times depending upon the length of the growth season of the particular rice variety and the number of weeds in the paddy. The seeds of Penicum crus galli can sprout a little more than 10 days after its heading time; therefore, when it begins to seed, it is very difficult to eliminate. The only way is to pull up each as soon as it is seen.

d. Irrigation System may be Utilized to Eliminate Weeds

Draining and sunning may help get rid of the weeds. Many of the mosses die after the paddy is sunned for three to five days.

e. The Practice of a Reasonable Crop Rotation System

Such paddy weeds as Moncharia vaginalis, Alisma plantago var. parviflorum, and Potamogeton polygonifolius, live under a layer of water, and they naturally die when the paddy is made into a dry field for such crop plants as soybean. Therefore, crop rotation also helps to eliminate weeds. In some areas, wheat or barley is planted in alternate rows with Medicago denticulata or Astragalus melilotoides. They method is also effective for eliminating weeds. The alternate use of paddy and dry field is a system which has been successfully practiced in the state-operated farms and the north, and is now considered as one of the most effective methods of eliminating weeds and guaranteeing a high yield.

f. Chemical Weed Killers

Chemical weed killers may save labor and their use is an important method. However, it has its limitations. At present none of them can completely get rid of the weeds, and all of them are more or less harmful to the rice plants. They may be used only as a supplement to other efforts.

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At present, the most popular ones are 2,4-D; 2,4,5-T; 2,4-D butyric ester; M.C.P.; and Copper sulfate. The effective element of 2,4-D is dichlorobenzene, while 2,4-D sodium salt is a derivative of 2,4-D. These two are now being manufactured in large amounts in China. They are effective for killing such weeds as Moncharia vaginalis,Alisma plantago, and Sagitaria sagitifolia, and some others, but are not effective for killing weeds of the families Gramineae and Cyperaceae. The best time to apply them is from the end of the tillering stage of rice plants to the time of the head evolvement. The amount to be used is about 60 g to 70 g per mou. The chemical should be diluted to 0.1 to 0.2%. The paddy should be drained first so that the weeds are exposed on the ground surface; then, they may be sprayed. Spraying is best done on a clear day with no wind, and the paddy should not be filled again for six hours. The temperature at that time should be between 20 and 30°C. If it is warmer than 30°, the chemical dries too fast, and much of it will be lost.

2,4,5-T is also called trichlorobenzene. It may be used in a similar way. The test result of the Kirin Branch of Academia Sinica showed that it should be sprayed at the end of the effectual tillering time, with a dose of 60 g (in 0.1 solution). Its effect on the rice plants is minor, and the killing rate for Moncharia vaginalis is almost 94%. It is not effective for Penicum crus galli and Scirpus.

M.C.P. and its sodium salt is not as strong as the above ones. However, a heavy solution of M.C.P. is effective for both the dicotyledoneae and the monocotylodoneae families of weeds. Generally, 125 g to 240 g per mou must be used.

Copper sulfate may produce a large number of copper ions when dissolved in water, and the copper ions destroy the cell structure of the mosses. If 70 g to 140 g is applied everyday for six to eight days, the effect is very good. It may be placed in a cotton bag and in mouth of the channel so that the water will wash it and bring it into the paddy.

The weeds on the roadside, the banks of the channels, and the temporary dikes, should be sprayed with sodium chlorate or potassium chlorate, about 50 to 130 chin per mou. This amount may remain effective for years.

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3. FIGHTING AGAINST DROUGHT AND PREVENTION OF WATERLOGGING [p 478]

The vast areas of rice culture in China have very different natural conditions, and the damage of drought and flood to rice plants cannot be completely avoided. At present, drought and flood continue to be an important problem in rice production. In the south, there are the autumn drought in July and August, and spring drought in the four months of February, March, April, and May. In the north, drought is usually suffered in April, May, and June. Flood is a problem of the river valleys and the lake basins. It is a problem in June and July in the south, and July and August in the north. Past experience proved that drought and flood may bring serious damage to rice production, but, positive measures may be taken to reduce the extent of the damage.

(1) The Effect of Drought and Flood on the Yield

a. The Effect of Drought

The rice plants can withstand drought to a different degree at different stage of growth. Generally speaking, during the time the seedlings are turning green, the plants are too weak to withstand drought. If there is not enough moisture, the seedlings may not live, and even if they do survive, their growth will be seriously delayed.

During the tillering stage, the rice plants may withstand drought a little better. However, since they now require more moisture, the lack of it may inhibit tillering.

At the time of the head evolvement, the transpiration of the leaves increases, and if moisture supply is limited during this stage, there will be less seeds per head.

During the stage of head development, especially during the time when the pollen cells are dividing, the rice plants are very sensitive to environmental conditions, and they can resist drought less now than any other time. If moisture is deficient, the inflorescence will be abnormal, and the pollen will not develop completely, and thus, fertilization and seeding will be affected.

During the fertilization stage, if there is drought, empty heads may be the result.

When the seeds are being filled, if there is not

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enough moisture the nutrients and the photosynthesis products cannot be successfully transferred, and many of the seeds will not be full.

Therefore, during the tillering and the head evolvement time of the entire growth season, the rice plants can withstand drought better. In Hupei, the farmers say: " A bin full of rice in spite of an early drought, a late drought sweeps the paddy clean." This is to say that a drought late in the growing season is much more serious.

b. The Effect of Flood

The rice plants may be damaged by flood, because the transpiration may be inhibited. The various varieties have different degrees of flood resistance, and the growth condition, the duration of the flood, the temperature of the water, and the speed of the flow all affect the extent of the damage. If the temperature of the water is warm and the water is muddy, then, transpiration is increased, while photosynthesis is inhibited; hence, the damage is serious. The fast flowing flood may damage the leaves and the stems to the extent of breaking them. If the water is deep, as long as the tip of the leaves are exposed, transpiration may continue; then, the damage will not be as heavy as with total submergence.

According to the studies of the Institute of Plant Physiology, Academia Sinica, rice plants may recover if they are submerged two to four days during the tillering stage. If they are submerged six to 10 days, the above ground portion of the plants will be rotten, but the growth point of the stem and the tillering tissue will not die. After they come out of the water, new leaves and tillers may appear. However, the longer the plants have been submerged, the longer it takes for them to recover. Ten days' submergence during the head evolvement stage will result in no heads. During the head development stage, submergence may cause the inflorescence to be incomplete or abnormal. If the plants are submerged for two to four days, they may still bloom after they come out of the water, but if the submergence is longer than six days, the pollen will die. Even though they may still bloom, there will be no fertilization.

In June of 1959, there was a great flood in the

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Tung-chiang Valley of Kwangtung. According to surveys, after the flood, the older seedlings of the late crop could resist the submergence better than the tender seedlings, and the seeds that had not sprouted withstood the flood very well too. With seven days' submergence, during the head development stage of the early crop, the young heads will be completely rotton, with no harvest at all. During the blooming stage, seven days' submergence will cause 95% empty hulls. The loss will be 40% if the plants are submerged for seven days during the milk-ripe stage. The damage is not as bad, if the plants are submerged for seven days during the wax-ripe stage. A harvest of 70 to 80% may still be expected.

It is apparent that the rice plants may withstand flood better after the milk-ripe stage. If the temperature is not too high, then three to four days of submergence will not bring serious damage. The worst time for a flood is during the head evolvement and the blooming stages.

(2) Experience in the Matter of Flood and Drought Protection

a. With Regard to Drought Protection

(a) All efforts should be exerted to find water, and whatever water that is available should be utilized reasonably. Various methods must be found to store rain water, and to make use of ground water. Then, there should be a system for water utilization. A special team should be appointed to control the source of water, so that the regulations for the use of water may be strictly carried out. When the water is rationed, the upper and the lower reaches of a stream should be treated fairly. Within a given area, the water of the lower region should be used before the water of the higher region, and the fresh flowing water should be used before the still water.

The paddies should be arranged in order; the most urgent ones obtain the water first. Irrigate those paddies where the plants are to be ripe earlier. As much as possible, the channels should be shortened so as to check waste. In the meantime, the intermittent and the damp soil methods should be adopted to raise irrigation efficiency.

(b) The following methods may be adopted if there

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is a water shortage during the sprouting season. First, the seedlings may be cultivated in areas near the source of water, so that the limited water resources may be utilized to the maximum. Second, seedlings may be cultivated on dry field also. They are actually easier to turn green again after being transplanted, and are more drought resistant when grown up. Third, The required amount of seedlings may be cultivated separately, depending upon the amount of local rainfall at the different times. Fourth, if the spring drought is so serious that the seed beds cannot be maintained, then, the seeds may be directly planted in the dry fields, to grow into seedlings with no water.

(c) If there is a water shortage at the time of transplantation, the following methods may be adopted: First, "Horse racing transplanting" is the method of filling and soaking the paddy with water; then immediately, it is plowed and raked over and over again; and the seedlings are transplanted right away. Then, pour the water in another paddy and start the same procedure. With this method, if there is water in the paddy for the three or four days after transplantation, the seedlings will live. Second, "seedling storage" is the method to be adopted when the seedlings are ready in the seed bed but there is not enough water to transplant them. They may be transplanted very closely together in a small paddy with water for storage. With this method, the transplantation may be delayed for about 20 days without affecting the final yield. Third, if the soil is kept moist, and leveled, holes may be dug with the seedlings planted in it carefully and then covered with fine soil. Then, sprinkle some water, and cover with another layer of soil. The seedlings should be sprinkled again every three to four days. With this method the seedlings will live, even though there is not enough water. Fourth, if the rain is late in coming, and the seedlings are getting too old, then, the paddy should be plowed very deeply, and the planting should be dense. The old seedlings should be trimmed so that they will tiller properly. If a drought is expected, it is better to limit the fertilizer and moisture of the seed bed to control the growth of the seedlings, and to train them to withstand drought better. According to the experience of the masses, this is better than using seedlings that are too old.

(d) The following methods are also important for fighting drought:

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First: The cultivation should be done earlier than normal to get rid of the weeds. When drought is here, but the paddy has not been completely dried the paddy should be cultivated in a hurry so as to encourage the development of the root system, to strengthen the drought resistance of the plants, and to prevent the weeds from robbing the moisture and nutrients of the soil. After cultivation, a thin layer of night soil may be applied, so as to make the soil hold moisture better. If the soil is already turning white and dry, then, cultivation may cut off the capillary action of the soil and thus reduce surface evaporation. This type of cultivation is done best to a depth of half to one ts'un.

Second: When the drought is serious, and the paddies have begun to crack, then, they should not be filled even when water becomes available, until the surface has been loosened and the cracks filled. At the same time, the dikes must be inspected first and mended, so as not to waste precious water.

Third: Stubble mulch is another effective way of fighting the drought. Leaves of trees and grass may be used to cover the space between the groups. About 500 chin per mou is needed. Add a small amount of lime to cause them to decompose. This method may effectively reduce evaporation so that the soil will remain moist longer to supply more nutrients to the seedlings.

Fourth: Silts of the ponds and rivers may be used to cover the area around the root system to reduce evaporation and to prevent the soil from cracking which may even break the roots.

(e) If there is a prolonged drought, and the season is becoming late, plans should be changed so that a late maturing variety may be chosen instead, or the paddies may be used for such dry field crops as corn, Fagopyrum esculentum, beans, and potatoes, so as not to waste the season.

(f) In some areas, through the understanding of the local rules of drought occurrence, special varieties are chosen to avoid damage. For example, in the Yangtze Valley, such as Kiangsi, Anhwei, and Kiangsu, the hilly regions have changed the medium ripening varieties to the early ones in order to avoid the much too frequent autumn drought. In the Autonomous Region of the Chuang Nationality, the early rice paddies have been used for a crop of corn.

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Upland rice is being used to replace paddy rice in such areas as An-tung and Ch'en-yang of Liaoning to avoid spring drought. This is a very effective method.

b. With Regard to Flood Protection

(a) When a paddy is being attacked by a flood, a labor team should be organized immediately and equipment should be immediately gathered to drain the paddy as fast as possible. The high paddies should be saved first. (If necessary, the low ones should be given up for a loss in order to concentrate all efforts to save the high paddies.) The high yield paddies should be attempted before the low yield ones. In a word, those which can possibly be saved should be saved first.

(b) After the seedlings have been submerged, when the water retreats they may still xhow signs of life. The dead leaves and other debris should be cleared at once, and the paddy fertilized with quickly effective fertilizer. If the seedlings are apparently all dead, then, new seedlings should be planted immediately, so that when the paddy is completely dried, they may be transplanted again.

(c) After being submerged, the paddy should not be drained all at once. Instead, a thin layer of water should be kept so that the seedlings may gradually recover. If the water is drained at once, the seelings, very weakened by the submergence, may wither and die. At this time, an application of night soil or ammonium sulfate is very helpful. Afterwards, the paddy may be sunned and cultivated to encourage the seedlings to recover. As the water is draining away, bamboo sticks should be used to sweep the mud and other debris off the seedlings. If the water seems very muddy, then, some fresh water should be given so that the seedlings may recover their functions of transpiration and photosynthesis. If the temperature is high, then, the water should be changed frequently.

(d) After the paddy is drained after a flood, it should be carefully inspected. If seedlings are found missing in some spots, they should be made up at once. We may use either the seedlings which are left over from transplantation, or we may transplant from other spots of the same paddy, where the plants are tillering very nicely. Or, if large areas of missing seedlings are found, then the seedlings of several

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paddies may be combined into one, while the other paddies may be leveled and cultivated for the direct planting of a late ripening crop.

(e) If the flood comes when the rice plants are in the wax-ripe stage of development, then, all efforts should be exerted to harvest them. If there is not enough time, then, they should be harvested immediately after the water retreats, so that the seeds will not all sprout or become rotten. In some cases, small boats may be used to cut the heads. If the flood comes at the time of blooming or head evolvement stages, then, as soon as the water retreats, the paddy should be immediately taken care of, in order to encourage the left over stem to sprout and evolve again.

(f) In some areas, the early maturing varieties are being chosen to replace the late maturing varieties in order to avoid or lessen the threat of flood between summer and autumn. In the very low paddies, the farmers sometimes plant deep water varieties or other flood resistant varieties so as to stabilize harvest. These methods have been found to be very effective.

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CHAPTER 17. ROTATIONAL PLANTING

[p 483]

The crop rotation system for the rice paddies has a long history in China. It says in Ch'i-min Yao-shu that " Beans are best as a crop before the rice; flax or millet are not as good...the rice crop must be rotated every year." In 1956, the party central committee proposed the "the General Outline for the National Agricultural Development from 1956 to 1967 (draft)" in which an index for repeated crops was given for the various regions. With regard to the crop rotation system of the rice paddies, the provisions are: single-seasoned rice culture is to be changed into double-seasoned; alternate rice culture is to be changed into continuous rice culture, medium ripening rice culture is to be changed into early rice culture with an autumn crop; a spring or winter crop (including green fertilizer) is to be added to the originally one-crop fields. The originally one-crop per year regions are to become two crops or three crops for two years, and the original two crop regions are to become three crops or five crops for two years. After this movement, by 1957, the index for the repeated crops had risen from 30.9% in 1953 to 40.6%, and more than 80% of the provinces have a high index of repeated crops. This change has, indeed, brought important effects to our country's grain production.

A crop rotation system for the rice paddies can increase rice production, improve soil fertility, and provide more animal feed. However, with regard to a reasonable crop rotation system, we must consider the following factor:

(1) We must be determined to carry out the production plan of the state regarding grains and economic crops.

(2) We must promote the development of animal husbandry, and increase the production of feed, especially pig feed.

(3) We must plant more forage legumes to raise soil

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fertility, and eliminate plant diseases and insects.

(4) We must try to utilize the beneficial natural conditions of each locality, and avoid or overcome all the disadvantageous environmental conditions of the different areas.

(5) We must organize labor reasonably so as to make full use of the nation's rural labor potential.

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SECTION 1. DOUBLE SEASON RICE ROTATIONAL PLANTING SYSTEM [p 483]

Double-seasoned rice culture includes the continuous crops of the early-ripening and the late-ripening rice varieties, and alternated crops of the rice varieties. In the areas of South China and Central China, the acreage of double-seasoned rice culture has rapidly grown, during recent years. While the acreage of the alternated rice crops is diminishing, as a rule the double-seasoned areas have added a winter crop or a crop of green fertilizer to form a three-crop system. In Hai-nan-tao, some paddies grow three crops of rice a year. In the Autonomous Region of the Chuang Nationality, of Kwangsi, after the medium ripening rice is harvested, some paddies are planted with a winter rice crop (the winter rice crop is planted at the end of September, transplanted in the early or middle part of November, and harvested at the end of May or the beginning of June next year,) to form a system of medium and winter rice crops. In Central China, and the southern parts of the Southwest Highlands, a winter fallow system has been introduced for some of the double-seasoned rice paddies, and in some other areas, there are systems of five crops or six crops in two years. The following is a description of the major crop rotation systems of our country:

1. ROTATION OF DOUBLE SEASON RICE AND WINTER DRY CROP [p 484]

The double-seasoned rice paddies are often planted with a crop of green fertilizer or barley, wheat, oil cabbage, and other vegetables. In South China, such crops as sweet potatoes, tobacco, flax, or Fagopyrum esculentum can be carried over the winter. The rotation system composed of double-seasoned rice crops and a winter dry crop takes the following forms:

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First Year
(1) Double-seasoned rice crops --- wheat or barley →
Second Year
Double-seasoned rice crops --- Pisum stivum
Ch'eng-hai, Kwangtung

Two to Four Years
(2) Double-seasoned rice crops --- forage legumes →
One or Two Years
Double-seasoned rice crops --- oil cabbage, vegetables, or winter fallow
Li-ling, Hunan
O-ch'eng, Hupei

First Year
(3) Double-seasoned rice crops --- forage legumes →
Second Year
Double-seasoned rice crops --- oil cabbage
Kiangsi, Szechwan

First Year
(4) Double-seasoned rice crops --- forage legumes, lima beans, or Pisum stivum →
Second Year
Double-seasoned rice crops --- oil cabbage →
Third Year
Double seasoned rice crops --- wheat or barley
Chekiang, Fukien

First Year
(5) Double-seasoned rice crops --- Paddy sunned through the winter →
Second Year
Double-seasoned rice crops --- wheat or vegetables
Ch'ao-an, Kwangtung

Unscheduled, but occasionally:
(6) Double-seasoned rice crops --- forage legumes →
One year
Double-seasoned rice crops --- wheat or barley →
Unscheduled but occasionally
Double-seasoned rice crops --- forage legumes
Li-ling, Hunan

The major form of the double-seasoned rice crop rotation system in our country is a rotation between the forage legumes, which include Astragalus sinicus (also called Hung-hua-ts'ao), Shao-tze, Medicago denticulata (also called Chin-hua-ts'ai), and turnip greens (also called fertilizer turnip). These legume crops are mainly to be used for fertilizer. The old double-seasoned rice culture regions all adopted this method, and this was the reason that soil fertility was maintained through prolonged cultivated of double-seasoned rice crops. Through the years, the acreage of forage legumes is now maintained at about 60%, and the production of fresh green fertilizer is about two to three thousand chin/mou. Thus, the soil contains about 3 to 6.5% of organic matter, and generally the yield of the double rice crops is above one thousand chin per mou.

According to the analysis of Kiangsi Provincial Institute of Agricultural Sciences, the nitrogen, phosphorus, and potassium content of the soil is higher when double rice crops are rotated with forage legumes instead winter fallowing. (Table 17-1) The experience in Lien-hu-hsien of Kwangtung proved that prolonged practice of this rotation system may cause the soil to become deep and thick with a black hue, and the yield of both crops of rice may become very high.

Table 17-1 Soil Nutrient Analyses of the Paddies with Both Rotation Systems

(1) 取样地点	(4) 轮栽方式	有机质 (7) (%)	銨态氮 (8) (p.p.m.)	有效磷 (9) (p.p.m.)	有效鉀 10 (p.p.m.)
宁 2 都	双季稻——冬闲 5	2.13	0.6000	0.10	7
宁 2 都	双季稻——綠肥 6	2.50	0.6500	0.15	13
萍 3 乡	双季稻——冬闲 5	4.88	0.1075	0.85	12
萍 3 乡	双季稻——綠肥 6	4.90	0.2115	3.40	19

注：表中p.p.m.为百万分之一。(11)

1. Place from which the sample was taken
2. Ning-tu 3. P'ing-hsiang 4. Rotation system
5. Double-seasoned rice crops --- winter fallow
6. Double-seasoned rice crops --- forage legumes
7. Organic matter (%) 8. Nitro-ammonia 9. Utilizable phosphorus 10. Utilizable potassium 11. Note: p.p.m. = parts per million

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However, if a paddy has been planted with double-seasoned rice crops and forage legumes for many years, winter plowing has been neglected too long, the weeds and the fungi which habitually accompany the forage legumes will become a serious problem, and the yield of the legumes will drop; so will the yield of the rice crops. Therefore, in areas of Hunan and Hupei, oil cabbage and vegetables are often used to rotate with the forage legumes. Thus, we have the other forms of crop rotation.

When oil cabbage is used as a winter crop, the soil is plowed in the winter, and the cabbage seeds provide extra oil. If field management is proficient, soil fertility may be increased also. It has been discovered that a crop of oil cabbage especially improves the phosphorus content of the soil. (Table 17-2)

Table 17-2 Soil Analyses of Paddies Rotated with Forage Legumes and Oil Cabbage

取样地点 (1)	轮栽方式 (5)	有机质 (%) 10	全氮量 (%) 11	速效磷 (p.p.m.) 12	速效鉀 (p.p.m.) 13
萍乡新村社 2	双季稻——綠肥 6	4.76	0.2290	0.80	16.00
萍乡新村社 2	双季稻——油菜 7	5.74	0.2410	3.20	44.00
萍乡新村社 2	双季稻——蔬菜 8	5.42	0.2414	1.70	18.00
萍乡年丰社 3	双季稻——休闲 9	4.88	0.1072	0.85	12.00
萍乡年丰社 3	双季稻——綠肥 6	4.90	0.2115	3.40	19.00
萍乡年丰社 3	双季稻——油菜 7	4.42	0.1595	4.20	29.00
萍乡东阳社 4	双季稻——綠肥 6	3.73	0.1830	0.65	22.00
萍乡东阳社 4	双季稻——油菜 7	3.37	0.1860	1.55	31.00

14 注：表中綠肥均为紫云英。

1. Place from which the sample was taken
2. Hsin-ts'un Commune, P'ing-hsiang 3. Nien-feng Commune, P'ing-hsiang 4. Tung-yang Commune, P'ing-hsiang
5. Rotation System 6. Double-seasoned rice crops --- forage legumes 7. Double-seasoned rice crops --- oil cabbage
8. Double-seasoned rice crops --- vegetables
9. Double-seasoned rice crops --- winter fallow
10. Organic matter (%) 11. Whole nitrogen (%)
12. Quickly effective phosphorus (p.p.m.)
13. Quickly effective potassium (p.p.m.)
14. Note: the forage legume used was Astragalus sinicus

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According to the experience of the masses in Ch'ao-shan, Kwangtung, if double-seasoned rice crops are rotated with Pisum stivum in one year, wheat or wheat and vegetables the next, the yield of the rice crops seems to be very good. With regard to fertilizer application, the planting of vegetables is better than beans, and potato crops are the worst for soil fertility. Therefore, in order to improve soil fertilizty and reduce the number of insects, winter crops should be rotated. In Hu-shan and Lien-chiang of Kwangtung, tobacco is used as a winter crop for the rice paddies, and it has been proven that there are less rice borers the year after the tobacco crop.

2. ROTATION OF DOUBLE SEASON RICE AND SINGLE SEASON RICE AND DRY CROP EVERY OTHER YEAR [p 486]

In some areas, there are shortages in water, fertilizer, and labor, and in some other areas, it is important to develop economic crops, and to produce seeds of the forage legumes, therefore, the rotation systems of a double-seasoned rice culture alternated yearly with a crop of single-seasoned rice and a dry crop. The following are the major forms of this method:

Two to Three Years
(1) Double-seasoned rice crops --- forage legumes →
One to Two Years
Early rice --- Fall Soybean --- forage legumes or winter fallow
Feng-ch'eng , Ling-ch'uan of Kiangsi, Heng-yang, Heng-nan of Hunan

First Year
(2) Double-seasoned rice crops --- oil cabbage or lima beans →
Second Year
Early rice or soybean --- Soybean or late rice --- wheat
Lien-p'ing of Kwangtung, and Fukien

First Year
(3) Double-seasoned rice crops --- barley →
Second Year
Spring soybean --- late rice --- wheat
Chin-chiang of Fukien

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First Year
(4) Double-seasoned rice crops -- forage legumes →
Second Year
Medium rice --- oil cabbage →
Third Year
Double-seasoned rice crops --- forage legumes
Hupei, Kiangsu

First Year
(5) Double=seasoned rice crops --- sweet potatoes planted before the rice harvest →
Second Year
Early-rice --- sweet potatoes →
Third Year
Double-seasoned rice --- Pisum stivum
Ch'ao-an of Kwangtung

Unscheduled but occasionally
(6) Double-seasoned rice crops --- seeds for forage legumes →
One to Two years
Single-seasoned rice crop --- forage legumes →
Unscheduled but occasionally
Double-seasoned rice crops --- forage legumes
Yuan-chiang of Hunan

First Year
(7) Double-seasoned rice --- seeds for forage legumes →
Second Year
Late rice --- late rice or a fall crop →
Third Year
Double-seasoned rice crops --- forage legumes
Ch'i-tung of Hunan

Unscheduled but occasionally
(8) Double-seasoned rice crops --- winter fallow →
One Year
Tobacco --- glutinous rice --- forage legumes →
Unscheduled but occasionally
Double-seasoned rice crops --- forage legumes
Li-ling of Hunan

* This is Hsueh-tou which is a variety of lima beans growing in high mountain regions. ** Sweet potatoes, in this case, are planted in the paddies before the rice is harvested.

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Among the rotation systems described above, the first three types have three harvests a year, to form six harvests in two years; and among the six harvests, three are rice crops. During the years when the single-seasoned rice crop is among the three harvests, it can either be the first crop or the second crop of the year. In the areas where there is a spring rainy season, then rice may be used for the first crop; in the areas where there is a rainy autumn, then, rice may be used for the second crop.

The fourth to the seventh systems have five harvests in two years. The fourth system is currently adopted over large areas in the newly developed double-seasoned rice growing regions in Hupei, Kiangsu, and Anhwei.

3. DOUBLE CROPPING OF DOUBLE SEASON RICE [p 487]

There are large areas of waterlogged paddies in South and Central China, as a result of the lack of fresh water or a faulty drainage system. Some of the waterlogged paddies have always been used as double-seasoned rice paddies, while others were used for single-seasoned rice crops with a winter fallowing season.

This system has also been adopted in the Yunnan and Kweichow Plateau, in the areas below 1,200 m elevation, and in some places there, instead of winter fallowing, another crop of dry plants is cultivated in the winter also.

4. OTHER ROTATION SYSTEMS OF MULTIPLE CROPPING OF DOUBLE SEASON RICE [p 487]

These systems include the triple-seasoned rice culture, the double-seasoned rice culture with four harvests in a year, and the two harvests system of a winter rice crop and a late rice crop. The triple-seasoned rice culture is being practiced in small areas in Wan-ning, Ling-shui, and Ya-hsien of Hai-nan-tao, with a histroy of more than 30 years, and is currently being enlarged. The first crop is planted

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just before the beginning of winter and harvested just after the beginning of spring. The second crop is planted in the beginning of spring, and transplanted soon afterwards. The harvest is in the beginning of summer. The third crop is planted and transplanted in the beginning of summer and is havested just after the beginning of winter. This system may be practiced only when the soil is very fertile, the water condition is good, and the labor is sufficient.

The double-seasoned rice culture with four crops a year is practiced in small areas in South China. For example, in Sha-hsien, Fukien, there are two crops of rice, a crop of turnips and a crop of of oil cabbage. In the southern parts of Chekiang, forage legumes or wheat is planted with both crops of rice to make four crops. According to the information of Hsien-ho Experimental Station, if a crop of forage legumes is planted before the early rice crop for fertilizer, the yield of the rice may be increased 19.4%. Therefore, this is a good method of solving the problem of initial fertilizer for the early rice crop.

The two-crop system of double-seasoned rice culture is practiced in Yung-ning and Lung-chin of the southern part of the Autonomous Region of the Chuang Nationality in Kwangsi, in the pasty paddies or hillside paddies of better water conditions. When the soil is fertile and the drainage is good, the rotation system of a winter rice crop --- late keng rice crop ⟶ forage legumes --- medium ripening rice crop is adopted.

Among the aforementioned rotation systems, the system with the rotated crops of double-seasoned rice and a winter dry crop is the most popular one. The winter dry crop includes forage legumes, oil cabbage, wheat, and beans. The crop of forage legumes is the most significant, because it improves the organic content of the soil. However, the green fertilizer crop should also be rotated with other winter dry crops, so that the soil may be plowed in the winter to encourage mineralization of the organic matter and to improve the physical characteristics of the soil.

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SECTION 2. ROTATION SYSTEM OF SINGLE SEASON RICE [p 488]

The rotation system of the single-seasoned rice culture varies with the local conditions. It includes mainly the paddy rice with a winter dry crop; paddy rice with summer and fall crops or fall and winter crops; and paddy rice with another hydrophytic crop, to form a rotation of two harvests and three harvests a year. When there are three harvests, the rice is often planted alternated with another crop.

When there are two harvests, the rice is generally the first crop, and the second crop may be wheat, oil cabbage, lima beans, Pisum sativum, or forage legumes. Occasionally, the rice may also be the second crop with the other dry crops as the first crop. If there are three harvests, the first crop is generally a paddy rice crop, the second is a fall dry crop, and the third is a winter dry crop. However, occasionally, the first crop may be a dry crop, the second the paddy rice, and the third is again a dry crop.

1. ROTATION OF PADDY RICE AND WINTER DRY CROP [p 488]

This rotation system with two harvests a year is distributed in the provinces of the Yangtze Valley, the central part of Yunnan, and the western part of Kweichow. In the South China, the temperature is higher. If the single-seasoned rice culture is the practice, then, there are generally two additional dry crops. In Central China, if the winter temperature is 3 to 5°C, then the winter crops, such as wheat, oil cabbage, lima beans, and Pisum sativum are usually harvested in the later part of April or the middle or later parts of May, before the rice season. The rice crop is usually harvested in the later part of August to the later part of October, and there are two months left to prepare the field for the winter crop.

In the regions of the Northeast and North, the growing season is short. Generally, single-seasoned rice is

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the rule, and the paddy is fallowed through the winter. In a few places, the system of a forage legume crop or spring wheat is adopted.

The rotation system of the paddy rice with winter dry crops takes the following forms:

(1) Paddy Rice and Wheat

This system is distributed chiefly in Kiangsu, Chekiang, Hupei, Anhwei, and Szechwan, and is the major rotation system in the important rice growing areas of Central China. The winter crop is usually wheat. In some areas, barley or other early ripening varieties of wheat may also be used so as to ease labor pressure at the rice transplanting time. With this system, if a certain amount of nitro and organic fertilizer is applied every year, a stable yield is not difficult to maintain. However, the growing season is thus very long, according to the experience of Wu-hsi of Kiangsu, and Hsin-shao of Hunan, the field is usually crowded with such weeds as Capsella bursa-pastoris and insect problem will become more serious also. Therefore, the practice is to rotate the wheat varieties with forage legumes, so that the spring plowing may be done before the the weeds bloom and seed. The experience of Hsin-shao-hsien of Hunan proved that if forage legumes, potatoes, or tobacco are planted instead of wheat in one year, then, in the next year, the yield of the wheat may be 20 to 30% higher, and the yield of the rice may be more than 10% higher too.

The major forms of the rotation system of rice and wheat are as follows:

a. Rice --- wheat (One to Two Years) ⟶ Rice --- forage legumes (One to Two Years)

Wu-hsi of Kiangsu
Hsin-shao and Wu-kang of Hunan

b. Rice --- wheat (Two to Three Years) ⟶ Tobacco or potatoes --- Rice (One Year)

Hsin-shao of Hunan

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c. Two to Three Years: Rice --- wheat → One Year: Rice --- vegetables
Hsin-shao of Hunan

d. First Year: Rice --- wheat → Second Year: rice --- barley

P'an-hsien of Kweichow

Although part of the areas which originally practiced this rotation system have been changed into double-seasoned rice crops, this is still an important system in the vast regions of the Central China. In the North, early-ripening varieties or wheat and barley have been selected for the adoption of this system in the north.

(2) Paddy Rice and Oil Cabbage

This is an important method of producing edible oil in the Yangtze Valley. Oil cabbage ripens early so that the rice plants may be transplanted early, and is also beneficial for the soil. However, in these regions, in the later part of the growth season of the oil cabbage crop, it is very hot and humid, and various forms of fungus diseases may occur and the soil may be infected. Therefore, in such provinces as Hunan, Kiangsi, Chekiang, Kiangsu, and Szechwan, oil cabbage is often rotated with other winter and summer crops to form the following five types:

a. One to Two Years: rice --- oil cabbage → One to Two Years: rice --- forage legumes

Hsu-p'u, Tung-k'ou of Hunan

b. Two Years: rice --- oil cabbage → One year: rice --- lima beans

Liu-an of Anhwei and I-liang of Yunan

c. First Year: rice --- oil cabbage → Second Year: rice --- forage legumes →

Third Year: Rice --- barley or wheat

Chekiang, Szechwan

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d. Two Years: Rice --- oil cabbage → One Year: rice --- Wheat

Tsun-i, Kweichow

e. Two Years: Rice --- oil cabbage → One to Two Years: rice --- autumn soybean --- forage legumes

Heng-yang and Heng-shan of Hunan

(3) Rice, Lima Beans and Pisum sativum

This form of rotation system is distributed chiefly in Szechwan, Yunnan, Hupei, Chekiang, and Kiangsu, and very little in other provinces. Since lima beans contract all types of diseases, this crop now is rotated with wheat, oil cabbages, and others in order to produce more edible oil and to improve soil fertility. This rotation system takes the following four forms:

a. First Year: Rice --- oil cabbage → Second Year: rice --- forage legumes → Third Year: rice --- lima beans

Hupei

b. Two Years: Rice --- lima beans —— One Year: rice --- oil cabbage

K'un-ming, Yunnan

c. First Year: Rice --- oil cabbage → Second Year: rice--- lima beans → Third Year: rice --- wheat

Pin-chou of Yunnan

d. First Year: Rice --- wheat → Second Year: rice -lima beans

I-liang, Yunan

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(4) Rice, Winter Vegetables, and Feed Crops

The winter vegetables include celery cabbage, turnip, and Brassica oleracca; winter feed crops include Beta vulgaris and early cabbage. These forms of rotation system are distributed in all the provinces, but more so in the vicinity of the cities and the mining districts. The paddies are deep plowed in the fall, with additional fertilizer for the winter vegetable crops; this is, therefore, a good system for soil improvement. In Wang-ch'eng and Ch'ang-sha of Hunan, this system has been introduced to improve the paddies of very thin soil, and the result is very good. However, neither the vegetables nor the feed crops should be planted year after year, and the major forms of rotation are as follows:

a. Medium ripening rice (One Year) --- vegetables or feed crops ⟶ Double-seasoned rice (One to Two years)
Wang-ch'eng, Hunan

b. Medium ripening rice (One Year) --- vegetables or feed crops ⟶ Tobacco, potatoes or Fagopyrum esculentum (One Year) --- single-seasoned late ripening rice
Wang-ch'eng, Hunan

c. Medium rice --- vegetables (One Year) ⟶ early ripening rice --- autumn kaoliang (One Year)
Ch'ang-sha, Hunan

2. ROTATION OF PADDY RICE AND SUMMER-AUTUMN (OR AUTUMN-WINTER) DRY CROP [p. 491]

With this system, there are three harvest in a year. Generally speaking, the rice is the first harvest, but sometimes, it may also be the second or the third. In some areas in the eastern and the central parts of Kwangtung, in the mountain regions of Wu-chih-shan of Hai-nan-tao, in the mountain regions of more than 500 m above sea level in

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Kwangsi, and in the northwestern mountains of Fukien, where irrigation is more difficult, single-seasoned rice is the general practice. During the recent years, the paddies originally used for winter water storage have been used for crops.

Unless the elevation is very high, areas of the Central China have a long frost-free season, a fall crop is planted after the harvest of the early ripening rice, and with the fall crop, a winter crop of forage legumes, oil cabbage, or wheat may generally be planted in alternate rows to be harvested early in the winter to form a three-harvest rotation system. Gradually, the original two-harvest system is changing into five harvests in two years. The rice harvest is generally in July to August, and it is a good time for fall plowing and weeding. Since the fall dry crops need less moisture than rice, this rotation system is usually adopted in the areas with less rainfall in the fall, in order to obtain one more harvest.

The areas of Yu-ch'i, Chiang-ch'uan, and Yuan-mou of the Yunnan and Kweichow Plateau are above 1,200 m in elevation, but the frost-free season is long and the temperature is high. Such dry crops as tobacco and cotton are often rotated with paddy rice to form a system of cotton --- paddy rice --- overwintering potatoes or tobacco --- rice --- lima beans. This system has three harvests in a year.

(1) Rice and Sweet Potatoes

According to <u>Ning-yuan Hsien-chih</u> of Hunan, the rotation system of early ripening or early medium ripening rice and sweet potatoes began long before the year 1700. It is currently being popularized in many provinces. In the northwestern part of Kwangsi, northern part of Kwangtung, and Min-pei and Min-hsi areas of Fukien, sweet potatoes are generally a fall crop of the rice paddies. In the southern part of Kwangtung, and in areas of Hai-nan-tao and Taiwan, sweet potatoes may be used either as a fall crop or as a winter crop after the late ripening rice harvest. Sweet potatoes are high yield crop plants, and the vines make good feed or fertilizer. This system is therefore especially significant now that the pig raising industry is being developed on a large scale.

Since sweet potatoes are planted on a mound, this crop can increase the depth of the plowing layer. According

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to the survey conducted in Chao-shan, Kwangtung, after planting sweet potatoes, the plowing layer may be increased from 13 to 17 or 18 cm. This is definitely beneficial to the rice crop. When the sweet potatoe plants grow large, the leaves and stems cover the ground surface, and the weeds are thus reduced. In areas of Hunan and Kiangsi, after every three or four years of double-seasoned rice crops, or rice and bean crops, a crop of sweet potatoes is often used purposefully for the elimination of weeds. According to the experience of Feng-ch'i Commune of Chao-an, Kwangtung, a crop of sweet potatoes before the late rice crop is better than an early ripening rice crop. However, in order to maintain soil fertility, sweet potatoes are often rotated with vegetables, peanuts, or soybean to form the following methods:

First Year		Second Year
a. rice--sweet potatoes--forage legumes		
	Hunan, Min-pei	
b. overwintering sweet potatoes --summer forage legumes -- late rice		
	Taiwan	
c. rice -- overwintering sweet potatoes		
	Chao-an, Kwangtung, Taiwan	
d. rice --spice--sweet potatoes		
	K'an-chiang, Kwangtung	
e. rice--sweet potatoes	→	rice -- beans
	Chia-i, Taiwan	
f. rice--sweet potatoes	→	peanuts--late rice--wheat
	Chao-an, Kwangtung	
g. rice--sweet potatoes--vegetables	→	peanuts--rice--oil cabbage
	Lien-hsien, Kwangtung	

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(2) Rice and Soybean or Peanuts

This type is distributed chiefly in Kiangsi, Hunan, Szechwan, Anhwei, Chekiang, Kwangtung, Kwangsi, and Fukien, and to some extent in the other provinces. In the central south of Kwangtung, and the southern part of Kwangsi, soybean and peanuts are often used before the rice crop, while in the provinces of Central China and Min-hsi and Min-pei of Fukien, soybean is often used as a crop after the early rice . This variation is related to the local rainy season and irrigation conditions. Rice plants require a large amount of nitro-fertilizer; both soybean and peanuts can improve the nitrogen content of the soil. According to surveys conducted in Chia-chiang and Tung-hsiang of Kiangsi, organic content and whole nitrogen content of the soil are higher when soybean is used to rotate with the rice crop instead of sweet potatoes, millet, or another crop of rice, and the nitrogen content is the worst when the paddy is fallowed for the autumn.

According to the experience of Mei-yu Commune of Chi-yang-hsien, Kwangtung, if peanut is used to rotate with a rice crop instead of another crop of rice, under similar field management, the yield may be 20% higher. In many areas of Hunan, Kiangsi, and Fukien, the rotation system of rice and soybean has been practiced for many a year, and the yield re-remains high. For further improvement, after the soybean crop, another crop of forage legumes may be planted. Repeated planting of peanuts is not advisable due to diseases of the plants; planting them in alternated years is better. The rotation system of rice with peanut or soybean, therefore, takes the following forms:

Two to Three Years
a. Eary rice --- soybean -- forage legumes ⟶
One to Two Years
Early rice --- soybean --- winter fallow
Hunan, Kiangsi, Anhwei, Chekiang

One to Two Years
b. Early rice --- soybean --- forage legumes ⟶
One to Two Years
Early rice --- soybean --- oil cabbage
Southern part of Kiangsi

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Two to Three Years
c. Early rice --- soybean --- forage legumes →
One to Two Years
Early rice --- sesame -- oil cabbage
Southern part of Kiangsi

d. Winter soybean (or early soybean) ---
Late seed bed --- Late rice
Pai-she, Kwangsi

First Year
e. Medium rice -- soybean -- oil cabbage →
Second Year
Medium rice --- Alisma plantago var. parviflorum
Min-pei, Fukien

First Year
f. Rice --- peanuts --- barley →
Second Year
Soybean --- rice --- oil cabbage Lien-p'ing, Kwangtung

First Year
g. Rice -- sweet potatoes →
Second Year
Peanuts --- rice --- oil cabbage
Lien-p'ing, Kwangtung

First Year
h. Peanuts -- late rice --- overwintering sweet potatoes →
Second Year
Late rice --- winter sunning process →
Third Year
Peanuts -- late rice --- vegetables
Chao-an, Kwangtung

First Year
i. Soybean -- late rice --- wheat →
Second Year
Peanuts --- late rice --- wheat
Ku-t'ien and P'u-t'ien of Fukien

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Table 17-3 Effect on Soul Fertility of the Various Rotation Systems

轮栽方式 (1)	有机质 13 (%)	全氮量 14 (%)	速效磷 15 (p.p.m.)	速效钾 16 (p.p.m.)	土壤情况 17	取样地点 26
2 早稻——大豆——油菜	2.7700	0.1933	3.00	81.0	山区垅田 18	峡江新陂社 27
3 双季稻——油菜	2.3500	0.0247	3.20	41.0	夹沙土 19	
4 早稻——大豆——绿肥	2.1952	0.1506	0.85	21.0	平原,肥力低 20	
5 早稻——小米——绿肥	1.9899	0.1396	0.65	25.0	沙泥田 21	东乡幸福六社 28
6 早稻——休闲——绿肥	1.6577	0.1309	0.45	18.0	22	
7 早稻——大豆——绿肥	2.1533	0.0996	0.65	21.0	山区,肥力低	东乡八一社 29
8 早稻——甘薯——绿肥	1.3715	0.0822	1.85	15.0	泥田 23	
9 早稻——休闲——绿肥	1.4586	0.0816	痕迹	25.0	24	
10 早稻——大豆——绿肥	2.5763	0.1099	1.75	13.0	丘陵,肥力低	东乡珀莲五社 30
11 早稻——小米——绿肥	1.4845	0.0731	0.95	2.5	沙泥田 25	
12 早稻——甘薯——绿肥	1.2752	0.0427	2.10	10.0		

1. Rotation system 2. early rice --- soybean --- oil cabbage
3. Double-seasoned rice --- oil cabbage
4. early rice --- soybean --- forage legumes
5. early rice --- millet --- forage legumes
6. early rice --- fallow --- forage legumes
7. early rice --- soybean --- forage legumes
8. early rice --- sweet potatoes --- forage legumes
9. early rice --- fallow---- forage legumes
10. early rice --- soybean --- forage legumes
11. early rice --- millet --- forage legumes
12. early rice --- sweet potatoes --- forage legumes
13. Organic matter (%)
14. Whole nitrogen (%) 15. Quickly effective phosphorus(p.p.m.)
16. Quickly effective potassium (p.p.m.) 17. Soil condition
18. Mountainous diked paddy 19. Sandy loam 20. plain paddy, with low fertility 21. Sandy paddy 22. Mountainous, low fertility 23. Clay soil 24. Hilly, low fertility
25. Sandy paddy 26. Place from which the sample is taken
27. Hsin-p'u Commune, Chia-chiang 28. Hsing-fu Sixth Commune, Tung-hsiang 29. Pa-i Commune, Tung-hsiang 30. P'o-lien Commune, Tung-hsiang

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(3) Rice and Corn

This rotation system is distributed chiefly in Kwangsi, Hunan, Szechwan, Hupei, Chekiang, and Kwangtung, mostly in the mountain regions, where irrigation conditions are poor. In the three provinces of Kwangtung, Kwangsi, and Fukien, corn is often planted as a fall crop after the early rice. In Pai-she and Nan-ning of the southern part of Kwangsi, the temperature in February is above 10°. Corn is planted there before the beginning of spring, and is harvested between May and June. Pai-she Experimental Station of the Autonomous Region of the Chuang Nationality of Kwangsi conducted a survey in Ching-hsi and Tung-lan, and discovered that the rotation system of rice and corn is not worse than either the system of double-seasoned rice or the system of rice and wheat. The rotation system of corn and rice does not reduce the soil fertility, if reasonably managed. When the rice is harvested, there may be another winter crop, and thus the system of corn --- rice --- winter crop is formed, with three harvests in a year. In order to cultivate soil fertility, the winter crop should be forage legumes, spring soybean, or the like. The following forms of this rotation system are being practiced in Pai-she and Yung-ning.

a. corn --- medium rice --- forage legumes — Kwangsi

b. corn with soybean --- medium rice --- forage legumes — Kwangsi

c. corn --- medium rice --- Fagopyrum esculentum — Kwangsi

d. early rice --- corn --- forage legumes — Min-pei

(4) Rice, Tobacco, and Flax

In the southern part of Kwangsi, flax is planted in the middle of March, and is harvested in the middle of July, just before the season for the late ripening rice crop. Tobacco is planted after the harvest of the medium ripening rice, and is harvested before the early or the medium rice is planted next year. Another variety of flax (Linum usitatissimum) is planted in November, after the harvest of the late rice crop, and is harvested in the March of the next year. In some areas before 1,200 m. in Yunnan and Kweichow Plateau, and in Kuang-han and Hsin-fan of Szechwan the rotation system is tobacco --- rice --- a winter crop (mainly lima beans and wheat). In

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Ch'eng-tu and Wen-chiang of Szechwan, flax (Corchorus capsularis) may be planted before the rice crop. In Taiwan, tobacco and Linum usitatissimum are important winter crops to be planted with rice and other economic crops to form a triple-harvest system. The following are the major forms of this rotation system:

a. Corchorus capsularis --- late rice --- forage legumes
Kwangsi

b. Medium rice --- tobacco — Kwangsi

c. Double-seasoned rice or medium rice --- Linum usitatissimum
Kwangsi

d. Corchorus capsularis --- late rice (first year) ⟶
Double-seasoned rice ---- wheat (second year)
Chao-an, Kwangtung
Min-nan

e. Tobacco --- rice --- winter crops (wheat, lima beans)
Yu-ch'i and Chiang-ch'uan of Yunnan
Kuang-han and Hsin-fan of Kwangtung

(5) Rice and Fagopyrum esculentum

This system is widely distributed in Szechwan, Hunan, and Kiangsi. The growing season of Fagopyrun esculentum is very short. If planting is delayed due to drought or flood, and it becomes too late to plant other crop plants, there will still be enough time to grow a crop of Fagopyrum esculentum to add some food to this year's production. In the provinces of Hunan and Kiangsi, it is planted mostly after the harvest of early or medium rice. It is usually planted in alternated rows with Astragalus sinicus or other forage legumes. When Fagopyrum esculentum is harvested, the forage legumes are kept in the field through the winter. This method is often used to eliminate weeds or to reduce insect or disease damage of the paddies of rice and oil cabbage, or rice and wheat. This system takes the following two forms:

Two to Three Years
a. rice --- wheat or oil cabbage ⟶
One to Two Years
rice --- Fagopyrum esculentum --- forage legumes
Hsin-shao, Hunan

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One to Two Years
b. Medium rice --- Fagopyrum esculentum --- wheat or oil cabbage ⟶
One to Two Years
Medium rice --- Fagopyrum esculentum --- forage legumes
Tung-k'ou, Hunan

Forage legumes are also included in the above arrangements to improve the soil. The forage legumes used here are usually Astragalus sinicus, Medicago denticulata, shao-tzu, and others. In some cases, lima beans, Pisum sativum, or barley may also be used as green fertilizer. In some areas, green fertilizer crops amount to 60%, while in others, they may be less than 10%. The green fertilizer crops not only guarantee the needed fertilizer for the rice crop, they also provide important feed products for animal husbandry. In the low yield paddies of Tung-hsiang-hsien, Kiangsi, green fertilizer crops were planted for two years in a row; the yield of rice was raised from the two to three hundred chin of the past to more than five hundred chin per mou. When the acreage of green fertilizer of the hsien was increased from the 160,000 mou of 1958 to the 320,000 of 1959, the food production of the hsien was increased 40.1%. This is a very good example of how green fertilizer crops may improve the soil and raise the yield.

3. ROTATION OF PADDY RICE AND AQUATIC CROPS [p 495]

The rotation system of rice and other hydrophyte crops is distributed mostly in the waterlogged paddies of the provinces of Central China. These paddies are formed because of the following reasons:

(1) In the past, water was scarce in the hilly regions, and in order to guarantee water for the transplantation of rice, some paddies are used to store water through the winter.

(2) Drainage is poor in the low areas. The clay soil is heavy. In order to maintain its soft texture, the paddy is often kept with water constantly.

(3) When there is a shortage of fertilizer, water is often kept in the paddy throughout the winter, so that the soil may accumulate organic matter and nitro-ammonium for next year's rice crop.

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The rotation system of rice and hydrophyte crops in the provinces of Szechwan, Hunan, Kiangsi, Kwangtung, and Kiangsu takes the following forms:

(1) Rice and Hydrophyte Fertilizer Plants or Feed Plants

As the industry of animal husbandry is rapidly developing in such areas as Ning-hsiang and Wang-ch'eng of Hunan, Oenanthe stolinifera is rotated with rice to provide feed. Oenanthe stolinifera has well developed roots which can utilize the nutrients of the low layers of the soil. If cultivated properly, a yield of twenty to thirty thousand chin of feed may be obtained per mou. With a crop of this feed product, the soil fertility is also improved and the yield of next year's rice crop may be higher too. In Tao-hsien of Hunan, hydrophyte green fertilizer is planted with a yield of twenty to thirty thousand chin per mou, and its nitrogen content is as much as .064%. The major forms of this rotation system are as follows:

a. rice --- (Unscheduled) hydrophyte green fertilizer
Tao-hsien, Hunan

b. Rice (One Year) → Oenanthe stolinifera (One to Two Years)
Wang-ch'eng, Ning-hsiang, of Hunan
Szechwan

c. Rice (First Year) → Polygonum hydropiper (Second Year)
Wang-ch'eng, Hunan

d. Rice (First Year) → Ceralopteris thaliclroides (Second Year)
Ch'ang-sha, Hunan

(2) Rice and Hydrophyte Foods

Hydrophyte foods include roots of lotus [Nelumbo nucifera], water chestnut [Eleo charis ppantaginea], Tz'u-ku [Sagilaria sagitifolia] and Shui-yu [Jussiena repens]. The growing season of lotus root and Shui-yu is long; they may only be rotated with rice, but the growing season of water chestnut and Tz'u-ku is short, and they may be planted after the rice harvest to make two harvests in one year. These plants require considerable fertilizer, and the soil must be dug up deep when they are harvested. These conditions help

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improve the rice crop afterwards. The major forms of this rotation system are as follows:

a. Rice --- green fertilizer (Four to Five Years) → Lotus root (One Year)
Feng-ch'eng, Kiangsi

b. Rice (Unscheduled) → Early rice --- water chestnut (One Year)
Heng-yang, Hunan

c. Rice (Unscheduled) → Shui-yu (One Year)
Ch'ang-sha, Hunan

d. Rice (Unscheduled) → Early rice --- Tz'u-ku (One Year)
Kao-yu, Kiangsu

As the irrigation condition is being improved, these waterlogged paddies may be gradually improved so that the number of crops a year may be increased. For example, of the 30,140,000 mou of waterlogged paddies of Szechwan, more than 5,000,000 mou were changed into double-seasoned rice paddies in 1958, and a small part of them form a seasoned rice culture region. In places such as Hsia-li-ho of Kiangsu, the waterlogged paddies have been changed into areas of rice and wheat crops. When the waterlogged paddies are changed into dry fields, forage legumes should be planted in the winter so as to improve soil fertility and structure.

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SECTION 3. YEARLY ROTATION OF PADDY RICE AND DRY CROPS [p 497]

This method is actually distributed in every rice growing area of the country to a limited extent. During the recent years the state-operated farms are experimenting with this type of rotation system. In the south, since the growing season is long, the adoption of this system will still be made on the basis of repeated harvests in one year. In the north, this system will produce one crop a year, or three crops in two years.

1. YEARLY ROTATION OF PADDY RICE AND DRY CROP IN THE SOUTHERN PADDY RICE REGIONS [p 497]

This system is distributed chiefly in the high lands of Yunnan and Kweichow, Central China, and South China. It may be described as follows:

(1) Rice and Cotton in Alternated Years

This system is adopted in large areas of Chekiang, Kiangsu, Hupei, Anhwei, Hunan, and Kiangsi, with most of them concentrated in the alluvium of the lakes and rivers. It takes the four major forms:

First Year
a. Double-seasoned rice --- green fertilizer →
Second Year
Double-seasoned rice --- barley and wheat →
Third Year
Cotton --- green fertilizer

Yu-yao, Chekiang

First Year
b. Early rice --- soybean --- green fertilizer →
Second Year
Cotton --- green fertilizer for the seeds

Feng-ch'eng, Kiangsi

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c. Two Years: Rice → The Third Year: Cotton

Hsiao-kan, Hupei

d. The First Year: Rice --- wheat → The Second Year: Cotton --- wheat (green fertilizer) → The Third Year: Rice --- wheat

Tung-t'ai, T'ai-ts'ang of Kiangsu

(2) Rice Alternated with Sugar Cane

This system is distributed chiefly in Hai-nan-tao, the central and the western parts of Kwangtung, the southern part of Fukien, Taiwan, Szechwan, and the southern parts of Hunan and Kiangsi, with a small area in Yunnan. The major forms of this system are as follows:

a. The First Year: Double-seasoned rice → The Second Year: Sugar Cane → The Third Year: Sugar Cane

Taiwan, the central part of Kwangtung

b. The First Year: Double-seasoned rice → The Second Year: Sugar Cane and early rice; The Third Year: Sugar Cane (for two years)

Eastern part of Kwangtung

c. The First Year: Rice --- green fertilizer → The Second Year: Sugar Cane; The Third Year: Sugar Cane

Taiwan, central part of Kwangtung

d. The First Year: Double-seasoned rice --- Pisum sativum with sugar cane; The Second Year: Sugar cane with soybean → The Third Year: Double-seasoned rice with wheat

Eastern part of Kwangtung

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	The First Year		The second Year		The Third Year
e. Rice		→	Sugar Cane	→	Rice

Nan-k'ang of Kiangsi

(3) Rice, Soybean, and Peanuts

This system is practiced in Tan-yang and Chin-yu of Kiangsu, where the water and fertilizer conditions are generally poor, and if some soybean is planted in the summer, it may serve to relieve the shortages. The system of rotating rice and peanut is practiced in Kiangsi, Hunan, Kwangtung, and Fukien. Since it is easy for the peanuts to contract diseases, they are usually planted once in more than two years. In Tao-hsien of Hunan and other areas, this system is often adopted to improve very poor paddies.

First Year		Second Year		Third Year
a. rice--wheat	→	spring soybean--Fagopyrum esculentum--wheat	→	rice -- wheat

Tan-yang, Kiangsu

b. rice--forage legumes	→	rice oil cabbage	→	peanuts

Feng-ch'eng, Kiangsi

c. rice--winter fallow	→	peanuts	→	rice ---winter fallow

Tao-hsien, Hunan

d. Double-seasoned rice	→	peanuts, vegetables

Lien-p'ing, Kwangtung

e. early, medium rice---wheat	→	peanuts planted with wheat	→	early,medium rice---wheat

Kao-an, Kiangsi

f. double-seasoned rice	→	sweet potatoes	→	peanuts,late rice

Fukien

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(4) Rice, Sweet Potatoes, Tobacco, and Flax

Rice is often rotated with sweet potatoes in Kwangtung and Fukien, generally after the double harvests of rice, sweet potatoes, peanuts, or flax are used to rotate with the early rice crop the next year to form a cycle of two to three years. The following are the major forms of this system:

	First Year	Second Year	Third Year
a.	double rice crops →	sweet potatoes, lima beans →	
		Ch'ang-lu, Fukien	
b.	double rice crops →	flax--sweet potatoes, wheat	
		Chao-an, Kwangtung	
c.	double rice crops →	sweet potatoes--- late rice --- wheat →	peanuts--- sweet potatoes
		Chao-an, Kwangtung	
d.	rice--forage legumes →	flax →	peanuts
		Nan-k'ang, Kiangsi	
e.	rice →	tobacco---second harvest of tobacco →	rice
		Kuei-yang, Hunan	
f.	rice --barley →	tobacco---wheat	
		An-shun, Kweichow	

(5) Rice, Vegetables, and Feed

Following the development of animal husbandry,

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vegetables as well as feed products are needed more and more. In every province, there is a certain acreage of vegetables and feed produce being rotated with rice. For example, in Lien-p'ing, Kwangtung there is a rotation system of the following:

First year: rice --peanuts--barley
Second year: Colocassia antiquorum --- onions

This system of rotating vegetables with rice is practiced in all the suburbs of the large cities, although the acreage may vary with the local production conditions. There is a greater proportion of the system of rotating rice with cotton, sweet potatoes, and soybeans.

When rice is rotated with the dry crops, the arrangement of the cycle varies with the soil condition. Generally speaking, peanuts, flax, vegetables, and tobacco should not be planted consecutively; therefore, it is better to establish a three-year cycle. According to the experience of Ch'ung-jen-hsien of Kiangsi, if the soil is thick and fertile, cotton may be planted for four to five years with the rotation of one year of rice. If the soil is thin and poor, then, cotton should be rotated with rice every year, if the yield of the cotton is to remain high. In Yu-yao of Chekiang, the practice is to plant two years of rice, then one year of cotton.

The arrangement of the various crops is very important with regard to yield. For example, rice, flax, and sugar cane all require a great deal of fertilizer and should not be arranged consecutively. After sugar cane or flax, there should be a crop of peanuts before planting rice. If flax or sugar cane is to follow peanuts, there will be a great number of insects in the soil. Therefore, the arrangement is generally as follows:

rice -- flax -- peanuts or sugar cane --- peanuts --- rice.

To rotate rice with dry crops is a system beneficial to the rice and the dry crops both. According to the survey conducted in Yu-yao-hsien of Chekiang, in the paddies of the rotation system of rice and cotton, the yield of the green fertilizer crops increased 71.64 to 89.83%, and the yield of rice was up 1.76 to 14.63%. When the system of rotating cotton and Astragalus sinicus with rice and Astragalus sinicus was practiced in Chung-jen-hsien, Kiangsi, the yield

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of cotton was up 31.3%, the yield of early rice was up 50.2%, the yield of soybean was up 46%, and the yield of Astragalus sinicus was up 165.3%. In Tao-ch'i-hsien of Hunan, when a peanut crop was rotated with rice, the yield of rice was increased from three to four hundred chin to five to six hundred chin; the yield of peanut was up to six to eight hundred chin.

The effect of the rotation system on high yield is due to the following reasons:

a. The change of the cultivating conditions promotes the mineralization process of the organic matter.

When sweet potatoes or sugar cane are planted in the summer, the mounds are built for them. Thus, the soil becomes thicker, and the lower layers of the soil have a chance to weather. The oxidization process helps to eliminate the harmful reduction products and promotes the mineralization of the organic matter. Meanwhile, the roots of such dry crops as sugar cane and cotton reach deep into the soil. This action helps to loosen the soil for the subsequent rice crops.

This rotation system of rice and dry crops also increases the total amount of exchangeable salts, which in turn promotes the activities of the soil microorganisms, and the decomposition of the organic substance, so as to adjust the accumulation and the supply of the nutrients.

The surveys conducted by the institutes of agricultural sciences of Chekiang and Kiangsi provinces proved that the nitrogen, phosphorus, and potassium content of the soil is obviously higher when the rice crop is rotated with sugar cane, or flax, or peanuts, and the content of the quickly effective phosphorus of the soil may be especially raised when rice is rotated with cotton.

b. The Elimination of Weeds, Insects, and Diseases

In the south, the temperature and the humidity are high, and weeds, insects, and diseases multiply very easily. The rotation of the paddy rice crop with dry crops facilitates their elimination. For example, according to the survey conducted by Kiangsi Provincial Institute of Agricultural Sciences in Ch'ih-ch'i-hsiang of Kao-an-hsien, when rice crops are planted consecutively, there are 532 weeds in a sq.m of

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rice paddies. When the rice crops are rotated with peanuts in alternated years, there are only 267 weeds per sq.m of the rice paddies.

c. To Adjust the Use of Water

If the irrigation condition is poor, a rotation system of rice and dry crops may save considerble water, so that all the crops may be irrigated sufficiently to obtain maximum yield.

d. To Make Fall Plowing Possible

When the soil is plowed in the fall, and when crop plants of the Leguminosae family are planted, the soil may be greatly improved. After peanuts were rotated with the rice in the poor paddies of Kiangsi and Hunan, the effect was very obvious.

Table 17-4 Soils of Paddies of Consecutive Rice Crops and Those of Rotated Crops Compared

(1) 调查地点	(4) 轮栽方式	有机质 (%) (12)	硝态氮 (p.p.m.) (13)	铵态氮 (p.p.m.) (14)	有效磷 (p.p.m.) (15)	有效钾 (p.p.m.) (16)	代换性盐基 (毫克当量/100克) (17)
(2) 江西南康	稻—花生 (5)	1.28	1.1	8.0	3.0	6.0	—
	水稻连栽 (6)	1.43	1.1	6.0	2.0	5.0	—
(2) 江西南康	甘蔗—花生—稻 7	1.028	9.0	2.2	2.5	9.0	—
	双季连作稻 (8)	1.427	6.0	1.1	2.0	5.0	—
	黄麻—花生—稻 9	1.187	7.0	1.5	3.0	12.0	—
(3) 浙江余姚	稻—棉 (10)	2.481	1.5	12.5	25.0	—	16.290
	水稻连栽 (11)	2.592	1.5	12.5	20.0	—	14.760

1. Places surveyed 2. Nan-k'ang, Kiangsi 3. Yu-yao, Chekiang 4. Rotation System 5. Rice --- peanuts 6. Consecutive rice crops 7. Sugar cane --- peanuts --- rice 8. Double-seasoned consecutive rice crops 9. Rice --- cotton 11. Consecutive rice crops 12. Organic matter (%) 13. Nitrites 14. Nitro-ammonium 15. Utilizable phosphorus 16. Utilizable potassium 17. Exchangeable salts (mg equivalent/100 g)

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2. YEARLY ROTATION OF PADDY RICE AND DRY CROP IN THE NORTHERN PADDY RICE REGIONS [p 500]

The rice growing areas of North China, the Northwest, and the Northeast have only one harvest a year, and the rotation system is therefore basically different from that of the south. Recently, due to the construction of the various sizes water conservation structures, the acreage of rice paddies is rapidly increasing, and rice production is becoming more important in the economic life of the north. At present, the rotation system of the rice paddies of the north may be divided into two types:

(1) Alternated Rice and Dry Crops with Rice as the Major Crop

One crop of rice is planted every year, with this system, for a few consecutive years; then, a dry crop is planted, or the paddy is fallowed for one year. This system is practiced in the lowlands, the saline marshes, and the areas of poor drainage. When the soil is not saline, irrigation water is obtained by digging ditches in the alluvium. If the soil is saline, in such areas as Po-hai-wan, Hsin-hsiang of Yu-pei, Ninghsia, and Sinkiang, a water level must be maintained constantly in the paddies, so that the saline content of the soil will not rise to harm the rice plants. Therefore, in these areas, rice crops must be cultivated consecutively year after year. According to the survey conducted in Ch'ing-ho Farm of Tientsin in 1954, due to consecutive cultivation of paddy rice, the saline content of the soil had been reduced from 0.07% of 1950 to 0.002% of 1954.

In the past, the paddies of the Northeast were planted with paddy rice year after year with no application of fertilizer. When the soil was no longer fertile and the yield of the rice crops dropped considerably, then the paddies were generally fallowed. For example, Ch'ao-kuang and Min-chu Agricultural Cooperatives of Kirin had planted paddy rice for more than 30 years, but the paddies have been regularly sunned and applied with organic fertilizer, and the average yield is 56 to 76% higher than other paddies of the area with no fertilizer applied. When machines are used for cultivation in these regions due to labor shortage, attention must be given to intensive field management so that the yield may not be affected.

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(2) Alternated Rice and Dry Crops, with All Crops Equally Emphasized

In alternate years, in some areas, paddy rice is rotated with such dry crops as wheat, corn, soybean, and Sesamum indicum. This system is often practiced in the areas of better irrigation and drainage conditions, and is becoming the most important rotation system here. When rainfall is scanty, and source of irrigation is limited, this method may cause water to be available for the cultivation of more new paddies.

a. The Major Forms of this Rotation System

This system takes various forms in accordance with the local natural and economic conditions:

First Year — Second Year — Third Year — Fourth Year

(a) rice → millet--wheat → rice

Fu-p'ing, Hopei

(b) rice → rice → spring wheat or soybean

Chu-liang-ch'eng, Hopei

(c) rice → spring wheat → potatoes

Yu-lin, Shensi

(d) rice → wheat with soybean and Medicago sativa → rice → wheat

Yin-ch'uan, Ninghsia

(e) rice → Sesamum indicum → corn

A-k'o-su, Sinkiang

(f) rice → fallow → oil cabbage → rice

A-k'o-su, Sinkiang

(g) rice → oil cabbage → oil cabbage → rice

A-k'o-su, Sinkiang

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(h) rice ——→ rice ——→ oil cabbage ——→ oil cabbage

Wu-shih, Sinkiang

When paddy rice is planted for one or two years (in some areas paddy rice is planted for three years followed with three years of corn), then, dry crops are usually planted for one or two years, to form a rotation cycle of three to five years. In I-lan-hsien of Heilungkiang, when paddy rice is planted for a few years, the land is converted to dry crops for a few years, but there is no definite cycle or schedule. The cultivation of paddy rice in these regions depends primarily upon the amount of available water and labor, but rice is seldom planted consecutively for more than three or four years.

b. The Effect of the Rotation System

The practice of a rotation system in the north obviously increases the yield of the rice crop as well as the dry crops. According to the information of the state-operated Lu-t'ai Farm, when soybean, corn, or wheat are planted before the rice crop, the yield of the rice crop is 4 to 34.1% higher than the rice crop planted consecutively The more years the rice crop is planted consecutively, the smaller is the yield. (Table 17-5)

Table 17-5 The Effect of the Rotation System on the Yield of the Rice Crop

资料来源 (1)	6 水旱分年轮栽		13 水稻连栽		21 增产量比较	
	前 7 作	水稻产量 (斤/亩) 12	前 14 作 15	水稻产量 (斤/亩) 20	22 斤/亩	23 %
2 1952年全場	大 (8) 豆	789	多年水稻	602	187	31.1
3 1953年全場	玉米，大豆，棉花 9	696	一部分多年水稻 一部分一年水稻 16	608	88	14.5
4 1953年一站	大 10 豆	670.5	连栽水稻 17	645	25	4.0
			四年连栽水稻 18	500	170	34.1
5 1954年一站	小麦休闲 11	676	种一年水稻 19	638	37	5.9

1. Source of Information 2. The whole farm in 1952

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3. The whole farm in 1953 4. First Station in 1953
5. First Station in 1954 6. Rice rotated with dry crops in alternated years
7. Previous crop 8. soybean 9. corn, soybean, cotton
10. soybean 11. wheat, fallow 12. Yield of the rice crop (chin/mou) 13. Consecutive planting of rice
14. Previous crop 15. Rice crops for many years
16. Some paddies with rice crops for many years, and some with one crop of rice in one year before the current one
17. rice crops planted consecutively 18. Rice crops planted consecutively for four years 19. Rice crop planted for the year before the current one
20. Yield of the rice crop (chin/mou) 21. Yield compared
22. chin/mou 23. %

When dry crops are rotated with the rice crop in the north, the soil is no longer submerged year after year; its effective nutrients are increased; the ground water table is lower, the weeds are reduced; and the utilization rate of labor and machinery is higher. Not only the yield of the rice crop is higher, the problem of water shortage becomes less serious also. According to the survey conduted in the Autonomous Region of the Hui Nationality of Ninghsia, the amount of water needed to irrigate one mou of paddy for a rice crop is sufficient to irrigate 3.7 mou of dry crops. Thus, if a rotation system is in practice, the same amount of water may irrigate more acreage. Rice and the dry crops are planted and harvested at different times, and thus, the labor, animals, and machinery may be utilized throughout a longer period of time and the rate of utilization is therefore higher.

According to the survey conducted in the state-operated Lu-t'ai Farm, if winter wheat had been planted for two years before the rice crop, then there were 18 to 26 weeds in each sq.m of paddy; if soybean had been planted, then, there were 109; if another rice crop had been planted, then, there were 271. A reduction of the labor needed for weeding is very significant in the northern rice growing regions where the population is sparse.

The practice of the rotation system of rice and dry crops may also lower the ground water table so that the soil becomes better ventilated and the decomposition of the organic substance is faster. For example, in Yin-ch'uan

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Irrigation District, the ground water table of the areas with consecutive rice crops was 94 cm. After dry crops were planted for one or two years, it was immediately reduced to 130 to 139 cm, and the yield of the rice crop was obviously higher.

Due to the different seasons of the various crops, after the rotation system was adopted, the rate of utilization of the machinery was considerably higher. In the state-operated Lu-t'ai Farm, the standard working hours for the tractor in 1952 were only 806 hours, and the work performed was only 3447 mou. When a rotation system was adopted in 1954, each tractor was used 1,400 hours, about 6% higher than 1952; and the work performed was 5,658 mou, about 81.8% higher.

Table 17-6 A Time Table of Work Performed for the Various Crops

作物种类 (1)	整地 (5)	播种 (9)	中耕除草 (13)	收获 (16)	秋耕 (20)
水 2 稻	4月上旬—中旬 6	10 4月中旬—下旬	14 5月上旬—7月下旬	17 10月上旬—中旬	10月上旬—下旬 21
3 中耕作物 (包括大豆)	3月上旬—中旬 7	11 4月上中旬	15 5月上旬—6月下旬	18 8月下旬—9月中旬	10月中旬 22
冬 4 麦	8 8月下旬—9月上旬	9月中下旬 12	—	6月下旬 19	7月—8月 23

1. Type of crop 2. Paddy rice 3. Summer crops (including soybean) 4. Winter wheat 5. Land leveling
6. First 10 days of April -- to middle 10 days of April
7. First 10 days to middle 10 days of March
8. The last 10 days of August to the first 10 days of September 9. Planting 10. The middle 10 days to the last 10 days of April 11. The first and the middle 10 days of April
12. The middle and the last 10 days of September
13. Cultivation and weeding 14. The first 10 days of May to the last 10 days of July 15. The first 10 days of May to the last 10 days of June 16. Harvest 17. The first 10 days to the middle 10 days of October 18. The last 10 days of August to the middle 10 days of September 19. The last 10 days of June 20. Fall cultivation 21. The first 10 days to the last 10 days of October 22. The middle 10 days of October 23. From July to August

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When the rotation of paddy rice and dry crops is practiced, green fertilizer may be planted to solve the problem of fertilizer of the rice paddies, and more feed plants may be planted to develop the industry of animal husbandry. As a result, the well developed industry of animal husbandry may provide more stable manure to guarantee the fertilizer needs of the rice paddies. In Lu-t'ai Farm, from 1952 to 1957, the acreage of rotated crops was increased 11 fold, and the fertilizer problem was solved as a result.

c. The Practice of the Rotation System of Rice and Dry Crops

The choice of the dry crops varies with the local conditions. According to the experience of Lu-t'ai, the best system is to plant corn or soybean in the first year. In the second year, winter wheat may be planted with medicago sativa in between the rows, so that the latter may be turned under to be the initial fertilizer for the next rice crop. Soybean may cause the soil to accumulate nitro-fertilizer, and its leaves cover the field and make good protection for the soil against excessive evaporation. When the soybean is harvested, there is plenty of time to prepare the paddies. A winter crop of wheat is the best for weed control. The forage legumes should be planted in the alternate rows just before the harvest of the winter wheat, so that they may be turned under in the summer before the paddy is fallowed.

According to the experience of the areas of Yin-ch'uan, the crops of the rotation system must be chosen in accordance with the nature of the soil and the adaptability of the crop. The choice of the crops and the arrangement of the rotation systems of that region are as follows:

	First Year	Second Year	Third Year
(a)	rice →	rice →	wheat
			The most fertile paddy
(b)	rice →	wheat with soybean →	wheat with millet, then Medicago sativa
			Better paddies

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(c) rice ——→ wheat with soybean ——→ Sesamum indicum or kaoliang

The paddies that are not very fertile.

(d) rice ——→ wheat or lima beans, Dolichos lablab, or Sesamum indicum ——→ fallow

The worst paddies

The above method is the rotation system for a three-year cycle. If a two-year cycle is adopted, then, the method of arrangement generally takes the form of rice --- wheat with soybean and Medicago sativa.

Table 17-7 The Effect of Medicago sativa on the Yield of the Rice

调查年份 (1)	(2) 水稻产量(斤/亩)		增产(%) (5)	备注 (6)
	苜蓿 3茬	4 水稻连栽		
1954	707	611	11.5	大面积调查资料
1956	1,030	880	11.7	

1. Year of survey 2. Yield of rice (chin/mou)
3. Medicago sativa planted 4. Consecutive crops of rice
5. Increase in Yield (%) 6. Note 7. The survey covered a large area of the paddies.

The production practice of the various areas proved the the rotation system of rice and dry crops may bring many beneficial effects. At present, the rice growing regions of the north are all changing from consecutive planting of rice crops of the past, gradually to a rotation system of rice and dry crops in alternated years. Many rotation systems are being tested and perfected. The following are a few examples which are being recommended by a few mechanized farms:

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First Year	Second Year	Third Year	Fourth Year

(a) rice → corn with soybean → winter wheat with Medicago sativa → Medicago sativa

Lu-t'ai Farm, Hopei

(b) rice → corn with soybean → winter wheat with forage legumes (Astragalus melilotoides)

Lu-t'ai Farm, Hopei

(c) corn with Medicago sativa → Medicago sativa → rice → rice

A-k'o-su Special District, Sinkiang

(d) oil cabbage with forage legumes → rice → rice

A-k'o-su Special District, Sinkiang

(e) rice → wheat with soybean → wheat with Medicago sativa or other forage legumes

A-k'o-su Special District

The rotation system of rice and dry crops may be adopted only when the saline content of the soil has been obviously reduced. If it is not, or if the cultivation method is not proper, then, the planting of the dry crops may cause the soil to be salinized once again. For the northern areas, aside from water conservation construction, planning and constructing of the irrigation channels in the fields, reducing the leakage of the paddies, and gradually introducing crop rotation systems, a large scale development of rice culcultre in these areas must also await the establishment of a suitable and correct arrangement of crop rotation system, so that the soil may be improved, the weeds may be eliminated, and the saline content of the soil may be constantly reduced, in order to guarantee high yield for the rice crop as well as the dry crops.

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CHAPTER 18. DIRECT SOWING

[p 507]

Direct planting and transplanting are two ways of cultivating paddy rice. In China, the method of direct planting is used generally in the very cold areas with short growing season. There is usually plenty of land, but very few people to work on it. These areas include chiefly the regions north of Kirin, Inner Mongolia, Ho-t'ao of Ninghsia, and Sinkiang. For example, more than 90% of the rice paddies of Heilungkiang are planted directly. There are also a few paddies in Kiangsu, Hunan, Hupei, Szechwan, Fukien, Kwangtung, and Kwangsi, that are planted directly.

The state-operated farms of the various regions have been experimenting with the method of mechanized direct planting during the last 10 years, and considerable experience has been accumulated. Since 1953, the present Hsing-huo people's commune (formerly Hsing-huo Collective Farm) of Heilungkiang has obtained stable high yield with mechanized direct planting method over a large acreage of rice paddies.

Mechanized direct planting may improve labor productivity. For example, in 1959, the state-operated Cha-ha-yang Farm planted 150,000 mou of rice. On the average, each worker took care of about 40 mou. Since there is no seed bed the rice plants become ripe sooner; therefore, this method is very suitable for the areas where the growing season is short. Besides, if there is a water shortage, the seeds may be planted in dry fields without having to wait for the rain. This method is also suitable for the highly saline soils, when the seedlings often have difficulty in turning green again after being transplanted. In the areas south of the Yangtze, if there is a labor shortage or if seed beds are hard to find, this method may also be practiced.

The direct planting method may be divided into dry planting and wet planting. The following is a separate description of each.

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SECTION 1. DRY DIRECT SOWING [p 507]

The method of dry direct planting has had a long history in our country. In the past, it was used only as a measure against drought. Since the liberation, the state-operated farms and the various scientific agencies have been practicing mechanized direct planting over large areas. During the past 10 years, considerable experience has been accumulated in the matters of soil cover, seed adherence, mechanized planting, and mechanized plowing, land leveling, weeding, harvesting, and others. Meanwhile, the paddies are improved to make them suitable for the mechanized tools. At present, in the Northeast, the dry direct planting method is adopted not only by those areas where there is a shortage of water; it is being practiced in some areas with sufficient water resources as well. It is also the major method of direct planting adopted by the state operated farms.

1. PREPARATION OF THE FIELD [p 508]

The method of land leveling for dry direct planting of rice is similar to that for such dry crops as millet and wheat. The field must be intensively turned, plowed, raked, leveled, and pressed. The quality of this preparation work may affect the quality of planting, and the uniformity of the irrigation water. Therefore, it is directly related to the quality of the future seedlings. If the deep soil cover method is adopted, then the mounds must be very carefully built. According to the survey of Pai-ko-chuang Farm (Table 18-1), if the field is intensively prepared, the sprouting rate may be as high as 29.3 to 42.3%, and the survival rate for the seedlings may be as high as 6.7 to 16.3%.

On the saline soils, the field must be flat and the soil must be fine, otherwise the soluble salts may become concentrated in one place, and the seedlings of the higher or the lower places may be seriously damaged.

In a word, a proper leveling of the land is one of the important measures of protecting the seedlings when the

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dry direct planting method is adopted.

Table 18-1 The Effect of the Quality of Land Leveling on the Sprouting Rate

(1)土块直径(厘米)	(2)土块数	(3)出苗率(%)	(4)保苗率(%)
6—10	103	55.2	78.30
4—6	105	62.0	88.86
3	124	68.2	94.58
1	230	97.85	91.60

1. Diameter of the lumps of soil (cm)
2. Number of the lumps of soil
3. Sprouting rate 4. Survival rate of the seedlings (%)

Table 18-2 The Growth of the Young Seedlings and the Flatness of the Field

(1) 调查地点	(4) 地势	苗(9 高 (厘米)	叶 10 数	11 可溶性盐类含量(%)		保苗率 12 (%)	盐害芽 13 (%)
				NaCl	$NaHCO_3$		
(2) 二场六队	平 (5)	8.5	2.4	0.030	0.012	88.1	25.0
	高 (6 处	4.6	2.0	0.101	0.040	34.6	52.7
试验田 (3)	平 7	4.9	2.0	0.045	0.025	86.2	16.9
	洼 8 处	4.5	1.7	0.214	0.021	35.7	29.0

注：播后浅灌落干。 (14)

1. Place of survey 2. The Sixth Brigade of the Second Farm
3. Experimental Field 4. Terrain 5. Flat 6. High
7. Flat 8. Low 9. Height of seedlings (cm)
10. Number of leaves 11. Content of soluble salts (%)
12. Survival rate of the seedlings (%)
13. Salt damaged seedlings (%)
14. Note: After planting, the field is irrigated with a shallow water level, then, the water is left to drain out by itself.

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The quality of land leveling work is closely related to the soil, the soil moisture, the plowing time, and the tools. If the soil is loose, with good structure and suitable amount of moisture, then it is easily crushed and leveled. Those old rice paddies, which have been planted with rice year after year, with heavy and clay soil of high moisture content are hard to be leveled. Fall plowing is easier than spring, because the winter weathering action has made the soil loose, and in the autumn, the soil is drier. Therefore, almost all the direct planting rice fields are plowed in the fall.

According to the experience of the state-operated farm in Po-hai District, it is better to plow and turn the ordinary clay soil when the moisture content is about 20%; for the heavy clay soil, it is better to be 18%.

Autumn plowing of the rice fields is usually done to 18 to 22 cm. If the soil is too damp, plowing may be delayed until late fall; then, the moisture of the freshly turned soil will not have time to evaporate before it is frozen. If the soil is crushed fine after plowing, evaporation may be reduced also. As soon as the ground is thawed, spring plowing and raking should be done. If the soil is saline, then, the sunning process will cause the salts to rise to the surface so that the irrigation water will wash them away. Aside from plowing and raking, it is important also that the soil of the higher places should be used to fill up the low areas, so that the paddy is leveled .

Spring plowing is generally not as deep as the fall plowing. The former is normally 16 to 20 cm deep. If the soil is light and loose, and the drainage is good, then, the soil should be crushed after being plowed. If the soil is heavy with clay, and if hard lumps still exist after raking, then, it must be raked again until it is very fine. Raking may be done after a rain, when the moisture is just right and the clay does not stick to the tools.

For the newly cultivated land, the irrigation system should be built first. The land should be turned and plowed after the accumulated water is drained off. In the Northeast, the virgin land always contains large and strong plant roots; therefore, plowing should be done before the rainy season, when the soil contains very little moisture.

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The depth to be plowed in the virgin soil is determined by the terrain and the depth of the soil. In the Northeast, if the plowing is too shallow, the plow may become lodged in the layer of grass roots, and the resistance may be too great. Therefore, if the plow reaches a little deeper, the resistanee may be reduced. According to the experience of Cha-ha-yang Farm, if a Wu-hua plow is used, plowing may be done to a depth of 16 to 18 cm; then, it may reach below the layer of plant roots and the future seedlings may grow better. The yield may be higher than the paddy which has been plowed to 10 to 12 cm only. After plowing, a heavy rake should be used to rake the field over once. Then, the field should be raked twice with a round rake before it is leveled and ready.

The various processes must be done consecutively so as to preserve soil moisture. According to the experience of Hsu-chou Special District of Kiangsu, the heavy clay soil should be plowed in the winter, just before the ground is frozen, to a depth of more than 5 ts'un. The soil then will be frozen and weathered in the winter. In the spring, it is plowed again, first deep then shallow. Then, after the fertilizer is applied, it should be plowed lightly again, and raked repeatedly. When the soil is thus prepared, the seedling survival rate is generally more than 20% higher than the paddy which has been plowed in the spring only.

In order to facilitate machine plowing, aside from the major dike, the temporary crosswise dikes should not be repaired until after the planting.

2. SOWING THE SEEDS [p 510]

(1) Planting Time

According to the experience of the various areas, early planting may prolong the growth period of the rice plants and the heads will develop better. It is important, however, to watch the temperature. During the early stages, the field menagement is rather complicated when the direct planting method is adopted. If the planting is done to early when the temperature is low, the seeds may become soaked for a long time without sprouting, and the sprouting rate may be greatly reduced.

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Generally speaking, planting may be done if the average temperature is above 10°C. With the dry planting method, the planting time is the same as the wet planting method, if the seeds are soaked first. If dry seeds are used, planting may be done a little earlier, because the seeds will not sprout until the paddy is irrigated. If the soil is saline, the paddy must be immediately irrigated after the seeds are planted, otherwise, the saline content may rise and damage the seeds, therefore, labor and machinery should be readied, if the planting is to be done suitably early.

(2) The Density and Method of Planting

The amount of seeds to be used depends upon the variety chosen (the length of the growing season, and the abundance of the tillers), the fertility of the soil, the irrigation condition, the planting time, and the temperature condition. The most important factor is, however, the sprouting rate. Therefore, when direct planting method is used, the seeds must be carefully selected, sunned, disinfected, and soaked, so that the sprouting rate will be high and the seedlings will be strong.

According to the survey conducted by the state-operated Pai-ko-chuang Farm, if the yield is to be above 1,000 chin per mou, then there must be at least 250,000 to 3000,000 heads per mou, which are effectual. According to the survey conducted in Ho-chiang Special District of Heilungkiang, a high yield paddy may contain as many as 400,000 heads per mou. Again, according to the information of Hsu-yueh Experimental Station, if there are 230,000 to 260,000 seedlings per mou, the number of effectual heads may reach 267,000 per mou.

In order to culculate beforehand the number of seedlings per mou, we must plant the amount of seeds according to the expected survival rate of the paddy. According to the survey conducted by Ho-chiang Special District, the sprouting rate is about 70 to 80% of the amount of seeds planted. When the loss after sprouting is calculated, each mou should generally be planted with 15 to 30 chin of seeds.

In the past, when there was very little weed problem in the paddies of the Northeast; seeds were generally planted in narrow rows of 15 cm, or wide rows of 15 cm.

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According to the test conducted by Chia-mu-szu Experimental Station in 1954, the double-row of 25 cm (one wide and one narrow) is the best for high yield. (Table 18-3) Weeding is difficult when the rows are too narrow. During the recent years, the planting machine has been adjusted to increase the width of the rows. In the state-operated farm of the Po-hai District, the round plate of the digger was replaced with a shoe-shaped plate, and the width of the planting row was made 5 cm wider. However, with the shoe-shaped plate, the land leveling must be done in very high quality; therefore, the round plate is still in use in most cases.

Table 18-3 The Yield of the Double-row and that of the Single-row Compared

行 1 距	4 平方米苗数	5 平方米穗数	6 产量 斤/亩)
15 厘米单条播 2	385	670	693.2
25 厘米双条播 3	395	680	713.2

1. Width the a row 2. 15 cm single-row
3. 25 cm double-row 4. Number of seedlings per sq.m
5. Number of heads per s.m 6. Yield (chin/mou)

Table 18-4 The Growth Condition and Yield of the Rice Plants with Different Space between the Rows

行距×播幅 (厘米) 1	平方米苗数 2	株高 (厘米) 3	分蘖率 (%) 4	穗长 (厘米) 5	产量 (斤/亩) 6	产量 (%) 7
18×3—4	317	90.0	8.6	16.5	668.1	106.2
18×1—2	329	89.9	6.8	15.9	605.6	96.2
20×3—4	311	87.3	14.1	16.3	616.5	98.0
15×1—2	325	88.0	7.5	15.3	629.1	100.0

1. Space between the rows x the width of the row
2. Number of seedlings per sq.m 3. Height of the stalk (cm)
4. Tillering rate (%) 5. Length of the head (cm)
6. Yield (chin/mou) 7. Yield (%)

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(3) Planting Method

Based upon the level of the cultivating technique, the quality of the land leveling work, the amount of weeds, the source of the irrigation water, and the condition of human and animal labor, the dry direct planting method may have the following variations:

a. Thin soil cover and damp cultivation

With this method, the root system is well developed, the stalk is strong, and there is little chance of falling. When the seeds are planted, the damp soil or shallow water irrigation method is used, combined with the draining and sunning processes. This method may be adopted if the soil structure is fair, the drainage is good, and there is very little weeds. Since the paddy is flooded immediately after planting, the soil cover must be light, otherwise, the seeds may be soaked too much. According to the mechanized planting experience of such areas as Hua-ch'uan and T'ang-yuan, if the soil cover is thick, the sprouting will be delayed, and the sprouting rate will suffer. If the seeds are planted as deep as 2 cm, the sprouting rate may be 50% less.

According to the survey conducted in the saline soils of the state-operated Ch'ing-ho Farm, if the soil cover is less than .5 cm, then the dead seedlings are 9%; if the soil cover is 1.6 to 2 cm, the dead seedlings are 20.6%; when the soil cover is 2.1 cm to 2.5 cm, then, the dead seedlings are 47.4%. Therefore, the soil cover should best be 0.5 to 1.5 cm. In production, it is normally controlled to below 2 cm.

A control ring may be attached to the round plate of the digger so that the depth of the soil cover may be even. The control ring is generally 3 cm wide, and 0.2 cm thick. It is attached to the round plate with a screw. The distance between the control ring and the edge of the digger on an animal-pulled ten-row planter is 1.5 cm; it is 0.8 cm on the tractor-pulled twenty-four-row planter. A shield may be attached to the control ring, if the soil is too moist, so that the sticky mud will not stick to the control ring and cause the seeds to be exposed. This shield is attached to the upper part of the digger, and remains 0.2 to 0.3 cm from the control ring. When the round plate is in motion, the shield will scrape the mud off the control ring.

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Table 18-5 The Effect of the Planting Depth on the Growth of the Young Seedlings

播种深度(厘米) 1	保苗率(%) 2.	苗高(厘米) 3	根长(厘米) 4	根数 5	叶数 6
1.0	66.8	4.5	3.3	4.0	2.0
1.7	58.7	2.4	2.9	1.5	2.0
2.0	52.6	0.8	2.4	1.2	1.5
2.5	41.0	0.8	0.7	1.1	1.0
3.0	15.0	0.1	0.1	1.0	0.2

1. Planting depth (cm) 2. Seedling survival rate (%)
3. Height of seedlings (cm) 4. Length of roots (cm)
5. Number of roots 6. Number of leaves

The state-operated farms of the Po-hai District use a shoe-shaped plate to replace the round plate, and a depth control device is placed in front of the digger. In the state-operated Lu-t'ai Farm a wheel-shaped digger is being used. On a well leveled field, the planting depth can be easily controlled with this machine.

If the soil is too loose at the planting time, the field should be rolled and pressed once so that the planting depth may be better controlled. The soil moisture must be just right when the field is rolled, otherwise, the soil may become too hard. According to the survey conducted in P'an-ching area, the moisture of the top 5 cm of soil should not exceed 16%.

b. The thick soil cover and dry cultivation method:

This is an old method in our country. The farmers used this method to combat drought. It is suitable for light and fluffy soils, with little weeds. It is not suitable for saline soils.

According to the experiment of 1956 conducted by Chia-mu-szu Experimental Station, the seedling survival rate is higher with this method. (Table 18-6) Since the paddy is

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not flooded until the seeds have sprouted, the field is easily weeded, and the planting time is not limited by the arrival of the rain.

If the drainage condition is good, the planting should be deep with this method. If the soil contains a great deal of moisture, then the seeds should be planted as deep as 2 cm. If the soil is dry, then, they may be planted as deep as 4 cm. If deeper than the aforementioned level, then, sprouting will be delayed; if not as deep, then the moisture content of the soil above the seeds is too unstable, and many of the seeds will remain dry. Generally, the depth should be about 3 cm.

Table 18-6 The Growth of the Young Seedlings when the Shallow and the Thick Soil Cover Methods are Used

播 (1) 法	播种期 (月/日) 4	初灌期 (月/日) 5	保苗率 (%) 6	株高 (厘米) 7	幼苗风干重 (克) 8
2 浅复土法	6/1	6/6	67.3	11.7	1.81
3 深复土法	6/1	6/28	86.0	13.8	2.55

1. Planting method 2. Shallow soil cover method
3. Thick soil cover method 4. Planting time (month/day)
5. Flooding time (month/day) 6. Seedling survival rate (%)
7. Height of stalk (cm) 8. Dry weight of the young seedling (g)

If the soil is sandy, then, the seeds may sprout if the soil moisture is 30% of saturation; if the soil is loam, then, it should be 30 to 40%; in clay soil, the seeds have difficulty absorbing moisture if it is only about 40% of saturation. If the soil moisture content is close to the miminum, then the seeds may be soaked first.

The seeds should not be soaked longer than the time when the sprouts are beginning to appear outside of the seed coat. In the eastern part of Hsu-chou Special District, there is a special tool of the short-teethed rake, which is used to rake the seeds after planting to loosen the soil cover. This process is best done after a rain.

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In the past, the wheat planting tools were generally used to plant the rice seeds when this method was adopted. At present, the tractor-pulled twenty-four-row planting machine or the animal-pulled 10 row planting machine are generally used.

c. Mud Coating Method

This was a new creation of Hsin-huo Collective Farm in 1953 when mechanized direct planting was first being popularized. With this method the seeds are soaked first; then, the seeds are mixed with very fine soil, about 20% of the weight of the seeds. The soil is slightly damped at first; then, in the process of mixing, the seeds are covered evenly with a very thin layer of soil. Then, the seeds are quickly dried in the sun, and mud lumps are taken out afterwards. The planting machine is then used to plant the seeds, with no soil cover at all. After the planting is done, the paddy is immediately flooded. Being covered with soil, the seeds do not float after the paddy is flooded. The field management of this method of planting is the same as wet planting.

The flooding controls the growth of the weeds, therefore the seedling survival rate is higher with this method compared with the shallow soil cover method. It is rapidly being popularized, especially in the areas of saline soils.

Sometimes, the mud covered seeds of this method are also planted manually. This method can shorten the planting time, and make planting easier since the farmers may work on dry field before the paddy is flooded.

3. IRRIGATION [p 514]

The irrigation method must vary with the planting method during the sprouting stage, while after the seedlings become established, then, all the paddies may be irrigated similarly. Therefore, this section deals with the irrigation method of the sprouting stage only.

(1) The Irrigation Method for the Thin Soil Method of Planting

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a. First stage

For the early varieties, the temperature of the water should be above 10°C. If the paddy is flooded too early with water that is too cold, sprouting may be delayed and the survival rate of the seedlings may be affected.

b. Method of Applying Water for the First Time

A damp environment is needed for the seeds to sprout, but damp soil also encourages the growth of weeds, especially Penicum crus galli. If a water level is maintained, the weeds may be controlled, but the soaking condition is not good for sprouting either. According to the survey of Chia-mu-szu Experimental Station, when the water level is at 6 to 10 cm, then, the seedling survival rate is 78%; when the water level rises to 10 to 15 cm, the survival rate will only be 43.7%. The survial rate of the seedlings has a tendency to fall when the water level rises. It is a common practice to irrigate with a shallow water level and to sun the paddy a few times. If there are not many weeds in the paddy, or if it is a newly converted paddy, then, the damp soil irrigation method may be used. The paddy is first flooded to a shallow water level; let the water drain off naturally, then, irrigate it in the same manner to keep the soil moist.

If the soil is not saline, then, the water may be filled to 5 to 6 cm for the first time. The paddy should be sunned a few times, when the sprouts are about to appear. A shallow level of water may be maintained when all the seeds have sprouted, and the roots have developed. The water should not be drained off too early, otherwise, there may be too many weeds.

Paddies of saline soils must be washed first. They may be washed once, twice, or three times, depending upon the extent of salinity. For the first washing, a water level of 7 to 8 cm is needed; 5 to 6 cm for the second time; and 3 to 4 cm for the third time. The drainage channels must be cleaned before washing. The water should be filled slowly for the first time, so that the seeds will not be damaged. When the average sprouts measure 0.1 to 0.5 cm, and less than 50% of the seeds have sprouted, the paddy should be drained. This timing is very important, and based upon the temperature

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and soil condition, water should be added in time to keep the soil constantly moist.

c. A Water Level

When leaves appear on the young sprouts, which are now about 3 cm high, a water level may be maintained. When the third leaf appears, the transpiration increases gradually, and the seedling requires more water. The temperature is higher then, and the evaporation is great.

However, the water level should not cover the lobe of the leaves. As the leaves grow taller, the water level may be raised gradually to 5 or 6 cm. According to a survey conducted in the Ching-p'an region, for heavily saline soil, the water level may be kept at 7 or 8 cm to suppress the rising action of the soluble salts.

(2) The Irrigation Method for the Thick Soil Method of Planting

With this method the paddy is not filled with water until the seeds have all sprouted. If the soil is half damp and half dry, the weeds will grow very quickly. According to the experience of the state-operated Lu-t'ai Farm, the paddy should be filled when the seedlings are about 7 to 8 cm high. The report from Chia-mu-szu Experimental Station, however, states that the best flooding time is when there are two leaves. If the flooding time is delayed, the stages of tillering, heading, and ripening will all be delayed, and the yield will suffer. (Table 18-7)

According to the results of the experiment conducted by Chun-liang-ch'eng Experimental Station, the paddy was filled on the 25th of May when the seeds had completely sprouted, and the yield was 831 chin per mou. When the paddy was filled at the tillering time on the 25th of June, the yield was 639 chin per mou. When the paddy was filled on the 15th of August, just before the node growth, the yield was 476 chin per mou. This report indicates that the best time to flood the paddy is when all the sprouts appear.

When the paddy is dry, there are many branch roots, and root hair. When the paddy is filled with water, the structure of the roots change. They usually no longer have hair or branch roots. Therefore, the first filling

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should be very slow. The soil should be maintained in a damp state for a few days first, so that the young seedlings may gradually adjust to a new environment. If the paddy is suddenly filled with water, the seedlings may turn yellow. If this should occur, the water should be drained immediately, and some fertilizer should be applied to bring the seedlings back to recovery. The water level should be about 2/3 of the height of the seedlings, and be raised as the seedlings grow taller.

Table 18-7 Effect of the Different Water Levels on the Growth of the Seedlings and the Yield

灌水時期 1	分蘖期 4 (月/日)	出穗期 5 (月/日)	蜡熟期 6 (月/日)	7/25测定茎叶干物量（克）7	平均单株分蘖数 8	产量(%) 9
2 深覆土法 第二完全叶	7/19	8/11	9/17	12.5	1.10	103.0
第三完全叶	7/21	8/16	9/20	11.3	1.02	96.2
分蘖始期	7/23	8/23	遭遇低温未成熟 10	10.3	0.87	69.9
浅覆土播法（对照）3	7/16	8/12	9/19	13.6	1.12	100

1. Flooding time 2. Thick soil method of planting; two complete leaves; three complete leaves; the onset of tillering 3. Thin soil cover method of planting (control group) 4. Tillering time (month/day) 5. Heading time (month/day) 6. Wax-ripe time (month/day) 7. Dry weight of stem and leaves measured on the 25th of July (g) 8. Average number of tillers per stalk 9. Yield (%) 10. Did not ripen because of problems and temperature

In the Special District of Hsu-chou, if there is not sufficient water, the following methods of irrigation are adopted:

a. The seedlings are left to grow in a dry state, and the paddy is filled not until the beginning of the tillering stage. A water level is maintained thenceforth.

b. Periodical damp soil method may be adopted. The soil is filled to saturation with each irrigation, but there

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is no water level. The paddy is irrigated whenever the soil is dry.

c. The seedlings may be left to grow in the dry paddy, which is irrigated during such growing stages as the head development stage and the blooming stage. The paddy is not irrigated if it rains. In this manner, the paddy rice is in fact cultivated like the upland rice. There may be a water level in the paddy after heavy rains. With this method, the yield is never stable.

When the seeds are planted with the thick soil cover method, the paddy is not filled until after the seeds have all sprouted, and a great deal of water may be saved. According to the calculation of Hua-ch'uan Irrigation Experimental Station of Heilungkiang, in 1956, at least 170.36 cu.m of water may be saved from one mou of rice, especially in those paddies where the leakage is great. (Table 18-8) Therefore, this planting method offers a solution to the areas with water shortage problems.

Table 18-8 Amount of Water Used at Different Flooding Times

灌水时期 1	渗漏量一般的田间节省用水量 (立方米/亩) 5	渗漏量大的田间节省用水量 (立方米/亩) 6
第二完全叶 2	170.36	310.41
第三完全叶 3	202.36	420.01
分蘖始期 4	249.08	572.61

1. Flooding time 2. When there are two complete leave
3. When there are three complete leaves 4. The onset of tillering 5. Amount of water saved when the leakage of the paddy is at the average level (cubic meter/mou)
6. Amount of water saved when the leakage of the paddy is high (cubic meter/mou)

(3) The Irrigation Method for the Mud Coating Method of Planting

With this planting method, the paddy is filled immediately after planting. The irrigation method is the

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same as the wet planting method. A water level of about two ts'un is constantly maintained after planting. Just before the sprouts are to appear, the paddy may be sunned 3 to 5 days according to the general conditions, so as to help the roots to grow stronger.

SECTION 2. DIRECT SOWING IN WATER [p 517]

This planting method is generally practiced in the areas with sufficient water resources. Or, if the soil is heavy with clay; the rain is heavy during the planting season; and it is difficult to drain the paddy, this method may be used to plant the seeds directly into the paddy.

With this method, the paddy is soaked with water, and it is difficult to use the planting machine. Planting is therefore, generally done by animals or the farmers may do it manually. During the recent years, with the creation of the rope-pulled tractor, wet planting may also be done by a machine.

When the seeds are planted on the soil surface, the roots are usually shallow. Cultivation, shallow irrigation, and sunning must be adopted with fertilizer application to help the roots to develop deeper so that the plants may grow stronger and more fall resistant.

1. PREPARATION OF THE FIELD [p 517]

The paddy still must be leveled and the soil raked fine, but when the paddy is soaked, even though the soil may be heavy, the leveling is not very difficult. If the paddy leaks a great deal, wet plowing and raking are also very helpful.

The land leveling method for this planting method is similar to that of the paddy being readied for transplanting. It may be dry plowed and dry raked before flooding, or it may be wet plowed. However, when either plowing method is adopted, after the paddy is flooded, it must be repeatedly raked again.

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In the south, the farmers often sun the paddy after it is dry plowed. Sunning promotes the decomposition of organic substance and the activities of the soil microorganisms. In the Northeast, the paddy is plowed in the fall. After the spring thaw, it should be plowed dry once or twice, and filled just before planting. If the paddy is plowed in the spring only, then plowing should be done very early so that the soil has a chance of being thoroughly sunned.

If the soil is saline, the lumps of soil should be no larger than the fist when they are exposed in the sun to be thoroughly dried before the paddy is filled to wash the salts. If the saline content is very high, then, the paddy should not be raked many times so as not to affect the washing action. The paddies of the state-operated farms in Po-hai District all contain more than 0.1% of salts. They are usually plowed in the fall but not raked and then they are left to be sunned thoroughly so that they may be washed more effectively in the spring. For the older paddies with saline soil, one or two washings are sufficient, for the newly cultivated paddies three times may be needed. After washing, fresh water should be used to replace the water used for washing before planting.

2. SOWING THE SEEDS [p 518]

When the wet planting method is adopted, in the north, the planting time is usually later than that of the dry planting method. The seeds should be soaked, disinfected, and sprouted first.

There are two ways of planting with the wet method: The drained method is similar to that used to plant seeds in the seed beds. The flood method may help prevent the growth of weeds. With this method, the seeds are planted in one ts'un deep of water.

The seeds may be planted in spots, in rows, or they may be broadcast. When they are broadcast, they are usually distributed not very evenly, and later the plants may suffer from bad ventilation and light exposure. Weeding will be difficult too.

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According to a survey conducted in Kirin, if the seeds are planted in spots, weeding will be very easy and 0.7 to 1.3 labor days of weeding work may be saved. When the seeds are planted in rows, the cultivating machine may later be used, and 0.5 to 0.7 labor day of weeding work may be saved per mou. The yield is higher when the seeds are planted in spots or rows. Therefore, this is the generally adopted method. When the seeds are planted in the individual spots, each spot contains many seeds, and the plants have a tendency to grow weak. Therefore, more and more, the seeds are planted in rows.

(1) Spot Planting

When the spot planting machine is used, each farmer may plant 3 to 6 mou a day. Since the planting tube of the machine is short, it is rather easy to deposit the seeds evenly. However, the hand switch of the seed bowls often breaks the seeds. Another style of the spot planting machine does not have this defect, but with the two planting tubes on the side, aiming is more difficult.

Before planting, a rope with the marks of the holes on it is laid in the paddy; then, two farmers with two planting machines may start planting from each end. It is best to have a third person delivering the seeds. The machines must be held straight, and the operators must take even steps. If the seeds have a beard it must be cleaned off first so that the machines will operate efficiently. The state-operated Pao-li Farm just designed a new planting machine, which is constructed very simply and is operated by two persons, to plant 30 to 40 mou a day. This is much more efficient than the old models.

The rows and the distance between the spots are usually 6 x 3 ts'un; 5 x 4 ts'un; or 6 x 6 ts'un, with 7 to 10 seeds to each hole. If the local growing season is short, each hole may be planted with 15 seeds. The amount of seeds needed for each mou is about 15 to 20 chin, a little more if the seedling survival rate is poor.

(2) Row Planting

A wood planting machine is usually used. Each machine may complete 20 mou of planting in one day. The rope

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marker should be pulled very straight when planting. In some cases, a tractor-pulled machine may also be used. The rows are usually 2 to 3 ts'un wide, and the distance between the rows is about 5 to 6 ts'un. About 20 to 30 chin of seeds are needed for one mou.

(3) Broadcasting

If the seeds are broadcast, they must be distributed as evenly as possible. The seeds may be divided into two portions, and be broadcast twice, horizontally and vertically. According to a survey conducted in Cha-ha-yang Farm, to broadcast the seeds twice in this manner may cause them to be distributed more evenly, and the yield may be raised 11.4%.

3. IRRIGATION [p 519]

The irrigation method of the wet planting process is different from that of the dry planting only at the time of sprouting. The paddy is managed same as the other method of planting after the sprouting is completed.

Under a water level, the sprouting of the seeds cannot be normal, therefore, the water should be drained. As a rule, after planting, a shallow water level should be maintained for 3 to 5 days. Then, the sprouts begin to turn green, and the water should be drained to expose the seedlings for a few days. After that period, if the temperature is low, then a deeper water level may be maintained. In P'u-tung of Shanghai, a shallow water level is maintained for 6 to 7 days until the seedlings are half a ts'un tall; then the water is drained and the paddy sunned for one or two days. By then, the seedlings begin to stand straight, and a half ts'un of water is maintained. When the seedlings are five ts'un tall, the water is maintained to one ts'un. In the Northeast, to protect the seedlings against low temperature, a water level of one and a half to two ts'un is constantly maintained after planting. When the sprouting is complete, then, the paddy is sunned for three or five days. By the tillering stage, except for using deep water to suppress weeds occasionally, the normal water level is about one and half to two ts'un. On a clear day, shallow water is best during the day; if the night is chilly, then, the water level should be deeper. If the water temperature is very cold, then, there should be

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storage ponds to sun the water before it reaches the paddy. In the south, the temperature is very high after the late varieties are planted, therefore, the water of the paddy should be changed frequently with cool water.

SECTION 3. FIELD CONTROL OF DIRECTLY SOWN PADDY RICE [p 520]

There are three aspects to the field management of the paddies directly planted with rice seeds, aside from the field management methods commonly practiced in the transplanted paddies.

1. DISTRIBUTING THE SEEDLINGS EVENLY AND REPLACING MISSING SEEDLINGS [p 520]

Poor land leveling, uneven planting, and varied water levels may cause the seedlings to be missing in some spots, and it is necessary to make up these missing seedlings in order to maintain sufficient numbers of seedlings for high unit yields.

If the seeds are planted in rows, then the center of the row should be dense, while the sides should be sparse. If they are planted in spots, then, each spot should have a similar number of seedlings. In order that the seedlings may grow strong with more effectual heads and heavier heads, the rows or spots that are too dense must be thinned, and the missing spots must be made up.

When the seedlings are 3 to 5 ts'un tall, the cultivation should begin. The seedlings pulled out of the dense spots should be immediately planted in the spots where a

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seedling is missing, roots, mud,and all, so that it will be green again very soon.

2. WEEDING [p 521]

The paddies with the rice seeds directly planted are usually plagued with weeds. There are Penicum crus galli of the Gramineae family; Scirpus lacustris var. tabernaemontani of the Cyperaceae family; Alisma plantago var. parviflorum of the Alismaceae family; Potamogeton polygonifolius of the Potamogetonaceae family; Spirodela polyhiza of the Lemnaceae family; Ceratophyllum demersum of the Ceralophyllaceae family; and in the saline soils, the weeds of the Chenopodiaceae family. Aside from the practice of a reasonable crop rotation system, intensive land preparation, and careful seed selection, the paddies should be managed carefully and weeded in time.

With the thick soil method of dry planting, the weeding process is similar to the upland rice fields before the paddy is flooded. A short-toothed rake may be used to loosen the soil and eliminate the weeds. Weeding should be done when the weeds are still few and small. When the seedlings are two ts'un tall, the paddy should be weeded the second time; when the seedlings are five ts'un tall, the paddy should be weeded the third time. When the seedlings are 8 to 9 ts'un tall, the node growth stage has begun, and raking is no longer necessary.

Deep water soaking is an effective method of getting rid of Penicum crus galli. In 1957, the state-operated Wu-t'ung-ho Farm used a deep water level over a large area to get rid of this type of weeds, the killing rate was above 70%, and from 30 to 50% of the weeding labor was saved besides. The survey of Luan-p'ing-hsien of Hopei showed that (Table 18-9) with deep water, the killing rate for this weed may be as high as 60 to 92%, while the loss in seedlings was only 1 to 16%.

The deep water method may be divided into the submerginng way, and the draining way.

The submerging way is more dangerous. When all the sprouts of the rice seeds have appeared, the sprouts of

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Penicum crus galli are already large enough (when there are two true leaves on these weeds.) On a clear day, the water level may be suddenly raised to 2 to 3 cm above these weeds. When they are dying, then, the water level may be reduced to 5 to 7 cm. According to observations, during the first and second day of soaking, air bubbles may be detected on the leaves of the weeds to show that photosynthesis is still functioning. The air bubbles disappear after three or four days. In five or six days, the leaves turn yellow, and the roots begin to rot. They die in another one or two days. By then, the water level may be reduced to five to seven cm so that the growth of the rice seedlings may be resumed.

The draining way is safer. This method is more suitable for the areas with better irrigation and draining equipment. According to the survey conducted by the Northeast Institute of Agricultural Sciences in Li-shu Farm, with this method, the paddy is flooded and soaked for five to seven days; then it is drained immediately and quickly, and sunned. The killing rate with this method is about 83.3%, and the effect on the rice seedlings is not serious. When the submerging method was tried in this farm, after ten days of soaking, the killing rate of the Penicum crus galli was 65.9%, while the death rate for the rice seedlings was as high as 19.8%.

Table 18-9 The Effect of Deep Water Soaking on Penicum crus galli of the Rice Paddies

品种名 1	地势 5	水层深度 8 (厘米)	稻苗损伤率 9 (%)	稗草死亡率 10 (%)	11 淹灌期间生长高度(厘米)	
					稻 12 苗	稗 13 草
小白籽 2	高 6 地	6.3	1.4	91.6	7.4	5.4
	洼 7 地	8.9	3.1	70.0	8.2	6.8
兴亚 3	高 6 地	8.0	0	92.0	7.9	1.3
	洼 7 地	9.4	16.0	88.8	4.3	2.2
京租 4	高 6 地	9.8	1.0	68.6	9.2	4.0
	洼 7 地	10.1	1.8	61.7	9.9	4.5

14 注：播种期兴亚为5月18日，小白籽、京租为17日；淹水日期兴亚为6月1—6日，小白籽、京租为1—7日，淹水平均水温为17.9—19.7°C。

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1. Name of Variety 2. Hsiao-pai-tzu 3. Hsing-ya
4. Ching-tsu 5. Terrain 6. High
7. Low 8. Depth of water (cm)
9. Rate of damage to the rice seedlings (%)
10. Death rate of Penicum crus galli (%)
11. Height of the plants at the time of flooding (cm)
12. Rice seedlings 13. Penicum crus galli
14. Note: Hsing-ya was planted on the 18th of May, Hsiao-pei-tzu and Ching-tsu were planted on the 17th of May. Hsing-ya was flooded from the 1st to the 6th of June; Hsiao-pai-tzu and Ching-tsu were flooded from the 1st to the 7th of June. The temperature of the water was 17.9-19.7°C on the average.

The seed of Penicum crus galli is very small in size. When the seedling of this weed is young, it cannot withstand submergence as well as the rice seedling. Rice seedlings can survive an evironment with no oxygen for a certain period of time, while in the same environment, the seedlings of Penicum crus galli will die of lack of nourishment, especially when two tb three true leaves have just appeared.

The temperature of the water used to soak these weeds must be quite warm, above 15°C on the average. The warm temperature promotes fast transpiration of the seedlings of Benicum crus galli, so that the nutrients stored within the plant body may soon be used up. If the temperature is too low, more days of soaking are needed to kill these weeds. Besides, water of low temperature may damage the rice seedlings seriously. When the water temperature is just right, the water level should be just two to three cm above the tip of the weeds.

Before this soaking method is adopted to kill these weeds, the following factors are very important:

(1) The paddy must be flat so that the water level is even and the damage to the rice seedlings will not be great.

(2) The soaking method must be administered when the weeds have two to three true leaves. When these weeds are bigger, it is not easy to drown them.

(3) The water should be 2 to 3 cm above the tip of the weeds; therefore, the water level should measure about

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10 to 15 cm.

(4) If the water is warm, then fewer days of soaking are needed to kill the weeds, and the killing effect is greater.

(5) During the soaking period, the growth of the rice seedlings is controlled; therefore, after the soaking period is over, such cultivating measures as cultivation, fertilizer application, and others should be administered immediately to hasten their recovery.

(6) A few weak rice seedlings will die during the soaking period; therefore, if this method is to be administered, additional seeds should have been planted to make up the loss, so that the yield may not be affected.

(7) If this method of killing the weeds is to be adopted, attention must be given to the choice of early maturing varieties of rice which must also be able to withstand deep water well.

The weed killing drugs are becoming more popular recently. The more effective ones are 2,4-D and 2,4,5-T, which are not harmful to the rice seedlings. In 1959, the latter was used for aerial spraying with airplanes in Heilungkiang. It was discovered that it is very effective for killing Monocharia vaginalis, and to certain extent, for Scirpus lacustris var. tabernaemontani, Alisma plantago var. parviflorum, and Ptamogeton polygonifolius.

The paddy may also be weeded before the rice seeds are planted. According to the experience of Hsiang-chih Farm of Heilungkiang, weeding before planting may reduce 78% of the weeds, 1.5 labor day of weeding work per mou, and the yield may be increased 120 chin per mou.

Weeding work is very important in the paddies planted directly with rice seeds. Although we have now several effective methods for eliminating the weeds, all of them are laborious. For the purpose of raising labor productivity, chemicals and machinery must be used more to solve the weed problem.

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3. FERTILIZATION [p 524]

The application of fertilizer is more complicated in the paddies planted directly with rice seeds. At first, the initial fertilizer must be sufficient, and as much as possible, organic fertilizer that is not wholly decomposed should not be used, so that harmful reduction products will not occur. Quickly effective nitrogen, phosphorus, and potassium in a properly balanced mixture is very important for the growth of the young sprouts; therefore, special attention must be given to the balance of nutrients when the initial fertilizer is applied.

When the seeds are planted directly, there is no turning green period for the seedlings as they do when they are transplanted from a seed bed, therefore, the seedlings grow faster and the tillering stage begins early. Supplementary fertilizer, therefore, should be applied earlier also. Due to the fact that there are more weeds in a directly planted paddy, and the field management and irrigation method are somewhat different also, more supplementary fertilizer applications are needed.

Table 18-10 The Growth Condition of Nan-t'e-hao Variety, when Planted Directly and When Transplanted from a Seed Bed

栽培法 1	播种期 4 (月/日)	插秧期 5 (月/日)	返青期 6 (月/日)	分蘖始期 7 (月/日)	稻穗分化期 8 (月/日)	出穗期 9 (月/日)
直 2 播	3/26	—	—	5/1	5/28	6/18
插 3 秧	3/25	4/29	5/10	5/24	6/5	6/23

1. Cultivation method 2. Direct planting 3. Transplantation 4. Planting time (month/day) 5. Transplanting time (month/day) 6. Turning green time (month/day) 7. Tillering begins (month/day) 8. Head evolvement (month/day) 9. Heading time (month/day)

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When the wet planting method and the mud coating method are used, the seeds are not deeply covered, and during the tillering stage, the roots are often distributed in the upper part of the plowing layer. Therefore, when the initial fertilizer is applied, attention must be given to mix the fertilizer into the entire layer of plowed soil, so the the nutrients of the lower part of the plowing layer may attract the roots downward.

With the dry direct planting method, since the paddy is not filled with water during the first stage, the soil is well ventilated. The nitro-ammonium may easily turn into nitrites, then, when the paddy is filled, the reduction action may cause denitrification and the nitrites may be easily lost. Therefore, when this planting method is adopted, it is not suitable to apply too much nitro-fertilizer initially, but just enough for the young sprouts during the first stage. After flooding, more fertilizer may be added with the cultivating measures.

Aside from the common fertilizer, at planting time, well decomposed manure, peat, calcium perphosphate, and a small amount of ammonium sulfate may also be applied. These ingredients have been mixed and made into ready-to-apply fertilizer. During recent years, when aerial planting method was adopted, this mixed fertilizer was used with the seeds. It was found to be both effective and economical.

There is a large area of direct planting rice culture in Heilungkiang, where the growing season is short. Planting is usually done in the middle of May, and in the middle of September, the rice is ready for harvest. During this growing period, the temperature is quite low at the beginning and at the end. In order to guarantee rapid growth and safe development from one stage to the next, supplementary fertilizer is applied during all stages of growth. Based upon the fertility of the soil, the initial fertilizer usually measures six to seven thousand chin per mou, with twenty to thirty chin of ammonium sulfate used for supplements. It has been proven that the supplementary fertilizer should be applied in several intervals, instead of one large application.

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In Wu-san Commune of T'ung-liao-hsien in the Autonomous Region of Inner Mongolia, the directly planted rice paddies are applied with 3,300 chin of miscellaneous fertilizer per mou before planting when the paddies are being leveled. (The average application for the 775 mou of rice paddies in 1956.) When the seedlings are about 8 ts'un tall 18 chin per mou of ammonium sulfate is applied. At the peak of tillering, 120 chin of chicken manure per mou is again applied. A very high yield is obtained as a result.

Pei-kung Commune of Liu-chiang-hsien, in the Autonomous Region of the Chuang Nationality in Kwangsi also has the high yield experience of applying supplementary fertilizer many times and in small amounts each time.

In a word, when the direct planting method is adopted, the seeds sprout in the paddy. The seedlings are not transplanted from the seed beds, and there is no period of turning green again in the paddy. Therefore, during the early stage of growth, the environmental condition required by the rice plants is different from that required by the transplanted seedlings. Therefore, the fertilizer application method should not be the same either. The application of fertilizer must be planned to meet the requirements and the conditions throughout each stage of the plant's growth.

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CHAPTER 19. CULTIVATION OF DRYLAND RICE

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The upland rice culture is distributed in every part of our country, although not over extensive areas. It is, however, distributed more in the provinces of Yunnan, Kweichow, Kiangsu, Honan, Shantung, Hopei, Liaoning, and Kirin. The total acreage of upland rice amounts to about 2% of the total rice acreage of the country.

The upland rice culture is more suitable for areas of high temperature and humidity. Upland rice is one of weaker crops among the dry crop plants with regard to drought resistance. Soil moisture affects its growth and yield to a very large extent. With regard to temperature, the northernmost area with upland rice in our country has an average temperature of 12.3°C between May and September which is the growth season of the upland rice varieties. The average temperature of May is 11.4°C, and the average temperature in September is 12.3°C. The highest temperature in July is 21.3°C. From here on south, the temperature is higher. Presently, this area of Hai-lun is the northern border of upland rice in our country.

Further north to the area of Hei-ho, the average temperature from May to September is 16.7. The average temperature in May is 10.8°; the average temperature in September is 12.7°C; and the highest temperature in July is 21.9°C. Therefore, the only difference is the temperature in May, which is slightly lower than that of Hai-lun. If the varieties of upland rice may be improved and the cultivating technique changed somewhat, there is no reason why the upland rice culture may not be brought further north.

With regard to rainfall, according to research on the subject, during the growth season, the upland rice varieties require 300 mm of rainfall or more. Although rainfall in the north is scarce, during the period from May to

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September, the rainfall is more than 400 mm. In Yunnan, the rainfall from April to September is 680 mm in Chao-t'ung, and 1,000 mm in Szu-mao. There is a large acreage of upland rice in the mountainous areas there. The only drought damage is during the very dry years.

The unit yield of upland rice, according to surveys, is higher than other dry crop plants, and is almost the same as that of the paddy rice. In T'ang-no-hsien, Honan, some low areas are too damp for the other dry crops, and the shortage of water supply makes it unwise to plant paddy rice; therefore, upland rice is just the crop. When it is planted in the spring, the yield is 87% higher than kaoliang. When it is planted in the summer, the yield is 53% higher than millet. In Chang-miao-hsiang, the yield of upland rice is 90 to 280 chin per mou more than that of the wheat and the soybean. In Fu-ning, and Ch'ang-li of Hopei, the yield of the upland rice is more than 200 chin more per mou than that of kaoliang and millet. In Yunnan, although the average yield of upland rice is lower than that of corn and sweet potatoes, it is higher than other dry crops. According to surveys conducted by the Northeast Institute of Agricultural Sciences in Liaoning and Kirin, the net income from upland rice crops is 9.7% higher than kaoliang crops, and 25.5% higher than millet.

The average yield of upland rice in our country is about three to four hundred chin per mou. With some improvement, an increase is quite possible.

Upland rice is rougher than paddy rice, however, the upland rice of the keng subspecies and the glutinous varieties are just as good as the paddy rice. According to chemical analysis, the carbohydrate content of upland rice is less than paddy rice, while the fat and protein content of the former is more. That is to say nutritionally speaking, the upland rice is not at all inferior.

In the Northeast, and the North, there are vast regions of low areas with insufficient water supply, but the soil is damp. If upland rice is planted, the yield may be made more stable than other dry crops. This crop is especially suitable for the highlands of Yunnan and Kweichow, and Ya-an and Lo-shan areas of Szechwan. In the provinces of Kwangtung, Hunan, and Fukien, upland rice may also be planted

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in the areas forested with bamboo, Cryptomeria japonica, Panlownia tomentosa, and Aleurites cordata, to provide a harvest while the trees are small.

In a word, there is a great future in the development of the upland rice culture in our country, which has its important significance in the growth of food production and the national economy.

SECTION 1. PHYSIOLOGICAL CHARACTERISTICS AND ENVIRONMENTAL REQUIREMENTS OF DRYLAND RICE [p 528]

Just like the paddy rice, the upland rice requires high temperature and humidity, and plenty of sunlight. When planted in the high latitude region, the upland rice does not have the protection of the water; it requires high temperature even more obviously than the paddy rice. Due to the fact that it grows on dry land, it is more drought resistant than the paddy varieties. It has a tendency toward the acid reaction in soil and fertilizer.

The following is a description of the relationship of its characteristics and the environmental conditions.

1. GERMINATION AND ROOTING [p 528]

The seeds of the upland rice absorb moisture more efficiently than those of the paddy varieties. During the sprouting, the requirements of temperature and moisture are lower; they may sprout when the average temperature is 10 to 12°C, with the soil moisture more than 10%. Liang Kuang-shang (2733 o342 0794) experimented with 10 varieties of upland rice and 40 varieties of paddy rice in Kwangtung, at the temperatures between 11.4 and 17.4°C, with the average temperature at 14.6°C. On the average, the seeds of the upland varieties took 10.3 days to sprout. The early varieties of paddy rice took 10.5 days; and the late varieties of paddy rice took 14.6 days. When the moisture content of the soil is 16%, and the soil temperature is 15°C, the seeds of the upland varieties take only four to five days to sprout. If

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the temperature is 20°C, sprouting only takes three to four days. During the sprouting period, the upland varieties require more oxygen than the paddy varieties. If the soil contains too much moisture, the sprouting is not very good.

The growth of the roots is closely related to the growth of the leaves. The upper roots branch out into many fine side roots, with a great deal of hair. If the soil moisture is just right, and the ventilation is proper, then, the root system grows better. According to the studies of Yu Shu-wen (0151 0647 2429) and co-workers, if the soil moisture is 70% of saturation, the development of the root system of the upland rice is better than either 45% moisture or saturation. However, when the soil moisture is 45% of saturation, the roots of the upland rice grow downward longer than any other moisture condition.

At the early stage, the root system grows downward into a vertical distribution; then, it begins to spread sideways before it grows downward again. It reaches a greater depth than the root system of the paddy rice. This is why the upland varieties are more drought resistant.

Table 19-1 The Weight of the Root Systems of the Upland and the Paddy Varieties Compared

稻 (1) 种	(5) 老来青			(8) 南通旱稻		
土壤水分状况 (2)	淹 (6) 灌 (5厘米)	(7) 旱种 70%	旱种 45%	淹 (9) 灌 (5厘米)	旱 (10) 种 70%	旱种 45%
(3) 根重 (克/单株)	2.6	1.2	0.5	2.3	3.1	1.6
%	100	46	.19	100	134	69
(4) 第一完全叶长度 (厘米)	1.4	2.8	2.5	2.7	6.2	5.9

1. Rice Variety 2. Soil moisture condition 3. Weight of the root system (g/single stalk) 3. The length of the first complete leaf (cm) 5. Lao-lai-ch'ing 6. Paddy flooded with 5 cm of water 7. Planted in dry field 8. Nan-t'ung upland rice 9. Paddy flooded with 5 cm of water 10. Planted in dry field

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2. LEAFING AND TILLERING [p 529]

The first leaf of the upland rice is stronger, grows faster, and is larger, than that of the paddy rice. When the first leaf of Nan-t'ung Upland is compared with that of Lao-lai-ch'ing, the former is twice as long. (Table 19-1)

Since the upland rice grows in dry fields, the tillering position is lower than the paddy rice. When the first leaf bract appears, the tillering growth begins also. If there is too thick a soil cover, then, the first tiller has difficulty in growing. According to observation, if the temperature is below 26 C, then tillering is delayed and is slower. Tillering will stop, if the temperature is from 17 to 20°C. The tillering of the upland rice, is therefore, closely related to the conditions of soil moisture, temperature, sunlight, soil cover, and density.

3. FLOWERING AND FRUITING [p 530]

The temperature at the blossoming time should be above 20°C, and the best temperature is about 30°C, slightly lower than the temperature requirement of the paddy rice. It blooms generally in the morning, and reaches the peak at 10 to 11 o'clock A,M. This may vary with the regions. Rain, low temperature, and high speed wind may affect fertilization very seriously at the blossoming time. The normal rate of empty hulls of the upland rice in Kirin is about 5%. In 1954, during its blossoming time (in May), there was 60.3 mm of rainfall, and the temperature dropped to 17.3°C, with a wind speed of 4.2 m per second. The average rate of empty hulls of the upland rice there was 38%. In 1955, the rainfall in May was 1.7 mm; the temperature was 17.6°C; and the wind speed was 6 m per second (for a short while); and the rate of emty hulls was 40%.

The relative humidity during the blossoming time is also important. Hsu-wen of Kwangtung is located on the edge of the forest district, and is also close to the seashore; therefore, the air there is constantly moist. When the upland rice was planted late and blossomed in the fall, although it had not rained for a long time, the yield was very high.

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According to the test conducted by the Comprehensive Experimental Station of Kirin in 1955, in one field, during the blossoming time, the soil moisture was 13%; the relative humidity between 49 and 80%, with an average of 65%; the morning dew was heavy; and the growth of the upland rice was normal. In another field slightly lower, the soil moisture was 25 to 28%; the relative humidity was 48 to 88%, with an average of 65%; and the upland rice was growing very well too. During the half a month blossoming time (1st to 15th of August), the relative humidity dropped to 39% at its lowest, with an average of 79.4%; the total rainfall was only 6 mm; the total evaporation was 101.6 mm; the average temperature was 23.9°C, with a highest of 30.6°C; the blossoming and fertilization processes proceeded very satisfactorily. Due to the fact that the relatively humidity was high, the upland rice was not affected by the drought. On the other hand, if the relative humidity should drop to below 40%, with a warm wind, then the hulls will be empty. If the soil moisture is below 30%, with little or no rain, then, relative humidity becomes the determinant factor.

During the ripening stage, the temperature should be above 15°C. If it is below 12°C, then, the ripening process will be delayed, the seeds will not be full, and the yield will suffer.

4. GROWTH PERIOD [p 531]

The growth period of the upland rice is closely related to the temperature, the moisture, the daylight condition, and the planting time. In An-tung of Liaoning, the growth period of the upland rice lasts about 150 days. When the same variety is introduced to Szechwan, with the higher temperature and shorter daylight, the growth period was shortened to 127 days. The growth period of Chin-ch'ien-tao No.1 of Kirin is about 130 days, and when it is introduced to Hopei, the growth period is shortened to 96 days. If the temperature is low and moisture is deficient, then, the growth is slower, and the growth period longer. When planted in the spring (23rd of April), the growth period of the upland rice is longer than those planted in the summer (10th of June). Such varieties as Ling-yu White Beard and Ling-yu Black Beard have a growth period of 131 days if planted in the spring;

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if they are planted in the summer, the growth period is shortened to 106 or 107 days. The varieties of Ling-yu Red Beard and Kuang-hu-lu have a growth period of 133 to 137 days if planted in the spring ; the growth period is shortened to 105 to 108 if planted in the summer. Such late maturing varieties as Hui-hsien Red Beard and Wu-shu Red Beard have a growth period of 140 to 147 days if planted in the spring; the growth period is shortened to 125 days if planted in the summer. In the spring, the temperature is low and the nourishing stage of growth is lengthened. In the summer, the temperature is high, the daylight period is short, and the growth period is short too.

5. TOLERANCE TO DRYNESS [p 531]

The upland varieties are formed from the paddy varieties with the influence of the soil moisture conditions. The farmers of Lo-p'ing-hsien, Kiangsu cultivated the paddy rice varieties of Huang-chin-ts'ao, and Nan-t'e-hao on dry fields and gradually made them adjust to the new environment to become very drought resistant upland varieties. The experiments of Ting Ying (0002 7336) and Yu Shu-wen (0151 0647 2429) also pointed to the fact that there is no fundamental difference between the paddy and the upland varieties. However, the two types do adjust to their environment differently. In the process of development, due to the difference in soil moisture, the physiological characteristic of drought resistance of the upland rice is gradually formed.

Table 19-2 The Growth of the Upland Rice and Soil Moisture (Hsiao-Hung-mang Variety)

土壤持水量 (%) 1	2 株高 (厘米)	3 穗长 (厘米)	4 一穗粒数	5 结实率 (%)	6 千粒重 (克)	7 产量 (斤/亩)	8 产量比 (%)
50—60	92.8	19.1	75.2	83.1	24.6	384.5	100.0
60—70	93.5	20.2	95.2	89.9	25.2	440.6	114.6
70—80	96.4	21.2	100.9	89.9	25.2	487.1	126.7
80—90	99.3	22.0	98.7	90.7	25.4	503.9	131.1

1. Soil moisture (%) 2. Height of stalk (cm) 3. Length of head (cm) 4. Number of seeds per head 5. Rate of seeding 6. Weight of 1,000 seeds (g) 7. Yield (chin/mou) 8. Yield compared (%)

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The growth and yield of upland rice are closely related to soil moisture. According to the research of the Institute of Water Conservation Studies of Shantung Province, the yield of the upland varieties rises with the soil moisture content (Table 19-2), and is more stable when the moisture content is between 70 to 80% of saturation. According to the studies of Yu Shu-wen (0151 0647 2429) and co-workers, when the soil moisture is 45 to 50% of saturation, the yield is 60% of the paddy which is regularly irrigated (5 cm of water).

The upland varieties are more resistant to potassium chlorate ($KClO_3$) poison than the paddy varieties. Liang Kuang-shang (2733 0342 0794) experimented with 20 varieties of paddy and upland rice in 1940, and discovered that the upland varieties had more resistance to poison (Table 19-3), although the poison resistance of the paddy varieties varies a great deal also, and the variety Li-tzu-hung is the strongest.

Table 19-3 Potassium Chlorate Resistance of the Upland and Paddy Varieties in Ch'eng-chiang, Yunnan

品 (1) 种	种子被害粒 7 (%)	发芽种子被害株 8 (%)	幼苗被害株 9 (%)	抗毒性强弱 10
陆 稻 2	15.05	6.66	16.26	最 11 强
李 子 红 3	36.54	63.33	46.20	强12
香 谷 4	51.51	36.66	56.38	中 13
中 红 掉 5	33.33	96.66	82.06	弱 14
中 白 掉 6	29.08	100.00	88.21	最 15 弱

1. Variety 2. Upland rice 3. Li-tzu-hung 4.Hsiang-ku
5. Chung-hung-tiao 6. Chung-pai-tiao 7. Rate of seed damage
8. Rate of sprouted seed damage 9. Rate of seedling damage
10. Poison resistance 11. The strongest 12. Strong
13. Moderate 14. Weak 15. The weakest

Liang Kuang-shang (2733 0342 0794) also tested the drought resistant characteristic of the upland and the paddy varieties, and discovered that under similar drought condition, the upland varieties began to wither four to six days later. Among the upland varieties, the drought resistant characteristic varies also.

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Table 19-4 Drought Resistance of the Major Upland Varieties of Kwangtung

项 1 目	5 陆稻					水稻（对照） 11
	曲江山禾 6	金包银58号 7	坡擂2号 8	英德大糯 9	走馬坪 暹逻粘 10	连山黄粘 12
苗 2 长（厘米）	31.30	30.21	29.86	28.23	25.19	27.21
开始枯萎日数 3	11.0	9	9	9	9	5
平均枯萎日数 4	17.8	16.8	16.7	16.5	14.7	12.0

1. Item 2. Length of seedling (cm) 3. Number of days before it begins to wither 4. Average days before it begins to wither 5. Upland Varieties 6. Ch'ueh-chiang-shan-ho 7. Chin-pao-yin No.58 8. P'u-lei No.2 9. Ying-te-ta-nou 10. Tsou-ma-p'ing; Hsien-lo-chan 11. Paddy rice (Control group) 12. Lien-shan-huang-chan

Table 19-5 The Leaf and Stem Structure of the Upland and Paddy Varieties Compared (Ch'eng-chiang, Yunnan Province)

	品 1 种	旱 23 稻	李24子红	香25谷	26 中红掉	中白掉 27
叶 2 部	长（厘米） 3	30.7	25.0	26.0	29.5	29.5
	宽（厘米） 4	1.7	1.1	1.2	1.3	1.3
	厚（微米） 5	227.0	156.9	165.9	165.0	171.0
	中肋厚（微米）6	925	346	524	345	566
	大维管束平均面积（平方微米） 7	2,734	1,633	1,493	1,576	1,795
	小维管束平均面积（平方微米） 8	246.0	201.1	165.7	155.2	166.1
	导管平均面积（平方微米） 9	675.0	512.7	395.0	358.1	446.9
	单位叶面积茸毛数（230平方微米内） 10	33.3	25.5	21.2	21.8	26.3
	表皮厚度（微米） 11	46.2	40.6	34.8	39.3	41.7
	叶面气孔数（0.16平方毫米内）12	7.4	14.2	12.6	14.4	10.2
	叶背气孔数（0.16平方毫米内）13	8.4	10.6	10.4	9.4	14.6
茎 15 部	大维管束数 16	25	28	30	25	36
	小维管束数 17	22	22	24	21	29
	大维管束平均面积（平方微米）18	1,466	1,439	2,998	2,083	2,498
	小维管束平均面积（平方微米）19	745	697	735	962	998
	导管平均面积（平方微米） 20	1,129	1,112	2,265	1,571	1,824
	厚壁细胞大小（长短径微米） 14	16.9×12.1	26.6×18.6	25.8×18.5	32.5×23.8	24.2×19.9
	薄壁细胞壁厚（微米） 21	13.2	10.1	10.6	9.0	10.4
	厚壁细胞壁厚（微米） 22	23.0	18.9	26.0	19.3	22.7

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1. Variety 2. Leaf 3. Length (cm) 4. Width (cm)
5. Thickness (0.001 mm) 6. Thickness of center vein (0.001 mm)
7. Average area of the large vascular bundle (0.001 mm^2)
8. Average area of the small vascular bundle (0.001 mm^2)
9. Average area of the petiole (0.001 mm^2)
10. Number of hairs on a unit area (within 230 0.001 mm^2)
11. Thickness of epidermis (0.001 mm)
12. Number of air spaces (within 0.16 0.001 mm^2)
13. Number of air spaces on the back of the leaf (within 0.16 0.001 mm^2)
14. Size of the cells of the cutin layer (length x width 0.001 mm)
15. Stem 16. Number of large vascular bundles
17. Number of small vascular bundles
18. Average area of the large vascular bundle (0.001 mm^2)
19. Average area of the small vascular bundle (0.001 mm^2)
20. Average area of the petiole (0.001 mm^2)
21. Thickness of thin-walled cells(0.001 mm)
22. Thickness of thick-walled cells(0.001 mm)
23. Upland rice 24. Li-tzu-hung 25. Hsiang-ku
26. Chung-hung-tiao 27. Chung-pai-tiao

The studies of Yu Shu-wen and co-workers prove that physiologically speaking, both the paddy and the upland varieties may grow very well in a paddy with a level of water, because they both have air vent structure. However, both of these types of rice plants can grow on dry fields, except for the fact that the upland varieties grow better on dry fields than the paddy varieties. Both types have a lower yield on the dry field than the paddy, but the reduction is less with the upland varieties. On the dry field, the moisture content of the plant body of all the varieties of rice drops, but that of the upland varieties drops less than the others. Thus, they conclude that the paddy and the upland varieties show an obvious difference in their adaptibility to dry field cultivation; however, this drought resistant characteristic of the upland varieties is not a permanent characteristic. For example, the moisture content of the leaf of Nan-t'ung Upland varies with the soil moisture (Table 19-6) . When the soil moisture drops during the day, the drop of moisture in the leaves of the upland varieties is less than those of the paddy varieties.

The leaf blade of the upland varieties bends down

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at the place 2/3 from the tip more obviously than that of the paddy varieties. This fact is related to the thickness of the leaf and the size of the vascular bundles. When suffering from drought, the leaf of the upland varieties takes longer to fold up, shrink, wither, and die than that of the paddy varieties. However, the duration and the extent of this drought damage vary with the varieties. In other words, the various varieties, upland and paddy, have different degrees of drought resistance.

The liquid exuded by the leaf of the upland rice is thicker than that exuded by the leaf of the paddy rice. Under high temperature (50°C), tests show that there is less an increase of hydrolytic substance in the cells of the leaf of the upland variety, and it is, therefore, proven that compared with the paddy varieties, the upland varieties are less damaged by high temperature.

Table 19-6 The Moisture Content and Loss of the Lower part of the Leaf under Different Soil Moisture Conditions

稻 (1) 种	(5) 老来青			(6) 南通旱稻		
水分状况 (2)	淹 (7) 灌 (5厘米)	旱 (8) 种 70%	45%	淹 (7) 灌 (5厘米)	旱 (8) 种 70%	45%
清晨含水量 (%) 3	80.5	76.9	74.1	80.1	78.2	76.5
日中水分亏缺 (%) 4	3.1	4.2	3.3	3.0	2.2	2.7

1. Variety 2. Moisture condition 3. Moisture content early in the morning (%) 4. Moisture loss at noon (%)
5. Lao-lai-ch'ing 6. Nan-t'ung Upland 7. Flooded paddy (5 cm)
8. Dry cultivation

6. TOLERANCE TO ACIDITY AND ALKALINITY [p 534]

The upland varieties have strong resistance to acids, but not alkalis. For the upland rice, the soil's pH value is best to be 5 to 5.5. It may be planted in neutral or slightly alkali soil, but heavy alkali soil is not suitable for its growth. In the highly saline northern soils, the upland rice often fails to sprout, and even if it does sprout

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the growth is very slow. Judging from the relationship of the soluble salt content and the growth of the plants, the critical margin for the upland varieties is 0.01% for sodium chloride, 0.005% for sodium carbonate, 0.005 to 0.0075% sodium bicarbonate, and 0.04% for sodium sulfate. All soils with saline content above these margins must be washed before the upland rice may be planted. If a great deal of acid fertilizer or organic fertilizer is applied, the alkalinity of the soil may be reduced somewhat.

SECTION 2. VARIETIES OF DRY LAND RICE [p 535]

The cultivation of the upland rice has had long years of history in our country, over vast areas. The different environmental conditions and cultivation systems have resulted in a large number of varieties. Just like the paddy rice, there are also the hsien and the keng subspecies, and the early, medium, and late ripening varieties. During the recent years, many excellent varieties have been judged and selected. For example, in Liaoning, the numerous local varieties were gathered together, and An-tung Upland and Hai-ch'eng Dry were judged as the best. Now, An-tung Upland has been introduced to the provinces of Hopei, Honan, and Szechwan with very good results. The variety of Fu-ning Dry was chosen from the Hopei varieties, Ling-yu Black Beard, Ling-yu Large Red Beard, and Ling-yu Little Red Beard are from Honan, Tzu-p'i from Shantung.

The Northeast Institute of Agricultural Sciences studied the advantages and disadvantages of the local varieties, and made use of the various superior upland and paddy varieties, to improve and to crossbreed them. After years of research work, the two varieties of Kung-lu No.4 and Kung-lu No.5 have been created. Both of them can withstand fertilizer and resist rice blight well, and the yield is 20% higher than Chin-ch'ien-tao No.1. The Institute of Grains of Hopei Province created the three varieties of T'ang-fu No.2, T'ang-fu No.3, and Upland 300, with selective breeding of the local Fu-ning Upland. All three varieties have a yield 65 to

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95% higher than the original Fu-ning Upland. Szechwan College of Agriculture also created 12 varieties of upland rice. After repeated comparison and testing, Yueh-chin No. 109 and Yueh-chin No. 110 are considered the best. Their yield is close to An-tung Upland.

The following is a description of the many local varieties and the superior ones which are selected from them.

1. VARIETIES OF THE NORTHEAST REGION [p 535]

The frost-free period in the Northeast is very short and the year's average temperature is rather low. Most of the local upland varieties belong to the keng subspecies, with a few nou /glutinous/ types of the keng subspecies. The varieties of the middle and northern parts of this region have long beards of yellowish white, yellowish brown, reddish brown, or purplish black colors. Only a few are beardless. The growth period of these varieties is short. Their reaction to light is weak. They are very drought and disease resistant. The stalks are short, the grain falls easily, and the quality of the grain is poor. The varieties of the southern part of this region all have long beards with the same good characteristics except that their growth period is long. The only two superior varieties are An-tung Upland and Hai-ch'eng Dry. The grain does not fall easily, and is of good quality. The upland rice is, in this region, planted in the lowlands and the areas between the low and the highlands. The major varieties are the following:

Pai-ta-tu (keng) : This is a Heilungkiang Variety, also called White Beard Dry. The stalk is about 75 cm tall. The head has a white beard. The grain is oval-shaped, and of good quality. About 70% of polished rice may be obtained from the rough. Its growth season is 135 to 140 days, and is considered late locally. It can withstand fertilizer well, and does not fall easily. Its yield is high and stable. It is widely cultivated in A-ch'eng, Shuang-ch'eng, Hu-lan, and Ping-hsien.

Hung-keng-tzu (keng) : This is an important local variety of the Harbin area , and is also called Red Beard Dry. The stalk is about 80 to 90 cm tall. It has a red colored long

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beard. The blossom is reddish brown, and the grain is long, and reddich colored, and of poor quality. About 65% of polished rice may be obtained from the rough. The growth period is 125 days, and it is considered one of the early ripening varieties. It likes fertilizer, and does not fall easily. It is cultivated mostly in the suburbs of Hu-lan and Harbin.

Kung-lu No.4 (keng) : This is one of the products of the Northeast Institute of Agricultural Sciences. Ch'ang-ch'un Beardless (an upland) and Shih-shou White Hair (a paddy) are used as parent varieties. The stalk is about 95 cm tall. The leaf is wide; the head is 19 to 21 cm long; and the main head contains about 111 seeds. The grain is oval; the hull is yellowish white; the beard is medium in length and yellowish white in color. The weight of 1,000 seeds is about 29 g. About 80% of polished rice may be obtained from the rough, and the quality of the grain is good. The growth period is about 135 days. If it is planted in the areas of Kung-chu-ling in May, it will sprout in the later part of May, come to a head in the middle of August, and be ripe in the middle or later part of September. It tillers poorly, and grows slowly during the early stages. The stalk is highly resistant to fall, and is not subject to blight. The grain does not fall easily, and the average yield is 21.4% higher than that of Chin-ch'ien-tao No.1. It is doing very satisfactorily in the various experimental stations.

Kung-lu No.5 (keng) : This is a sister variety of the above one. The stalk is about 90 cm tall. The head is 20 to 22 cm long, and the main head contains about 120 seeds. The grain is oval; the hull is yellowish white; and the beard is short and sparse. The weight of 1,000 seeds is about 30 g. The grain is of good quality. About 81% of polished rice may be obtained from the rough. The length of the growth period is similar to that of Kung-lu No.4. High yield has been obtained in all the experimental stations where it is being tried.

Chin-ch'ien No.1 (keng) : This was the product of the Kung-chu-ling Agricultural Experimental Station of the puppet Man regime. The stalk is about 85 cm tall. The head is 18 to 20 cm long. Each head contains 70 to 100 seeds. The beard is long and reddish brown colored. The grain is oval. The weight of 1,000 seeds is 23 to 26 g. It is of

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medium quality. About 75% polished rice may be obtained from the rough. The growth period is 135 days. It tillers well, but does not have very strong resistance to blight. The grain falls easily. It is planted abundantly in Yung-chi, Chiu-t'ai, and Chi-lin, and to a moderate extent in Huai-te, Tung-feng, I-t'ung, and Li-shu. It was introduced to Hopei in 1955, and used as a summer crop for the wheat field. Its growth period in Hopei is only about 96 days, 16 days earlier than the local Wen-tzu-tsui. After its harvest, there is still time to plant wheat. It is very suitable for the southern part of Hopei

Hua-tien-pai (keng) : This is a local variety of Hua-tien, Kirin. The stalk is 82 cm tall. The head is 17 to 20 cm long. Each head contains 80 seeds. The grain is oval. The beard is long and yellowish white colored. The weight of 1,000 seeds is 25 to 27 g. The quality is poor. The growth period is about 135 days. It has medium resistance to blight, and the seeds fall easily. It was introduced to Hopei in 1955; the growth period was shortened to 93 days., 18 days earlier than the local Wen-tzu-tsui. Two crops may be grown in a year.

An-tung Upland (keng) : This was introduced from Korea by the farmers of T'ung-tien-kou, An-tung, and Liaoning The stalk is about 1 m tall, strong, and does not fall easily. The length of the head is 17 cm on the average, and each head contains about 95 seeds. The grain is oval, and large. The weight of 1,000 seeds is about 30 g. About 76% polished rice may be obtained from the rough, and the quality is good. The growth period is about 150 days. In Liaoning, if it is planted in the later part of April, it comes to a head in the middle of August, and becomes ripe in the later part of September or the early part of October. It is very adaptable, and can resist low temperature, drought, blight, or falling. The seeds do not fall easily. However, during the seedling stage, it is rather fragile, and grows very slowly. This variety is currently being cultivated in the central and the southern parts of Liaoning. It was introduced into Szechwan in 1956; the growth period was shortened to 120 days. It is now being widely popularized in that province.

Hai-ch'eng Dry (keng) : This is chosen as a superior variety from Liaoning. The stalk is 110 cm tall, and

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the head is about 20 cm long. The grain is of good quality. The growth season is about 145 days. In Liaoning, if it is planted in the later part of April, it comes to a head in the middle of August, and becomes ripe in the middle or later part of September. During the early stage of growth it is very drought resistant, and during the later part, it is very flood resistant. The seeds do not fall easily, and the stalk can resist falling. It is distributed in the areas of Hai-ch'eng and Liao-yang, and has been selected as one of the superior varieties from Liaoning.

Pu-fu-ching (nou) : This is a variety of Hsiu-yen-hsien of Liaoning. The stalk is 114 cm tall, and the head is about 18 cm long. The head is shaped like a stick, with no beard. The grain is oval, and the rough rice is white colored, and is of very good quality. The growth period is 145 days. The seeds do not fall easily. It has strong resistance to blight and drought, and is very suitable for the poor land of the mountain slope.

2. VARIETIES OF THE NORTHERN REGION [p 537]

In North China, upland rice is planted mostly in the three provinces of Hopei, Shantung, and Honan. According to the studies of T'ang-shan Agricultural Experimental Station, the local varieties of Hopei may be divided into six types according to their characteristics:

(1) Bearded Yellow Hull :

This type may be divided into the three kinds of early, medium, and late, according to their growth periods. The early ripening kind has short stalks, short heads, and the seeds fall easily. The medium ripening kind has medium tall stalks. It resists the blight disease well. Its yield is moderate but stable. It is the major type in the northern and eastern parts of that province. The late kind has long heads with many seeds. It has great potential for high yield, but is subject to blight. It is more suitable for areas of fertile soil with good irrigation conditions.

(2) Bearded Brownish Red Hull:

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This type may also be divided into the three kinds of early, medium, and late. The last two kinds are not very drought resistant, and the yield is poor. They do not have too much of a future.

(3) Bearded Red Hull:

This type may be divided into the two kinds of medium and late. The stalks are tall and large, soft, and fall easily. However, it resists blight very well.

(4) Bearded Black Hull:

Mostly medium and late ripening varieties. The stalks are moderately tall, and the yield is also moderate. These varieties resist blight very well.

(5) Beardless Yellow Hull:

This type is also divided into the three kinds of early, medium, and late. Most of these varieties have serious problems of falling seeds, and are, therefore, not very valuable.

(6) Beardless Brown Hull :

This type may be divided into the late and the medium kinds. There are not very many varieties, but their yield is generally high. The seeds do not fall easily.

The province of Shantung also has many varieties of upland rice. In Honan, most of the upland varieties are distributed in the south and the north. The following is a description of the varieties of these three provinces.

Fu-ning Dry (keng) : This is a local variety of Fu-ning-hsien, Hopei. It was originally produced in An-tung, Liaoning, and was introduced to Fu-ning in 1938. At present, it is popularly cultivated in T'ang-shan regions. The stalk is 110 cm tall, and the head is abut 22 cm long. Each head contains 110 seeds, and in some cases, as many as 169 seeds. The grain is oval. The weight of 1,000 seeds is about 22 g. About 78% polished rice may be obtained from the rough. The growth period is about 160 days. It tillers abundantly, resists drought well, and the yield is about 15.8% more than Ta-hung-mang. When planted in the thin land of the hills,

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the yield remains high. From 1957 to 1958, Hsu-chou Special District Institute of Agricultural Sciences of Kiangsu introduced it to Hsu-chou, and discovered that its yield was 8.3% higher than the local standard variety, and its growth period in Hsu-chou was only 115 days. It is very suitable for the area of Hsu-chou in the wheat fields or as a repeated crop .

Lu-lung-ta-hung-mang (keng) : This is a local variety of Lu-lung-hsien, Hopei. The stalk is about 115 cm tall, and the head is 21 cm long. Each head contains about 86 seeds. The weight of 1,000 seeds is 26 g. The growth period is 167 days. It is highly resistant to drought, disease, and flood, and its yield is stable. It is distributed in the areas of Lu-lung and Fu-ning.

Ling-yu Black Beard (keng) : This is a local variety of the northern part of Honan. The stalk is about 1 m tall, with black beard, and large heads. Each head contains about 200 seeds, and the weight of 1,000 seeds is about 25 g. The seeds do not fall easily, and about 76% polished rice may be obtained from the rough. If planted in the spring, the growth period is about 135 days; in planted in the summer, it is about 105 days. It resists diseases well, and ripens uniformly. It is now a recommended variety for all the areas of the north of Honan.

Ling-yu Little White Beard (keng) : It is a local variety of the northern part of Honan. The stalk is about 1 m tall, with a white beard, and very few empty hulls. Each head contains only a little over 100 seeds, and about 77% polished rice may be obtained from the rough. It is highly disease resistant, and ripens early. When planted in the spring, the growth period is 130 days; when planted in the summer, it is about 105 days. The yield is high and stable.

Ling-yu Big Red Beard (keng) : This is a local variety of the northern part of Honan. The stalk is 107 cm tall, with a long red beard. The weight of 1,000 seeds is about 25 g. It is highly resistant to fall. The seeds do not fall easily. About 76% polished rice may be obtained from the rough. In planted in the spring, the growth period is about 135 days; if planted in the summer, it is about 107 days. In the summer, if planting is done after the 1st of July, it will not have enough time to become ripe.

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Tzu-pi Dry (keng) : In 1949, Ts'ung Shu-te (0654 2885 1795), a farmer of Wen-teng-hsien, Shantung, discovered a strange looking four-head rice plant in his paddy. He cultivated it on dry land for several years, and this variety is the result of his labor. The stalk is about 145 cm tall. The head is huge, and full of seeds. The average head measures 19.7 cm in length. Each head has about 141.6 seeds. The grain is oval. The weight of 1,000 seeds is 23 g. More than 75% polished rice may be obtained from the rough. The growth period is about 140 days. If it is planted in the later part of April, it will come to a head in the middle of August, and the harvest will be in the later part of September. The seeds do not fall easily during the ripening stage. It tillers poorly, and the stalk is weak and falls easily. The seedlings do not resist drought very well. It is more suitable for the damp areas. This is now the recommended variety in Shantung.

3. VARIETIES OF THE SOUTHERN REGION [p 539]

Upland rice acreage is small in central and southern China. However, due to the difference of natural conditions, there are many varieties. The following is a description of the major ones.

Shu-yang Hsien (hsien) : This is a local variety of the northern part of Kiangsu. The stalk is about 1 m tall. Each head contains about 50 seeds. There is no beard. The weight of 1,000 seeds is 29 g. About 78% polished rice may be obtained from the rough. The rice is red colored, of medium quality. It tillers abundantly, and is highly drought resistant. It ripens early, and the growth period is about 110 days. The yield is high and stable. It is considered a good variety for the wheat field or for repeated crops.

Li-ch'uan Shan-ho (hsien) : It is a good variety of Li-ch'uan-hsien, Kiangsi. The stalk is strong and big, with well developed roots, and does not fall easily. The seed is larger than that of the paddy varieties. The grain is fat and round, of very good quality. It tillers abundantly, and is highly resistant to drought and disease. The yield is high.

Lo-ping Upland (early hisen) : It is the chosen variety of Lo-p'ing-hsien, Kiangsi. The stalk is strong and big; the leaves are wide; the head is long, with many seeds.

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The grain is golden yellow colored, and the rice is a clear white. It is very adaptable, and is highly resistant to drought. However, it tillers poorly.

P'u-lei No.2 : In 1932, this variety was the product of a selective breeding program of the College of Agriculture, of Chung-shan University, Canton. The stalk is moderately tall. The leaves are dark. It tillers moderately, and is highly resistant to drought. The main head is about 18 cm long. Each head has 72 seeds. The seeds are slightly oval-shaped. The growth period is 103 days. It is now considered a superior variety of the western part of Kwangtung.

Ai-chueh-p'u-ho : This is a local variety of Wu-ch'uan-hsien, Kwangtung. The stalk is generally 70 to 80 cm. The head is medium length. It tillers abundantly, and is highly resistant to drought. It cannot withstand low temperature or thin soil. The growth period is 90 to 100 days. In 1957, it was introduced to Hsu-chou by the Hsu-chou Special District Institute of Agricultural Sciences. The test results of two years show that the yield is high and stable, but the growth period is lengthened to about 110 days.

Ya-chou-chan (hsien) : This is a superior variety of Hai-nan-tao, Kwangtung. The stalk is strong and big, and the seeds are large. It is highly resistant to drought, and does not fall easily. The growth period is 120 days. It is suitable for sandy or loam soils of high or slope terrain.

Hei-k'u-keng : It is an old local variety of Ya-hsien, Hai-nan-tao, Kwangtung. The stalk is strong and big. It can withstand drought, cloudy days, fertilizer, and is highly resistant to diseases. The growth period is 150 days. It is suitable for the terraced fields.

Yueh-chin No.109 : This was the product of the selective breeding program of Szechwan College of Agriculture in 1958. The stalk is 94 cm tall, with 1.8 effectual tillers. Each head contains 71 seeds. The weight of 1,000 seeds is 29.9 g. The growth period is 141 days. It may be harvested before the 20th of August.

Yueh-chin No.110 : This is also a product of Szechwan College of Agriculture. The stalk is 97 cm tall, with 1.7 effectual tillers. Each head contains 64 seeds. The weight of 1,000 seeds is 29.4 g. The growth period is 142 days.

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SECTION 3. TECHNIQUES OF CULTIVATING DRY LAND RICE [p 540]

1. PREPARATION OF THE FIELD [p 540]

The soil preparation for the upland rice is mainly deep plowing and weeding. The timing and the method vary with the area, the temperature, the soil, the season, and the previous crop.

(1) Northern Areas

In the north, upland rice may be planted in the spring or the fall. The field is plowed after the fall harvest for better yield. The field is first plowed shallow, and the stubble is burned. Then the fertilizer is applied, and the field is deep plowed. If the snow or rain is abundant, then, the field is not raked. Next spring, it is raked as soon as the ground thaws. If a spring drought is likely, then, the field is raked in the fall after plowing, so that the plowing layer will be soft. The weeds are eliminated in the fall too, so that they will not grow rapidly in the spring.

Spring plowing should not be as deep as fall plowing, and the field is carefully raked and leveled immediately after plowing. If the soil is saline, then, the soil should not be pressed after raking, so that the salts will not rise to the surface. If the field is fallowed in the winter due to poor drainage, and has not be plowed in the fall, then, spring plowing should be done when the soil moisture is just right. If the soil drains slowly in the spring, ditches should be dug in the fall, and the soil should be sunned. This method can raise the soil temperature and promote soil weathering, so that spring planting will not be delayed.

If the upland rice is planted in the summer, it is generally planted after the harvest of barley, wheat, or potatoes. At that time, the temperature is high and the evaporation is great. Plowing should be done at the same time the previous crop is harvested, and the fertilizer should be applied at the same time. The soil should be pressed while the seeds

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are being planted. This method makes the seeds sprout easier.

(2) The Southern Areas

In the southern areas, the crop before that of the upland rice is usually a winter crop or a fall crop. When such crops as barley, wheat, oil cabbage, turnip, fall sweet potatoes, or fall peanuts are harvested, the field is plowed, and raked for three to five days to make flat mounds ready for planting again. On the slopes of the mountainous regions, or or the newly cultivated fields where terracs have not been engineered. the mounds should be made in contour lines to protect the soil from erosion. In Kwangtung, upland rice is often planted in the young forests of bamboo, Cryptomeria japonica, tea, Aleurites cordata, rubber, and others. The land has been plowed before, and once a year, the space between the rows of trees is carefully plowed and raked for the cultivation of the upland varieties.

2. SOWING THE SEEDS [p 541]

With reasonable density, the planting of the upland rice should be timely, with the correct amount of soil cover and pressure. The following is a description of the concrete methods:

(1) Seed Treatment

Before planting, the seeds must be selected, cleaned, and sunned. The beard is taken off, and the seeds are disinfected. If saline water (in mud) is used to hasten sprouting, the seeds may grow four to six days faster, but the process should last only until about 10% of the seeds are turning slightly white. If the planting is to be done early, when temperature is low, the seeds may easily become rotten. If the soil is very dry, this process may cause the soil to absorb the moisture from the soaked seeds and harm the young sprouts.

(2) Planting Time

Generally speaking, when the temperature is above 12°C, it is time for planting. In the north, the spring

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arrives late, planting must wait until the early or the middle part of April (North China); in the later part of April (Kirin); or the early part of May (Heilungkiang). When planting is delayed, the yield suffers. According to Pa-hsien Experimental Station of Hopei, if planting is done on the 6th of May, instead of 29th of April, the yield is 17.6% lower. In Pao-ti-hsien, when planting is moved from the 8th of June to the 27th of April, the yield was doubled.

If upland rice is planted in the summer (North China) then, it is best to be done in the later part of May to the middle part of June. After the harvest of the previous crop, the field should be prepared immediately, otherwise, toward the later part of the growth period of the upland rice, the temperature is going to be very low, and the yield will suffer. According to the experiments of Pai-ch'uan Experimental Station of Honan from 1955 to 1956, if planting is done in the later part of June, instead of the early part of June, then, the yield is 50% less.

In the south (Hunan and Szechwan) planting is often done in the early part of April. In Kwangtung, as far as the temperature is concerned, planting may be done in the winter. However, the growth may become very slow. Upland rice is generally planted just before the beginning of spring.

(3) Amount to be Planted, and the Method of Planting

The key to high yield is a reasonable density on the basis of deep plowing and fertilizer application. According to test results (Table 197), by either reducing the space between the rows, or widening the rows, a larger area of the field is planted with seeds so the number of effectual heads may increase within a unit area, hence there will be a higher yield. If the width of the rows and the space between the rows remain the same, a larger number of seeds planted in the rows may bring similar results.

The studies of Hopei Provincial Institute of Agricultural Sciences showed that if the space between the rows is 9 ts'un, then, if 16 chin is planted per mou, the yield is 12.9% higher than the field planted with 10 chin per mou.

Pai-ch'eng Special District Institute of Agricultural Sciences experimented in 1958 with narrow rows 4.5 ts'un apart, and with double rows 15 ts'un and 3 ts'un apart, and discovered that the former method resulted in 80% more effectual

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heads, and the yield was 51.3% higher.

Table 19-7 The Various Planting Methods Compared

地 点 (1)	行距×播幅 6 (寸)	播种量 7 (斤/亩)	有效穗数 8 (万/亩)	一穗粒数 9	产量 10 (斤/亩)	增产比率 11 (%)
(3 河北省宁河县幸福农业生产合作社[4] (1956)	18.6×6.6	6	7.0	54.0	270.0	100.0
	4.5×0.5	12.4	17.7	49.0	570.0	211.1
(3) 河北省唐山农业试验站[5] (1957)	16×7	6	19.9	66.8	377.2	100.0
	14×5	6	20.2	68.3	396.3	105.0
	12×4	6	23.0	65.2	414.2	109.8
河北省农业科学研究所 (1957) (4)	9	10		72.8	397.9	100.0
	9	16		60.4	449.3	112.9
	4.5	13		60.9	440.9	110.8
	4.5	19		55.1	451.0	113.3
(5 吉林省白城子农业科学研究所[14] (1958)	(12) 18 (机播双行)	13	16.4	82.6	566.0	100.0
	4.5 (机播单行) (13)	26	29.5	65.0	855.0	151.6

1. Place 2. Hsing-fu Agricultural Cooperative, Ning-ho-hsien, Hopei Province (1953) 3. T'ang-shan Experimental Station, Hopei (1957) 4. Hopei Provincial Institute of Agricultural Sciences (1957) 5. Pai-tzu-ch'eng Institute of Agricultural Sciences, Kirin Province (1958) 6. space between rows x the width of the row (ts'un) 7. Amount planted (chin/mou) 8. Effectual heads (10,000/mou) 9. Number of seeds per head 10. Yield (chin/mou) 11. Increased yield (%) 12. 18 ts'un (double-row, machine planted) 13. 4.5 ts'un (single-row, machine planted)

If the planting method is correct, below a certain density, the plants should be able to receive sufficient light and soil fertility, and field management should not be hampered. In the northern provinces, the space between the rows is often 6 to 8 ts'un. After the establishment of the people's communes, agriculture has been rapidly mechanized, and narrow

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rows 4.5 ts'un apart is more and more becoming the practice. For the convenience of machine cultivation and weeding, sometimes the method of 15 ts'un space with 4 ts'un rows is adopted. A machine can plant 40 to 60 mou a day, and the seeds are deposited very evenly at uniform depth.

(4) Soil Cover and Pressing

In the south, the rainfall is abundant. After the seeds are planted, they are covered with a layer of soil, but the soil is not pressed down. In the north, about 1 ts'un of soil is used to cover the seeds, and a wooden or stone presser is used to roll over the soil once to three times, so that the seeds may adhere to the soil tightly. If the soil is highly moist when the seeds are planted, then, pressing is not suitable.

If the soil cover is too thick, the sprouts may grow too fast and the nutrients of the seeds are used up too fast. The sprouts will become weak after they are above the soil.

According to the studies of Pai-ch'uan Experimental Station of Honan, if the soil cover is 4.5 cm, the sprouting rate is as much as 85%. If the soil cover is 6.6 cm, the sprouting rate is 74%. If the soil cover is 9 cm, the sprouting rate is 51%. Generally, the soil cover should be 3 to 4 cm. If the soil cover is less than 1 cm, the surface soil becomes dry very quickly, and the seeds will not sprout. Therefore, if the soil is sandy or dry, the soil cover may be a little thicker. If the soil is clay or loam, and damp, then, the soil cover should be tinner.

3. APPLICATION OF FERTILIZERS [p 543]

(1) The Amount of Fertilizer

Within a certain limit, the more fertilizer is applied, the better is the yield of the upland rice. In 1956, in Tientsin Special District of Hopei, generally 2,000 to 5,000 chin per mou of fertilizer is used for the initial application. In Pao-ti-hsien, the 75 mou of high yield upland rice fields is applied with 4,000 chin per mou of initial fertilizer, with 10 chin per mou of ammonium sulfate for supplements. The yield is 485 chin per mou. The Pai-ch'eng Special District Institute of Agricultural Sciences of Kirin experimented with

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deep plowing combined with applications of 4,000 chin of silt and manure, with 13 chin of ammonium sulfate per mou. During the various stages of growth, another 33 chin of ammonium sulfate, 260 chin of night soil, and 20 chin each of calcium perphosphate and potassium sulfate were applied. The yield was 800 chin per mou.

Using the presently available varieties, and under the present level of cultivating technique, according to the experience of the various regions, 3,000 to 5,000 chin of silt and manure with 10 chin of ammonium sulfate should be applied in the Northeast for each mou of upland rice. In Hopei, 2,000 to 5,000 chin of stable or pig manure, with 15 to 20 chin of ammonium sulfate as supplements should be sufficient. In Honan, 4,000 to 5,000 chin of miscellaneous fertilizer, with 1,000 to 2,000 chin of night soil or 15 to 20 chin of ammonium sulfate as supplements should bring high yields. The yield may even be improved if there is more fertilizer; the seeds are made to withstand fertilizer better; and the management level is raised.

Nitro-fertilizer should be the primary fertilizer applied, with some phosphorus and potassium. The cultivating method must be in accordance with the climate, the soil, the varieties, and other cultivation methods adopted.

(2) Method of Applying Fertilizer

a. Initial Fertilizer

Generally speaking, about 60 to 80% of all the fertilizer applied is initial fertilizer. The proportion is less for the medium and late maturing varieties. Compost is the best. It should be applied with plowing, so that it may be evenly mixed in the soil. If there is not enough fertilixer, then shallow ditches or holes may be dug for fertilizer application and planting. In some areas, the best effect is obtained, if 20 chin of calcium perphosphate is mixed with the initial fertilizer.

b. Planting Fertilizer

In order to meet the needs of the young sprouts, and the early stages of growth, a fine well-decomposed fertilizer may be applied directly in the holes where the seeds are being planted. Chemical fertilizer or grass ashes may also

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be used for this purpose. The method of mixing a small amount of fertilizer with the seeds has been tried in Honan and Kiangsi, and very good results have been obtained.

(3) Supplementary Fertilizer

Supplementary fertilizer generally amounts to about 20 to 40% of the total applied. Quick acting organic fertilizer, night soil, or such chemical fertilizer as ammonium sulfate are generally used. The amount and the time of application vary with the climate, soil, and the growth condition of the seedlings. The early varieties are generally fertilized with supplementary fertilizer once or twice at the tillering time and the node growth time. The medium ripening varieties are fertilized three times, at the time of tillering, node growth, and head evolvement. According to Hopei Provincial Institute of Agricultural Sciences, supplementary fertilizer is best applied when the young heads are being formed. However, in case of the early varieties, if the soil is thin, supplementary fertilizer should be applied early. In North China, the supplementary fertilizer is applied by pouring it into the soil about 2 ts'un from the seedlings. The application is often done when there is no dew on the leaves of the seedlings. After the application, the cultivation begins, so that the fertilizer may be mixed with the soil. If the fertilizer application and the cultivation are both done after a rain, the result is better.

4. FIELD CONTROL [p 544]

(1) Before Sprouting

a. Eliminate the Weeds

Weeds affect the young sprouts a great deal. If there are too many weeds, then the planting should be delayed so that the weeds will grow a little bigger before the field is prepared. According to the experience of the Comprehensive Experimental Station of Kirin, if the weeds are eliminated on the 15th of May before planting, compared with planting on the 5th of May without weeding, there are 41% less weeds. In Kwangtung, wild-grown rice (ghost grains) is often mixed with the upland rice plants. If the soil is plowed early

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to encourage the wild-grown rice plants to grow quickly, then, they may be raked and eliminated, the yield of the upland rice may be greatly improved.

b. Prevention and Elimination of Insects in the Soil

Such insects as Lema flvipes and Gryllotalpa alfricana reside under the soil, and they may harm the young sprouts and seedlings. Drugs may be used to kill them.

Two to three chin of 666 powder may be mixed in 6% solution and 50 chin of soil to apply to one mou of the field before the rice seeds are planted. This must is effective as well as lasting.

In areas where damage from Gryllotalpa alfricana is serious, then 2 liang of arsenic or 3 liang of sodium silicafluoride per mou may be used a bait. These drugs are mixed with cakes of fertilizer or grain, and scattered in the field at night. Or, 2 chin of 666 powder may be mixed with 100 chin of half cooked millet, and the mixture may be dried in the sun to about 70% dry. Then, 3 to 4 chin per mou of this mixture may be mixed with the seeds at the planting time.

c. "Hug" the Sprouts

Sometimes, due to too much rain or too thick soil cover, the soil surface may become too hard for the young sprouts. In the north, when the spouts are about 20 to 30% above the soil, a small-toothed rake is often used to pick off a thin layer of soil to get rid of the weeds as well as to loosen the soil.

(2) During the Seedling Stage

After all the sprouts are above the ground, the following measures are important:

a. Inspection:

The sprouts should be inspected to see if any are missing. Supplements must be made immediately. Seedlings may be transplanted after a rain, or the soil may be irrigated before the supplements are planted. The newly added seedlings should be watered frequently to encourage rapid growth.

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b. Cultivation and Weeding:

Timely cultivation and weeding may loosen the soil for more ventilation, raise the soil temperature, and preserve soil moisture, so as to create better conditions for the growth of the rice plants. The first cultivation and weeding should be done when the seedlings are three ts'un tall. The second cultivation should be done 10 days later. Then, there should be a third or a third and a fourth after two weeks. Aside from the hand rakes and cultivators, the five-toothed or seven-toothed cultivating machines may also be used to improve efficiency. During the early stage, cultivation should be done very carefully so as not to crush the young seedlings. Later, while cultivating, effort should be made to pile soil around the plants so as to control ineffectual tillering, and to prevent the plants from falling.

The saline soils of the north must be cultivated more often to keep the salts from rising to the surface. According to Chi-wei Irrigation Management Bureau of Honan, the soil of Yen-chin-hsien contains 0.127% of salts in the 0-20 cm layer, and 0.31% of chloride; the 20-50 cm layer contains 0.98% of salts and 0.22% of chloride (Table 1908). If the soil is cultivated after a rain, the surface salts may be effectively reduced.

Table 19-8 The Effect of Frequent Cultivation After Rain or Irrigation on the Saline Content of the Soil

土层 (厘米) 2 / 中耕时期(月/日) 1	0—20		20—50	
	全盐量 3	氯根 4	全盐量 3	氯根 4
4/1 (灌前)	1.27	0.31	0.98	0.22
4/9	0.39	0.01	0.95	0.04
6/29	0.40	0.01	0.56	0.04
7/21	0.46	0.02	0.98	0.03
8/11	0.46	0.01	0.68	0.03
9/18	0.24	0.02	0.49	0.02

1. Soil layer (cm) 2. Cultivation time (month/day)
3. Salts 4. Chloride

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c. The Prevention of Insections and Diseases

The soil must be inspected for insects and the plants be inspected for diseases. The drugs and poisons may be applied again. Or horse manure may be piled and scattered in the field to attract the insects. If the soil is extremely acid or alkali, the plants may be affected by the disease of yellow blight due to lack of manganese of the soil. The plants may be sprayed with a ferromanganese fertilizer, and more compost and manure should be applied.

(3) Field Management During the Later Stages

Aside from the early measures, fertilizer application during the head development stage and watering may increase the number of seeds and the weight of the seeds. Fertilizer application must be timely and in proper amounts. During the later stages of growth, the field should still be inspected for insects and diseases, and proper and timely measures should be taken if any is discovered so as to insure a high yield.

5. IRRIGATION [p 547]

Although compared with the paddy rice, the upland rice is more drought resistant, it is not as drought resistant as the other dry crops. It is more drought resistant during the early stages of growth. After the head evolvement time if there is a drought, and the soil becomes dry, then, the yield will be seriously reduced. As we have mentioned before, the yield of the upland rice increases with the soil moisture content. The rainfall during the growing period of the upland rice is fairly sufficient in the various areas, but it is not distributed evenly;therefore, a reduction in yield due to drought may easily occur.

In 1955, there was a bad drought in Wu-ch'uan-hsien, Kwangtung, the upland rice was irrigated five times during its growth period to keep the soil constantly moist, and the average yield was 618 chin per mou, an increase of 47% over the yield of the year before.

In the First Agricultural Cooperative of Hsi-hsien,

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Honan, the field that was irrigated during the head development stage produced 480 chin per mou, 35% above the field that was not irrigated.

Pai-ch'eng Special District of Kirin is in an arid region. The year s average rainfall is only 300 mm. From 1958 to 1959, Pai-ch'eng Special District Institute of Agricultural Sciences cultivated upland rice on irrigated fields, and the yield was about 800 chin per mou.

The irrigation method for upland rice varies with the rainfall. According to Hui-ch'eng Experiemental Station of Shantung, the soil should be maintained at 70 to 80% of saturation, and the total amount of water needed is about 556 c.m, of which 238.7 c.m of water is from irrigation (over and above the rainfall.)

According to Pai-ch'eng Special District Experimental Station of Kirin, when the rainfall was 227 mm, the irrigation water used was 319.3 c.m per mou.

As far as the upland rice is concered, the need for water is most urgent at about 20 days before heading time. The soil moisture content at that time has great effect on yield. Of course, in areas where spring drought is frequent, the field should be irrigated early also.

The source and the quality of irrigation water are very important. If well water is used, we must also pay attention to the water temperature. If the water contains a great deal (as much as 0.1%) of sodium chloride, it should not be used to irrigate upland rice.

6. MULTIPLE PLANTING AND INTERPLANTING [p 547]

In order to make maximum use of land and growing season, the method of repeated and mixed planting is often used. In North China, during the recent years, upland rice is often used to grow repeated crops with wheat, barley, potatoes, Pisum sativa, and corn. If upland rice is planted after the summer crop, as a rule, more than 200 chin per mou of rice may be obtained; sometimes, as much as 500 chin per mou. The growing season is, by then, quickly coming to a close; therefore, with this method, the early ripening

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varieties should be used in order to obtain maximum yield. If upland rice is to be planted in the potato field, or wheat field, it is usually planted in the space between the rows (20 ts'un) in the end of May or the beginning of June before the potatoes and wheat are ready for harvest. According to the information of Tientsin Special Bureau, planting upland rice in the potato field is the best, because it is well ventilated, with high soil temperature. Planting is easy, and the yield may reach 700 chin per mou. If planted in the wheat field, the yield is about 330 chin per mou. In Szechwan, the general practice is to plant upland rice in the space between the rows of oil cabbage. After the harvest of the oil cabbage, a row of corn is planted in every seven rows of upland rice. Sometimes, instead of corn, sweet potatoes may be planted in the same manner. In some cases, after the upland rice is harvested, another crop of rice is planted again to form three harvests. In northern Kwangtung, sometimes upland rice is planted in alternate rows with watermelon. This method may reduce insect damage of the watermelon.

7. CROP ROTATION [p 548]

Practice proved that growing upland rice year after year is not good for the soil. The weeds begin to multiply; so do the insects and plant diseases. And the yield of the upland rice will drop. In Lo-p'ing-hsien, Kiangsi, a field was planted with upland rice for three years consecutively. The yield of the first year was 350 chin per mou; that of the second year was 300 chin, and that of the third year was 180 chin, a 49% drop of the first.

Crop rotation is a good method for nurturing soil fertility, saving fertilizer, improving soil structure, reducing weeds, preventing insects and diseases, and raising the yield of the rice crop. In the rice growing areas of our country, the major crop rotation systems of the upland rice take the forms of one, two, or five year cycles.

One year crop rotation system:

a. upland rice → forage legumes (Astragalus sinicus, Shao-tzu)
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b. Upland rice → turnip
(oil cabbage)
Practiced in Kiangsi

c. Upland rice → wheat
(beans)
Practiced in Hopei, Shantung

d. Upland rice → wheat
(barley, oil cabbage, lima beans)
Practiced in Honan

e. Wheat → Upland rice → celery cabbage
(three harvests)
Practiced in Honan

Two-Year Crop Rotation System:

	First Year	Second Year
a.	Upland rice → sweet potatoes;	Peanuts (flax) → sweet potatoes Practiced in Kwangtung
b.	Upland rice → soybean;	Dioscorea japonica Practieed in Kwangtung
c.	Upland rice → sweet potatoes;	Upland rice → Eleusine corcana Practiced in Hunan
d.	Fallow → sweet potatoes;	Tobacco → upland rice Practiced in Kweichow
e.	Upland rice	Corn (kaoliang, sweet potatoes, peanuts) Practiced in Hopei

Three-Year Crop Rotation System:

	First Year	Second Year	Third Year
a.	Upland rice	Soybean (Colocassia antiquorum) Practiced in Yunnan	Corn
b.	Corn → wheat	Tobacco Practiced in Kweichow	Upland rice

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c. Upland rice	Soybean	Corn (kaoliang, mixed corn and soybean)	
		Practiced in Liaoning, Kirin	
d. Upland rice	Corn (kaoliang)	Soybean	
		Practiced in the Northeast	

Four-Year Crop Rotation System:

First Year	Second Year	Third Year	Fourth Year
Upland rice	Soybean	Corn (kaoliang, corn, soybean)	Kaoliang(corn, or mixed corn and soybean)
		practiced in the Northeast	

Five_Year Crop Rotation System:

First Year	Second Year	Third Year	Fourth Year	Fifth Year
Upland rice	Soybean	Kaoliang (corn)	Corn (Kaoliang)	Soybean
		Practiced in the Northeast		

As a previous crop for upland rice, soybean, peanuts, oil cabbage, Pisum sativa, and turnip are the best; sweet potatoes, wheat, kaoliang, and corn are the next best; millet and Eleusine corcana are the worst. When a rotation system is being designed, attention should be given to the problems of soil fertility, insects, and diseases. Crops of the Leguminosae family, such as soybean and peanuts are good for nurturing soil fertility. Crops requiring deep plowing, such as turnip, are good for improving soil structure. Broadleafed crops, such as Setaria virdis and Phaseolus var. radiatus, or crops that require cultivation are good for eliminating weeds. Tuber type crops, such as potatoes, when rotated with upland rice may help eliminate the diseases and insects for one another. In the south, Dioscorea japonica is used to rotate with upland rice so as to adjust labor for field preparation. If a field is always bothered with weeds, then, it is not suitable for upland rice. Crops that absorb a great deal of fertilizer, such as barley and wheat, are not suitable for rotation with upland rice.

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8. TRANSPLANTING [p 549]

In the north, in the wheat field, or in the lowlands, transplanting method is sometimes used to cultivate upland rice. It is usually planted in the middle or later part of April, in the same manner as the paddy rice. The seedlings are left to grow in the seed beds for 40 to 50 days, until there are five leaves. A thin ammonium sulfate solution is applied a few days before transplantation to insure a high survival rate for the seedlings.

The seedlings are transplanted in the early part of June, on a cloudy day with temperatures about 18°C. The work is usually done early in the morning or at dusk to avoid high temperature which may harm the seedlings. The plants are watered immediately after being transplanted. The field is prepared first, with the initial fertilizer applied. The space between the rows is about 6 to 7 ts'un, and the space between the groups is about 4 to 5 ts'un. The seedlings are planted about 1.5 to 2 ts'un deep, and mud is pushed to cover the roots. After they are planted, they are watered once a day for three days. Then once every other day for another three days, to help the seedlings to become green again. Sometimes, a round stick about 4 cm in diameter, is used to poke a hole for fertilizer application, transplanting, and watering. Then soil is used to cover the seedlings. After transplanting, the field management is the same as direct planting.

Moreover, the seeds of upland rice may also be planted into the space between the rows in the wheat field before the wheat is harvested. At the time of the wheat harvest, the rice plants are generally several ts'un high. After the wheat harvest, the rice seedlings are moved over to the wheat rows on a rainy day, or after the soil has been irrigated. The masses believe that when the transplanting method is used, the land utilization rate is higher, and the spring drought may be avoided. Besides , they also believe that there are less weeds when this method of planting is adopted.

9. HARVESTING [p 550]

The upland rice is ripe about 30 to 40 days after

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it comes to a head. The ripening time may vary with the area, the variety, and the temperature. In the south, when the upland rice is ripening, the temperature is high; then, the ripening stage is shorter. Generally, when the leaves turn yellow, the tip of the head is yellow, and not a single green seed may be found in the head, except very few green seeds in the lower part of the stalk; then the crop should be harvested immediately. If harvest is too early, some seeds may still be green, and the quality of the harvest will suffer. If the crop is harvested too late, the seeds may be blown off by the wind, and the harvest will suffer too. In Kwangtung, the harvest is generally in the early part of June; in the early part of September in Yunnan, and the latter part of July or the early part of October in some cases; in North China and the Northeast, it is from the middle of September to the early part of October.

Harvest is best done in the morning before the dew dries. The portion of seeds which are kept for next planting should contain less than 13% (south) or 14% of moisture. Especially in the Northeast, if the temperature is low during the harvest time, the seeds should be sunned in time. After they have been dried properly in the sun, they should be kept in a place that is high, dry, cool, well ventilated, and not directly exposed to sunlight.

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CHAPTER 20. SPECIAL CULTIVATION OF PADDY RICE

[p 553]

SECTION 4. TRIPLE SEASON RICE [p 568]

Triple-seasoned rice culture in our country is distributed primarily in Hai-nan-tao. It is located in the tropical zone, with high temperature and plenty of rainfall. The coldest month of January has a temperature above 18°C. Frost is often not seen all year long, and rice plants can grow anytime. Ya-lin Kung-she of Ya-hsien has had over 60 years of history of cultivating triple-seasoned rice. Areas of Wan-ning and Ling-shui have also cultivated triple-seasoned rice for more than 30 years. Recently, in order to raise the index for repeated crops and land utilization rate, triple-seasoned rice culture is being introduced to other areas of high temperature and sufficient water supply.

1. SEASONAL ARRANGEMENT AND COMBINATION OF VARIETIES [p 568]

The first key to high yield in triple-seasoned rice culture is a reasonable arrangement of the seasons. In the plain areas of Hai-nan-tao, the temperature may satisfy the needs of the rice plants all year long. After the early part of March, the daily average temperature rises steadily to about 20°C. After the later part of October, the daily average temperature drops to a possible below 20°C. Therefore, to be safe, the early crop of rice must come to a head after the early part of March, and the late crop must come to a head before the end of October. Among the varieties currently used, the early crop usually grows in the paddy from 100 to 120 days; the middle crop 85 to 90 days; and the late crop more than 100 days. Therefore, the early rice must be transplanted from the middle to the later part of December,

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and harvested in the later part of April. The middle crop must be transplanted in the early part of May and harvested in the early part of August. The late rice must be planted in the early part of August, and harvested in the middle to later part of November.

All the varieties used in the triple-seasoned rice culture must be high yield ones. The early varieties must be able to withstand low temperature. At present, in the eastern and the western part of the island, there are P'eng-lai-chung type of keng subspecies, which are the varieties of Chia-nan No.2, Kao-hsiung No.10, and others. The old local varieties of Lien-chou-tzu and Ku-heng cannot withstand too much fertilizer, and therefore, do not have potential for high yield. In the south, in such areas as Ya-hsien, Ling-shui, and Kan-en, there are, besides the P'eng-lai-chung type, Taiwan Pai, Pai-mi-fen, Kuang-ch'ang No.13, and Lu-yu 132.

The middle crop requires the varieties to have resistance to high temperature, and the growth period must be steadily within 85 days. The shortage of this type of varieties is the weak link of the triple-seasoned rice culture of this island. Such varieties as Wan-ning-hsien 60-Days, and Hsin-lai-pai have to grow 90 days in the paddy. Kuang-ch'ang No13 is suitable for Tung-fang-hsien, but when planted in other areas, the growth period is more than 90 days. At present, the most hopeful varieties are the newly introduced Nan-t'e No.16 and Ai-chiao Nan-t'e.

The late crop requires the varieties to be sensitive to light exposure. They should be able to withstand the wind, and should be fall resistant, and must have a growing period of more than 100 days. Among the current varieties T'ang-p'u-ai is the best. Wan-pai-chan No.3 is the most popular. Besides, in the eastern part of the island, there is also Chiu-chan, but its yield is not high.

2. SEVERAL PROBLEMS IN CULTIVATION OF TRIPLE SEASON RICE [p 569]

(1) The Problem of Low Temperature during the Growing Period of the Early Crop

Although Hai-nan-tao is in the tropic zone, it

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is often affected by the cold waves of the continent in the early spring, and the temperature may drop suddenly. According to the weather information of Hai-k'ou-shih from 1951 to 1960, the temperature dropped seven times from the 26th of March to the 5th of April, and the daily average temperature reached the level below 20°C. In 1953, the temperature of the 1st of April averaged only 16°C. This kind of temperature may be dangerous for the fertilization of the early rice crop. According to survey, the low temperature had once caused the rate of empty hulls in Liang-hai-hsien to be 20 to 30%. Since from the early part of March to the end of that month, the temperature regularly stays at 20°C, if the early crop may come to a head during this period of time, yield should be more assured. To solve this problem, we must select suitable varieties and emphasize field management. The seedlings should be transplanted as soon as it is warm. A water level should be kept before and through the cold wave, and fertilizer should be applied after the cold wave, so that the seedlings will be strong enough to resist low temperature, and will come to a head on time.

(2) The High Temperature during the Growing Period of the Middle Crop, and the Problem of Insects and Diseases

According to surveys, the major rice field insects such as the leaf bugs, the stalk borers, and the weevils have all caused serious damage before. All field insects should be eliminated during the growing period of the early crop, so that they may not become more serious a problem for the middle and the late crops.

(3) The Problem of Typhoons during the Blooming and Ripening Stages of the Late Crop

The late varieties, the local ones or the newly introduced ones, especially T'ang-p'u-ai and Teng-ch'iu No.5, must bloom and seed in the early or middle parts of October, while September and October is the typhoon season in Hai-nan-tao. The seeds of most of the varieties will fall in a typhoon. This is a problem which we must solve through scientific studies of the various varieties.

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CHAPTER 23. MECHANIZATION OF PADDY RICE CULTIVATION [p 633]

Since the liberation, the farmers and the farm tool research agencies of our country have improved and created many tools which are suitable for the rice paddies. In this chapter, we shall discuss mainly the types and the characteristics of the many major mechanized and semi-mechanized tools being used for production in the rice paddies, with a description of our achievements and experience in the subject of mechanization, and the direction of its future development.

SECTION 1. MECHANIZED POWER [p 633]

Tractors fueled with gasoline and diesel oil and the internal-combustion engine are the most common machines used in the farms of our country. Besides, charcoal, firewood, and coal are also used in some instances as fuel for the motive power. In rice culture, the work of irrigation and drainage, and milling and processing of the grain are usually done by electric power in the areas where electricity is available. In the future, as the electric capstan /rope propeller/ is further improved, electric power will be used more and more in rice production.

1. TRACTOR [p 633]

The best advantage of the tractor is its mobility and its wide applicability. It may be used to pull the plow, the rake, the planter, and the harvester, or it may be used as the motive power for the pump and the milling machine. The ordinary tractors are fueled with gasoline or diesel oil, but some are fueled with charcoal and

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firewood also.

Tractors are usually designed for dry land. They may skid, sink, and have difficulty in turning around if they are operated in the rice paddy. Certain conversion is necessary. After years of research, this conversion problem has be more or less solved, and the converted tractors have been used in production practice.

The following are the important aspects concerning the conversion problem of the tractor.

(1) The moving parts must be such that the tractor can move around in a paddy, be the motive power for deep,wet plowing, and provide transportation between the paddies.

(2) With regard to weight and efficiency, any tractor of 25 to 40 horsepower with an effective power of 50 to 60 kg per horsepower may be effectively used in a rice paddy. As long as the efficiency is sufficient, the tractor should be as light as possible so that there may be less trouble from slipping and sinking.

(3) The tractor must be highly movable so as to be suitable for the small rice paddies, and it must be equipped with a hydraulic lift.

(4) The weight of the tractor must be distributed properly so that the back wheels will not sink in the mud. The parts of the engine must be tightly sealed and the body of the tractor must be at least 40 cm above the ground.

In the past the conversion studies concentrated on the problems of the moving parts and the protection from water and mud. At present, on the basis of the successfully converted models, new models are currently being engineered and tested.

(1) The Wheel Styled Tractors

This is the most widely used type at present. According to the experience in the south, the models Feng-shou No.35 and Feng-shou No.27 are very suitable for the paddies. Each of the tractors of these two models can take care of

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700 to 1,000 mou. Aside from field work, they are also useful to provide transportation and do such work as irrigating, draining and milling.

To be used in the rice paddies, iron wheels must be placed on the wheel styled tractors. The cogged style and the lugged style of Kiangsi Province are the more popular ones at present. Generally speaking, if the plowing layer is not so deep, and if the plow sole is rather hard, then the cog-wheeled tractor is quite efficient. It moves around steadily, with very little friction. However, it has the disadvantage of leaving deep tracks.

The lug-wheeled tractor has very good traction, and can work in paddies with a soft and deep plowing layer. Mud does not accumulate on the wheels and they do not leave deep tracks. The traction (that means the largest tractive effort as a percentage of the working weight of the tractor) is generally a little more than 50%. The tractive efficiency (that means the largest traction as a percentage of the engine efficiency) is generally about 50%, with some as high as 68%. Its disadvantage is the tremendous vibration on the road, and at the same time, the lugs are also found to be bad for the plow sole.

After these iron wheels are placed on the tractors, their usefulness in the rice paddies is found to vary with the soil condition of the paddy. According to actual experience, the currently available ones are useful when the plowing layer is less than 6 ts'un. If the plowing layer is as deep as 8 ts'un, then the economical efficiency of the tractor drops sharply. They cannot work in the paddies which are called Ou-tien, that is the paddy which has no obvious plow sole. Therefore, further improvement is needed before the wheeled tractors are useful for the rice paddies with deep plowing layer.

In order to raise the efficiency of the tractor (the percentage of pure working hours in the total working hours), the paddies should be made longer. It has been calculated that for every turn it makes, the tractor runs 20 to 30 seconds withouth working. In a paddy of less three mou, the pure working period amounts to only about 50%. If the paddy is made 150 to 200 m in length, and a width of about 10 mou, then, the efficiency of the tractor may be more than

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doubled.

Although at present the wheeled tractors are still not completely adapted to work in the rice paddies, they are useful in most of the rice growing areas. With regard to labor efficiency and the quality of work, the tractors are far superior to animal power.

(2) Caterpillar Tractors

In the north, the large state-operated farms do all the field preparation work when the paddy is dry, and they use caterpillar tractors for most of the work. The primary model is Tung-fang-hung No.54.

In the south, Tung-fang-hung No.54 and K'o-te No.35 are adapted to work in the paddy. These tractors can do the basic field preparation work such as plowing before the seedlings are transplanted.

When the caterpillar tractors are put to work in the paddies, the moving parts must be sealed against mud, and a shield must be attached to the caterpillar tread to prevent skidding and to increase adhesion.

Compared with the wheeled styled tractors, the caterpillar tractor has the following advantages:

a. It is adaptable to the various types of soils.

It has been used in the sandy soil of the Pearl River Delta of Kwangtung (there are some clay paddies in the delta.); with the plowing layer as deep as 30 cm sometimes, the caterpillar tractor has proved to be able to perform the work, while the wheeled styled tractors cannot.

b. It has large tractive efficiency and is able to do deep plowing.

c. If it is used in large paddies, the labor efficiency is higher.

The largest disadvantage of the caterpillar tractor is the fact that the caterpillar treads and the axles are easily broken when the tractor is used in a paddy. According to the experience of Chung-shan-hsien, Kwangtung, the

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repair cost was very high even for the tractor to work for one hour in a paddy. It becomes impracticable to use it for any prolonged period of time. Besides, a wider space must be kept for the tractor to move about, and as it turns around the ground surface is seriously disturbed. Before it can be widely adopted for use in the rice paddies, it must be made considerably lighter, with less friction in its moving parts, and able to perform more varied forms of work.

(3) Small Single-Cylinder Tractor

A single-cylinder tractor of three to ten horsepower(it was called a cultivator in the past, or a garden tractor) is small and inexpensive. It is very suitable for the work of cultivating and weeding in the sugar cane field, the orchard, and the vegetable garden. Besides, it may also be used to pump water, to remove husks, or to spray. According to its use in Tzu-ch'i-hsien, Chekiang, if a seven horsepower, diesel powered single-cylinder tractor is used to plow, it may finish the field preparation work of 10 mou in 8 hours. Thus, the diesel oil consumed amounts to 1.23 kg per mou, and the productivity is no worse than the wheeled large tractor. Its utilization rate may be as high as 95%, because it is less affected by the small size of the field.

The largest disadvantage of a small single-cylinder tractor is the fact that the plowing can only be about 4 ts'un deep. The labor efficiency is low, and the work is harder for the farmer. Therefore, it is not suitable as the major machine in our country's rice growing paddies. It may very well be adopted as a supplementary machine , and with some improvement, it may also be used in the terraced fields.

2. CABLE DRAWN FARM EQUIPMENT [p 636]

The capstan is a machine used by our laboring masses three hundred years ago. However, its productivity is rather limited if it is to be propelled manually or by animals. Therefore, in the current tool reform movement, scientists everywhere are studying various froms of motive power for the capstan.

The mechanized capstan has obvious advantages with respect to the development of automation and economical

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utilization. This fact is demonstrated concretely in the following aspects:

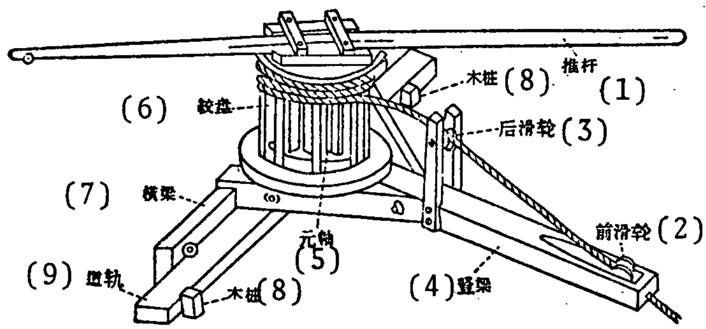
(1) Due to the fact that the capstan is not placed in the paddy, its use is not limited by the soil condition. It may be used for dry fields, and soft or hard paddies alike.

(2) It may propel various types of farm tools to perform the work of planting, transplanting, and others without destroying the leveled state of the paddy.

(3) It will not destroy the plow sole as the tractors do.

(4) When it is used to perform work in the paddy, its efficiency is higher than that of the tractors, usually above 75%.

Figure 23-1 The Capstan



1. capstan bar 2. the front pulley 3. the back pulley 4. the vertical beam 5. the round axle 6. the spindle or barrel 7. the crosswise beam 8. wooden peg 9. the track

In 1959, many types of mechanized capstans were created in the various areas of this country. Wherever there is electricity, the capstan was driven by electric power; wherever there is no electricity, internal-combustion engines are used to propel the capstans. At present, the more popular models in use may be divided into three types:

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(1) The stationary, single-engined, four-point propelled capstan:

This type may be represented by the improved 58-2, which may be converted for electric or mechanical power, and is called the South 41102 model.
(Note: these capstans may be divided in accordance with the number of stationary pulleys which are placed on the corners of the paddy, into three-point propelled, or four-point (or four-corner) propelled styles. There are also two-point propelled capstans, the cable of which is the shortest.

(2) Semi-automatic moving, four-point capstan:

This type may be represented by Chiang-tung-2 of Nanking and Che-nung-3 models.

(3) The automatically moving type:

This type may again be divided into the single-engined and the double-engined.

The automatically moving, single-engined, two-point propelled type may be represented by the 59-10 model of Shanghai and the 59-4 model of Fukien. The automatically moving, two-engined, two-point propelled type may be represented by the 58-4 model of Nan-p'ing, Fukien.

These capstans may be used to perform such work as plowing, raking, planting, and transplanting. After several years of study, the work they perform is becoming more and more dependable. To be able to use them, the small fields or paddies should be 120 m long and 25 m wide. The paddies or field should be arranged in a row, with a road and electric cable on the short side of the field, so as to save the time spent on transfer of equipment from one field to another.

At present, with the improved models, the stationary platform is no longer needed. The machine can rest by itself, or it is a movable style. The semi-automatic, and the automatically movable styles are improved to the extent that they no longer requre a considerable time and energy to transfer from point to point.

At present, the major disadvantage of the capstans

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is the fact that its transfer is still a time consuming job. With the road uneven, and the existence of the various high and low dikes, the small engine is not sufficient to take on any transport jobs. When used over a large area, its efficiency cannot match that of the tractors.

3. STATIONARY POWER MACHINE [p 638]

Aside from the tractors and the capstans, the motorized machines currently used in rice production also include the stationary machines such as electric motors, the steam boilers, and the various forms of internal-combustion engines, which are used to pump the water, to remove the husks, and to mill the rice.

(1) Electric Motors

The electric motors are used primarily for irrigation and drainage. Then, they are also used to a certain extent in the rice processing work. They are dependable, easy to operate, and inexpensive to maintain. Their efficiency is low in the processing work, but in the irrigation stations, they are very efficient.

The electric powered motors made in our country are in various styles. The irrigation stations often use the small ones of less than 100 kw. There are also some between 100 and 300 kw. These are J, JS, JC, or JR series. The larger ones over 300 kw are usually the JSQ series (the Q represents the heavier insulators). The JO series (which is the sealed watertight type) should be used, when the work requires the machine to be in constant contact with water. The electric motor which propels the capstan is usually less than 10 kw, and the JS, or the JC series are very suitable.

(2) The Steam Engine

The technique of utilizing the steam is very simple, and the machine is sturdy and long lasting. It may be operated by the inexpensive fuels such as coal, firewood, straw, and husks. Its disadvantage is the fact that it requires a great deal of metals, and is very heavy. It is not easily moved, and its heat efficiency is low. To operate

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it consumes 1.5 to 3.5 kg of coal per horsepower hour. The steam engines made in this country are usually 5 to 300 horsepower models, and are usually used for irrigation and rice processing work.

(3) Internal-combustion Engines

The fuels used in the internal-combustion engines are gas, diesel oil, and gasoline.

If gas is used, the fuel may be obtained locally. For each horsepower hour, it consumes half a kg to one kg of smokeless coal or charcoal, or one and half to three kg of firewood. Husks and other fuels may also be used. In some instances, natural gas or marsh gas may also be utilized. The disadvantage is the maintenance and repair. A different firebox must be used for the different fuels. Recently a brick and porcelain firebox is being built in the farm villages. This is a great creation of the masses, because it means a large saving of steel for the state. The gas engines made in this country have many specifications varying from 3.5 to 135 horsepower.

The diesel engine is an internal-combustion engine using using very inexpensive fuel. It may be used for the stationary motive power of irrigation and draining work, and for propelling the capstans or the single- cylinder tractors. There is no need of accessory equipment. It is easily moved about, and the heat efficiency is high. For each horsepower hour, it consumes 0.18 to 0.25 kg of diesel oil. High level skill is required to repair the diesel engine. The ones made in this country now have standardized parts, so that the more than 20 different models of farm machinery from five to three hundred horsepower may have interchangeable parts.

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SECTION 2. FIELD PREPARATION MACHINERY [p 639]

The field preparation work may be divided into the two steps of plowing and leveling. At present, for the paddy the same mechanized plow is used as the dry field. This is really not the ideal practice, but the work quality is not too bad.

1. PLOWING MACHINERY [p 639]

(1) The Animal-pulled Plows

In the past the old plow broke easily when used in the rice paddy. The new ones have been designed on the basis of the advantages of the old. With improvement, the new ones, however, have reduced friction, so that plowing may be done deeper, and the work quality is made more stable. The new ones may be represented by Hua-tung 15 paddy plow, Kiangsi Paddy Plow, and Kwangtung-51 Plow. They may be used to plow as deep as 17 to 20 cm, with more than 100 kg of pull. With one ox, three to four mou of paddy may be plowed in one day. Many provinces (regions) have their own designed and manufactured paddy plows using animal power.

In March of 1959, the Ministry of Agriculture and the First Ministry of Industrial Machinery called a national conference on deep plowing tools. Eleven different types of deep plowing plow using animal power were recommend in the conference.

To use it for deeper plowing, the plow may be adjusted in three methods:

a. Using the double plowing method

The Hunan-55 Paddy Plow and the deep plowing shovel may be pulled by an animal each.

b. The share may be made narrower, and the landside

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longer, and only one animal is needed.

c. Add an additional center plow or shovel, and use to animals. Plowing may thus be done as deep as 30 cm. In the rice paddies, the major animal power is the water buffalo and the ox. For continuous work, a water buffalo may pull about 110 kg, and on ox about 80 kg.

The double bottom plow may be used for dry plowing in the rice paddies. It makes a flat furrow and covers the soil well. After some adjustments, it is just as efficient in the paddy. The remodeled types are currently adopted on a large scale in Chekiang. The remodeling is mainly for preventing the mud from clinging to the moldboard, and to reduce the pulling resistance. With two oxen and a double bottom plow, seven to eight mou of paddy may be plowed in one day. If the soil resistance is minor, then one ox is sufficient. If one plow blade is removed, and one center shovel is added, then deep plowing may be performed with this plow.

(2) The Caterpillar-pulled Plow

The state-operated farms of the north use the LS-5-35 Model five bottom plow for dry plowing of the rice paddies. The plow used in the double-seasoned rice culture regions of the south may be used for both dry and wet plowing. The plows pulled by the caterpillar tractor may be divided into three major types:

a. The three bottom plow with 30 cm wide shares and similar sized four bottom plow are pulled by Tung-fang-hung-54 or K'o-te-35. They may plow to a depth of 20 to 25 cm. The productivity of each shift is about 70 mou. However, they do not plow deep enough for the fall and winter; therefore, some farms exchange the plows from one season to the next.

b. The rack of the aforementioned plows may be used with disks to turn the straw under to be used as fertilizer. In this manner, the straw will not interfere with the action of the shares. Of course, if the straw is laid flat on the ground facing one direction, the multi-bottom plow may be used to turn it under also, but this method is not as convenient as the disk.

(3) The Wheeled Tractor Plow

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Currently plows may be hung on the wheeled tractor with a hydraulic lift to do dry or wet plowing. The plow thus used is generally the five bottom plow. (Figure 23-4) The shares are generally the same as those used on the double bottom plow, but this plow plows the soil fine and thorough, and it also raises the productivity of the tractor. Each shift can take care of 40 to 60 mou. However, these small but numerous shares have their limitations also. They do not plow deeper than 16 cm. The plow is not strong enough to plow any deeper. When a paddy full of forage legumes is to be plowed and turned, and the plowing level is to be deepened every year, this five bottom plow is gradually found to be insufficient.

The three bottom plow with shares about 20 cm wide, and pulled by a wheeled tractor of more than 30 horsepower will actually plow a furrow over 1 m wide, and as deep as 20 cm. It is not easily stopped by the forage legumes. When this is combined with a paddy rake, each shift may accomplish 40 to 60 mou. However, for the regions requiring good sunning, this plow plows too wide a furrow.

The paddy disk designed by Hua-nan College of Agriculture is very efficient, especially when it is used in the paddy where the stubble is turned over as fertilizer.

The plowing resistance of a paddy is less than the dry field. If wet plowing is required, then, the capstan-pulled plow should be used for wet plowing. If a tractor is used for wet plowing, then, wet plowing may not be such an economical procedure. For dry plowing, rubber wheels may be used to cut down resistance; the oil consumption is far less than wet plowing. If the plowing layer is very deep, dry plowing is more suitable. However, if the soil is to be finely broken, then, wet plowing is more suitable.

When pulled by the single-cylinder tractor, a double direction plow is generally used. The work of very small paddies can thus be done very efficiently. It is easier to turn around than the ox-pulled plow. However, the plowing is shallow. The productivity is about double that of the ox.

(4) The Harrow

In parts of the double-seasoned rice growing

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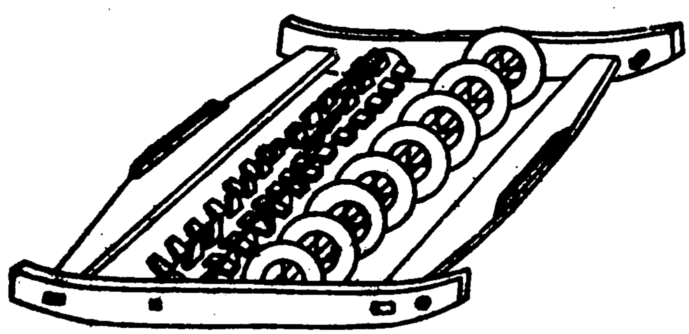
regions, after the harvest of the early crop, the late crop is immediately planted. It is the tradition to use the animal-pulled harrow (Figure 23-3) to work the rice paddy over without draining it first. The harrow is used to turn the stubble over and mix it into the soil, and to make the soil loose. Many farms and stations of the southern provinces designed harrows pulled by mechanized motive power instead of animal, and they are being welcomed by the masses.

Figure 23-2 A Small, Hanging Type Five Bottom Plow

Figure 23-3 Harrow



The harrow currently used in Kiangsi is the wide type. Its major parts are two parallel steel tubes of different sizes in diameter, with round disks on one, and wide

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blades about 10 to 12 cm long on the other. The harrow is hung on a wheeled tractor, and it may reach as deep as 12 cm. It is able to turn the stubble into the 5 to 10 cm layer of soil. The quality of the work is better than the harrow pulled by an animal. According to the experience of Kiangsi, with this harrow, the seedlings of the late crop turn green again faster. The roots reach deeper, and the plants are more drought resistant. There are less weeds. The harvest is three to four days earlier, and the yield is about 10 to 15% higher. If a tractor of about 30 horsepower is used to pull, and the raking is done twice, then, each shift may accomplish 60 to 80 mou, which is about 10 times as many as that pulled by an animal. This type of harrow is also being developed in the Autonomous Region of the Chuang Nationality of Kwangsi.

2. POWERED CRUSHERS [p 642]

(1) The Dry Field Leveling Tools

In the north, the winter plowing and the spring raking of the mechanized rice paddies are worked over with such dry field tools as the disk, the toothed rake, and the drag. They are pulled by the caterpillar tractors. When the disk is used, the plate should be the proper weight with a rather large diameter. In the south, after the harvest of the winter wheat, or a summer dry crop, the paddy should be dry plowed, and if the farm work has been mechanized, a disk should also be used for raking.

(2) The Wet Paddy Leveling Tools

For the wheeled tractor, the currently most popular wet rake is the simple knife rake, which is based upon the original knife rake pulled by animals. The knife rake used with the Feng-shou-27 Model tractor in Kiangsi, is 220 cm wide, with teeth about 19 cm long, forming a 30° angle with the bar. This tool may reach 8 to 11 cm into the soil, and the resistance is about 200 to 400 kg. In Chekiang and Kwangtung, the hanging disk harrow is used, with a rolled around or curved blade. The axle is perpendicular to the direction of the motion; therefore, the resistance is perhaps less than that of the knife rake. The Autonomous Region of the

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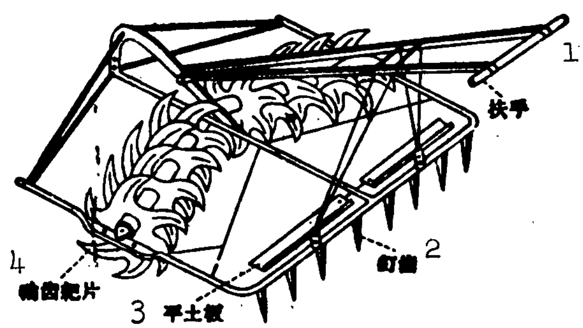
Chuang Nationality of Kwangsi is currently experimenting with a claw-shaped paddy rake, the structure of which is similar to the disk harrow, except that the claw-shaped plates are used instead of the round plates, so that the soil clods may be broken with more force. A rolling pin, or a board is generally attached in the back of the rake to level the soil.

Based upon the rake (the horizontal bar with teeth) pulled by the animal, a same-shaped rake is designed to be pulled by a tractor. This tool can work a width of over 4 m in one operation. However, for a good leveling quality, another tool must be used to drag the soil.

Figure 23-4 A Paddy Rake Pulled by An Animal



1. the handle 2. tooth 3. soil leveling board
4. toothed disks

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SECTION 3. SOWING AND TRANSPLANTING MACHINERY [p 643]

1. PADDY RICE SOWING MACHINERY [p 643]

Generally speaking, the tools which are used for direct planting, may be divided into the two types of dry planting tools and wet planting tools.

(1) Dry Planting Tools

With the dry planting method, the seeds are generally planted in rows. The tools currently being used are are modifications of the original 24-row planter or the animal pulled 10-row planter. The primary modification is an extension of the width and an added depth control to meet the needs of dense planting.

Normally, the modification is done by adding an extra planter in the center, which makes the planting row 4 cm wider. In some areas, such as Po-hai Farm, the round plate is replaced with a shoe-shaped cutter, and 5 cm is added to the planting row. However, with the shoe-shaped cutter, the land leveling must be of very good quality.

A thick iron ring may be attached to the round plate of the planter to control the depth at which the seeds are planted. A depth control device may also be attached to the shoe-shaped cutter.

If the wide-row wheat planter is used to plant rice seeds, the result can also be very satisfactory.

(2) Wet Planting Tools

When the wet planting method is adopted, the land leveling work is easier. Moreover, the frequent summer rains of the south make dry planting very difficult. Therefore, in many areas, the wet planting method is still prefered.

In the south, the wet planter is a modification of

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the row planter. The method is to remove the cutter and other lifting mechanism which is not needed, and retain the seed tube. A cross bar is placed to stabilize the seed tube, and to adjust the distance between the mouth of the tube and the ground surface. The seeds fall from the tube directly onto the ground. This tool may plant 24 rows in one operation, and the space between the rows may be easily adjusted.

The wet planter of P'an-ching Farm of Po-hai District can use the seeds that have been soaked to hasten sprouting, and sunned after soaking. The soil should be irrigated and damp. The width of the row, and the space between the rows should both be 15 cm. Four rows may be planted in one operation, and 20 mou may be planted in one day, about 1.5 times faster than manual planting. There is a cross bar attached to this machine; as the seeds are planted, the cross bar clears out the foot tracks.

Spot planting is a good method. It makes weeding and cultivating easy, and the seedlings may thus develop well. Pao-li designed a simple, manually operated planter for spot planting. It is to be pulled by two people, and when the machine is lifted, it automatically stops the seed depositing action. About 30 to 40 mou may be planted with this planter. The spaces between the rows and the groups are both 18 cm.

The two planters mentioned here are both simply constructed and easy to operate. But neither of them plant enough in a day. Further improvement is awaited for these tools.

2. TRANSPLANTING MACHINERY [p 644]

Transplanting the seedlings is very heavy manual labor, and a highly efficient tool is generally considered impossible to design. Under the direction of the party five different models were selected for consideration at the national conference of transplanting and semi-mechanized farm tools in February of 1960. The following is a brief description of these:

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(1) The General Theory of a Transplanting Machine

Many theories of operation and utilization are being adopted in the many different models of transplanting tools currently being used in our country. The operation process of these tools may be divided into the following: the preparation of the seedlings, the lifting, the delivery, the dividing, and picking, and the transplanting of the seedlings.

The preparation of the seedlings is actually a combination of pulling out the seedlings, washing them, arranging them, and transporting them. At present, the entire process is not mechanized. The study is concentrated in the simplification of the work procedure and the organization of labor, so as to raise the labor efficiency of every step of the process. After the Nan-105 Seedling Box was made, the seedlings are pulled and washed at the seed bed and then immediately put in the box; they are no longer tied into bundles. The work efficiency is raised 1/3.

Lifting the seedlings means putting the seedlings into the seedling box of the transplanting machine. The seedling box of the transplanter should be made replaceable, so that a boxful of seedlings may be placed in the machine to replace the empty one without the machine being stopped. For example Nan-105 model makes use of the original seedling box which is filled with seedlings at the seed bed,and after being transported to the paddy, it is directly placed in the transplanter.

The delivery of the seedlings from the seedling box must be even and continuous. If the delivery depends upon the weight of the seedling, the process is not very dependable. The transplanter designed in Kiangsi in 1959 makes use of a knocking action,and is an obvious improvement. The recently designed friction method makes the process automatic and even. The Lai-yang model of Hunan and the P'ing-yang-model of Chekiang make use of the swinging motion for seedling delivery. Nan-105 model makes use of a rolling pin. The Nan-wei model of Shanghai and the Lung-ching model of Kirin use a belt conveyor, which not only delivers the seedlings evenly, but also holds more seedlings at a time.

Dividing the seedlings is accomplished either with

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a comb method or with a pair of prongs. The comb method has been experimented by the Nanking Institute of Farm tools of Chinae Academy of Agricultural Sciences and found to be applicable.

At present, the straight transplanting method is generally prefered. The rows are straighter, the holes are smaller, and the seedlings are planted more firmly with this method. The rolling method is simpler, and easier for continuous operation. It is more efficient, but the seedlings are usually tilted. The two methods may be combined in such models as the Nan-105 and the Che-nung No.4 transplanter.

Most of the existing designs are manually operated, because the structure is thus simpler, and the machine may thus be used in the small paddies with various types of soil. When the seedlings are being transplanted, the machine does not move, and the space between the rows is controlled by the worker. The disadvantage is the fact that not much is improved in the matter of labor efficiency over manual transplanting. Aside from a few models with an attachment for controlling the distance between the rows, the other models depend upon the skill of the worker.

The transplanter may be pulled by an animal, a tractor, or a capstan. When pulled by an animal, the steps are usually not even, and the animal tramples the soil and destroys it levelness. Those pulled by a capstan are not limited by the depth of the plowing layer as those pulled by a tractor do, and the soil is not disturbed. A small motorized automatic transplanter has already made its appearance; instead of being operated by two people as the other motorized models, this small machine requires only one person.

All of the current models have automatic seedling dividing mechanisms, and all of them have the seedling box. All of them are mounted on two runners to convey the load. In one operation, a certain number of seedlings per group, and certain groups per row, are transplanted all at once.

(2) Models of Transplanters

At the national conference of transplanting and semi-mechanized farm tools in February of 1960, seven models of transplanting tools were selected and recommended. They are

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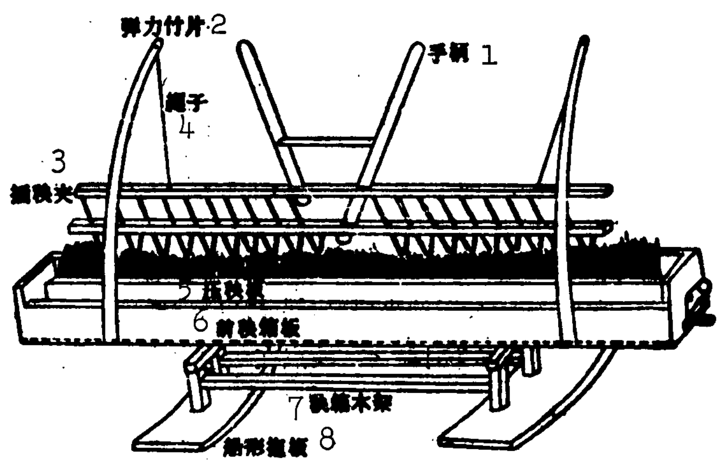
Kiangsi-59, Kwangsi 59-3, Han-ch'uan-59 of Hupei, Li-ling-No.2 A, Nan-wei-No.1 of Shanghai, Nan-105 B, Che-nung No.7. Another 13 models won hornorable mention. The following is a brief description of five of these models:

a. Li-ling No.2 A of Hunan (Figure 23-5)

This machine was created by a young farmer named Ho Chi-sheng (6320 4949 3932), with the support of the party, in July of 1958. It has been improved with the experiments of the various regions. The machine does the work of a width of 135 cm. With one operator, it can transplant the seedlings for one to two mou a day. The work efficiency is about 2 to 5 times (a skilled farmer can only transplant 12,000 groups a day) that of a manual worker. The machine weighes 11 kg. It may be used on the plain, the hilly areas, the large paddy, or the small paddy. It is made entirely of wood and bamboo. It is easy to manufacture, and the cost is low.

Figure 23-5 Li-ling No.2 A Model Transplanter of Hunan



1. Handle 2. Elastic split bamboo 3. Transplanting prongs 4. string 5. seedling presser 6. front of the seedling box 7. Seedling box holder 8. boat-shaped runners

This machine is operated and controlled manually

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and the prongs are operated intermittently. The prongs and the seedling box are two independent structures. A whole row of seedlings are picked up by the prongs in one operation. The worker operatesthe prongs by the handles, and after the row of seedlings are dropped into the soil, he withdraws the prongs by the handle, and as he uses the prongs to pick up seedlings once he pushes the seedling box forward one step before he repeats the operation.

b. Kiangsi-59 Model Transplanter

This is designed by the Kiangsi Provincial Institute of Agricultural Sciences after combining the advantages of many other models. The machine weighes 45 kg, and is constructed with iron and wood. It is operated by one person, and transplants a 6 x 6 ts'un row. With this machine, one person may transplant five and a half to seven mou a day. In one operation, the transplanting width is 106 cm.

It is operated on the basis of repeated action of of a pair of shuttling toothed combs. When the operator pushes the handle, a row of six groups of seedlings are planted. When he pulls the handle, he pulls the entire machine a step backward. Thus the operator retreats step by step, as he repeatedly pushes and pulls the handle. There are many transplanters which operate in this manner. Compared with Li-ling No.2 A, their structure is not as light and simple. They are slightly more efficient, and requires less skill to operate.

c. Nan-105 B Transplanter

The Nanking Institute of Farm Machinery of China Academy of Agricultural Sciences gathered together the experience and designs of the various regions during the last few years, with regard to the transplanter, and designed this model. The machine weighes 145 kg, and is made of iron and wood. (Figure 23-6). It is to be pulled by an ox, and can transplant 20 to 25 mou a day. If it is pulled by a small single-cylinder tractor, it may accomplish 30 mou. The width it transplants in one operation is 144 cm.

It operates by a combination of a pair of shuttling toothed combs and a roller. It requires two operaters. One takes care of the ox, the other operates the seedling box to feed the machine.

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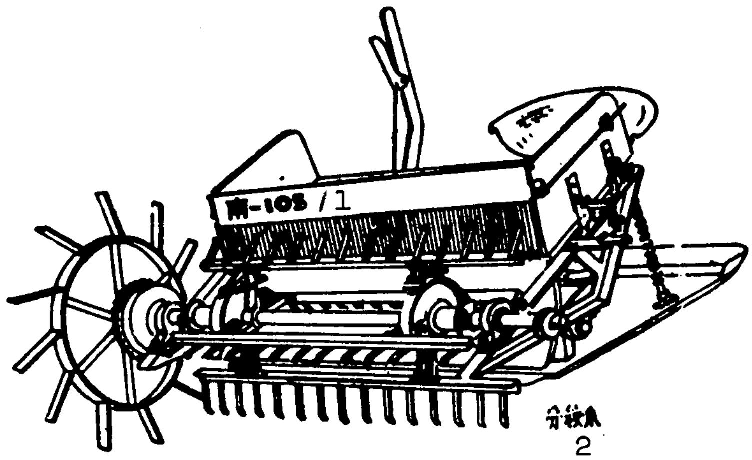
Figure 23-6 Nan-105 B Model Transplanter



1. Nan-105 2. Seedling Dividing Claws

d. Kwangsi 59-3 Model

This was created by the Institute of Agricultural Sciences of the Autonomous Region of the Chuang Nationality of Kwangsi. The machine weighes 20 kg, and is made of wood. It is operated by one person, and the seedlings of half a mou may be transplanted in an hour. The width of one operation is 108 cm. Since the machine is light, it is especially convenient for the mountainous regions and the small paddies.

The operation makes use of a pair of prongs, which is, unlike the Li-ling No2, controlled mechanically instead of manually. The operator uses one hand to push the hand back and forth to complete the entire process of transplanting, and the other hand to move the machine.

e. Lai-yang-6016 of Hunan

This was desinged by Lai-yang Farm Machinery Plant of Hunan. It uses a pair of rolling prongs for straight transplanting. This is altogether a new style, and is one of

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the 13 models that won an honorable mention at the conference. The machine weighes 130 kg, and is made of iron and wood. It is to be pulled for continuous operation.

Of the aforementioned models, the first four models have been repeatedly tested and approved. They are currently being recommended and utilized in the various rice growing areas.

(3) The Yield and the Growth of the Rice Plants When the Transplanter is Adopted

If a transplanter is operated with skill, the quality of the transplanting work may be described with the following indexes.. The rate of missing seedlings is below 3%; about 7% of the seedlings planted are crooked; about 2% of the seedlings planted are damaged; if the number of seedlings per group is 3 to 10, then, the qualified ones rate about 70 to 80%, and sometimes as high as 90%; and the depth of the transplanting is about 5 cm. Judging from these indexes, the machines operate almost as well as manual transplanting.

Judging from the experience of the last few years since 1957, and the experience of the tests done at the national conference in 1959, we may conclude as follows:

The work of the transplanting machines compares very favorably with such high quality manual transplanting work of the farmers of the areas of Central and South China. As the tests in Ho-chiang and Chiang-chin of Szechwan show, unless the skill of the operator is very poor, the use of the transplanting machine can result in a higher yield. In 1959, a yield of 5 to 20% higher than manual transplanting was obtained in Kweichow. The test of Kiangsi Provincial Institute of Agricultural Sciences in 1959 shows an increase of 4 to 8% in yield. With the same density, the transplanting machine brought an increase in yield of 1 to 10% in Chekiang.

The reason for the good performance of the transplanting machines is as follows:

a. The number of seedlings as specified by the density requirement is better guaranteed by a transplanting machine, and the space between the groups and the rows is more even.

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b. Since the machine is more efficient than manual work, a large area may be transplanted in a hurry so that the various cultivating measures may be done on time.

c. The machines transplant the seedlings in a more uniformed depth, about 4 to 5 cm; therefore, the technical requirements are easily met.

d. With the machines, the seedlings of each group are more evenly spaced. There is no center seedling being crowded by all the others. The roots can thus grow better.

Besides, according to the observations of the various regions, with the machines, the transplanting holes are smaller; there are less foot prints in the paddy; the seedlings are transplanted immediately after being pulled up, without long hours of exposure in the sun; and the prongs gently pull up the seedlings; all are factors which promote the growth of the seedlings for a higher yield.
(Note: Since 1957, all the areas which have tested the Model Nan-102 Transplanter have used the figure 3 to 10 seedlings per group. As the efficiency of the machines has been raised considerably since then, the density should be changed to 5 to 6 seedlings.)

(4) The Use of the Transplanters

Although many models are currently being used in our country, the following are the common factors that demand attention from all who use any of the models.

a. The Land Preparation Work of the Seed Bed and the Paddy

If a transplanter is to be used, the seedlings should have strong stems and short roots. Dry field seedlings work better with the machines. The seedlings are the best if they measure 6 to 7 ts'un. As much as possible, when the seedlings are pulled up and washed, the roots should not tangle.

The land preparation should still meet the general requirements. The water level should be maintained at about 1 ts'un. The soil should be fine, but should not be pasty. If the soil is very fine, then, transplanting should

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not be immediately after the paddy is filled; otherwise, the transplanting machine may not operate very efficiently.

b. The Preparation and Use of the Machine

The machine should be thoroughly inspected before use, to see if all the mechanisms are operating perfectly.

The machine should be moved in even steps, and the seedling box should be straightened out periodically. If the simple mechanism of the prongs is used, the seedling box must be in a proper position, and the pressure on the handle must be exercised evenly each time.

c. Labor Organization

It is best to organize a small team to be responsible for the various procedures of pulling up the seedlings, delivering them, exchanging the seedling box, and transplanting, while others look after the water and other jobs, so as to raise labor efficiency.

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SECTION 4. IRRIGATION MACHINERY [p .650]

The old irrigation tools of the rice paddies which were created by our laboring masses many long years ago, have been improved and modified to raise efficiency during the recent years, and attention has been given to mechanize the irrigation process.

Great achievements have been made. Until 1959, about 35% of our country's irrigated acreage was benefited by machines entirely or partially. The acreage of completely machine irrigated paddies amounted to about 11%, 6 times the rate before the liberation.

1. SEMI-MECHANIZED IRRIGATION MACHINERY [p 651]

The efficiency of the Lung-hua pump, the Chieh-fang pump, and the windmill pumps has been greatly improved. These tools have the advantage of making use of local materials, easily built, and very inexpensive. According to the experience of the various regions, the improvement is done in the following aspects:

(1) To adjust to the local utilization conditions

Adjustments are being made in accordance with the new conditions of motive power. Sometimes more tubes are added to the single-tube pumps; in others, as more animals are becoming locally available, the manual pumps are changed into animal operated pumps.

(2) To change the form of operation to lighten the pumping work

For example, the hand operated pumps are changed into foot operated pumps, or levels are added so that the worker does not have to perform the exhausting motion of running in circles.

(3) To improve the method of pump construction

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As much as possible local materials are utilized. Measures are being taken to use substitutes for materials that are not locally available.

(4) To raise mechanical efficiency

For example ball bearings are being adopted to reduce friction. The axle of the Lung-ku pump is now completely and tightly sealed so as to increase the volume of this type of pump.

(5) To make use of such natural source of energy as the water and the wind

For example, simple wooden wheels are made to operate Lung-ku pump by water power, or small windmills can also be added.

A small windmill provides the energy of 2 to 3 animals. The windmills currently used in our rice growing areas have three styles. One is the standing sail style (also called Ta-pa-kua), which is the oldest style in our country. It operates with the wind in any direction, and never needs to be turned. However, this style requires a great deal of lumber, and the rate of wind energy utilization is low. The second is the tent style, with six sails. The moving plain of the wings is perpendicular to the direction of the wind. It is made of wood and bamboo, with cloth or mat for the wings. There is another style with many blades. It is made of a wooden frame, with wooden axles and iron toothed wheels.

2. WATER PUMPING STATION [p 652]

An irrigation station is responsible for the irrigation and draining work of a certain area. An irrigation center with motorized irrigation machinery may also be called an irrigation station.

(1) The Arrangement of the Irrigation Stations

When the area of an irrigation district has been determined, the job of irrigating the paddies of this district

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may be given to one large irrigation station or several small stations depending upon the local conditions of terrain and finance. Each irrigation station may have one or several mechanized teams. The arrangement of the irrigation stations may be divided into the following forms:

a. Multiple Station with multiple channels

The district may be divided into several pump areas, and each area may have its independent pump station, water supply and draining system. Aside from the reasons of economics, this divided method of arrangement is also a matter of necessity due to the terrain and the water resources. This method of arrangement is the most popular in the provinces of Kiangsu, Chekiang, and Anhwei.

b. One Station and One channel

The entire irrigation district may be served by a single station, and the water is delivered to all the paddies with pressurized tubes. The drainage water is taken through the main drainage ditch to a river. This is a large scale arrangement, and is suitable for the plain areas or areas with low paddies easily waterlogged.

C. One Station with Multiple Channels

The entire district may be divided into several divisions according to terrain, and each division has its own main channel. The water is supplied by the main station to each of the main channels with pressurized tubes. With this arrangement, there are generally several mechanized teams. Each takes care of a number of divisions. This method is suitable for the hilly regions with the terrain not extremely high.

d. Multi-leveled Water Supply

The irrigation district may be divided into several pumping divisions. From the lower to the higher, each pumping division pumps the water and sends it to the station of higher elevation. This arrangement is most suitable for the areas with very steep slopes.

The aforementioned arrangements may be adopted simultaneously by one irrigation district if the conditions

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require such multiple arrangements. When water is pumped by one station, all the water must be brought to the highest level before being delivered to the various levels of the district; the mechanized equipment usually requires more horsepower, with the result of more capital investment and more fuel consumption. However, since the mechanized equipment is thus concentrated in one place, its management is much easier.

(2) The Selection and the Use of Water Pumps

The major equipment of an irrigation station includes the water pump, the motor, the distribution equipment, and the water pipes. Generally speaking, the pump is the major item; the other items must be designed to meet the demands of the pump. Therefore, the quality of an irrigation station is largely determined by the choice and the use of the water pump.

a. The Type of Pumps

In the rice growing areas of our country, there are the two types of the centrifugal and the rotary pumps. During the last two or three years, a new type jet pump has been introduced. The centrifugal pump is suitable for the areas with small water volume but higher terrain, while the rotary and the jet pumps are more suitable for lower terrain and higher water volume areas.

At present the types of pumps for agricultural use manufactured in our country are the following:

K Model Pump: The casing is in elbow shape. This centrifugal pump has a single suction, is light, and easily adjustable at the delivery end.

D Model Pump: This type of centrifugal pump has two suctions, with a horizontal casing, and is used for larger flows.

Feng-ch'an Brand Jet Pump: This is simply constructed, easily assembled, and is very light.

P.V. Model Jet Pump: This is a jet pump manufactured in Shanghai. The flow volume is very large, but it

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takes up very little space, and is easily transported.

Other ordinary pumps are described in Table 23-1.

Table 23-1 The Specifications of the Various Models of Water Pumps

	克型泵 7	德型泵 8	丰产牌混流泵 9	第一机械工业部1958年标定混流泵 10	彼维型轴流泵 11
吸水口径 1	$1\frac{1}{2}$—8吋 12	6—48吋 12	10—36吋 12	8—12吋 12	500—1,200毫米 (13)
流量(升/秒) 2	1.3—100	31—3,472	92.8—7,720	47—290	520—3,500
扬程(米) 3	8.8—98	8.6—140	4.02—24.5	2.3—14.7	2.5—5.5
功率(馬力) 4	0.7—41	15.4—914	11.3—118.5	3.5—54.1	30—350
效率(%) 5	35—84	41—89	69—87.5	55—76	—
转速(转/分) 6	2,900—1,450	2,900 1,450 970 730 485	245—990	900—1,270	365—960

1, Size of the inlet 2. Volume of flow (liter/second)
3. Height of delivery (m) 4. Work Efficiency (horsepower)
5. Efficiency rate 6. Turn speed (turn/minute)
7. K Model Pump 8. D Model Pump 9. Feng-ch'an Brand Jet Pump 10. 1958 Standard for Jet Pumps formulated by the First Ministry of Industrial Machines 11. P.V. Model Jet Pump 12. hours 13. mm

b. Number of Pumps and the Height of Delivery

When the number of pumps and the height of delivery are chosen for an irrigation station, the following factors must be considered:

(a) The equipment must satisfy the moisture requirements of the crops of the irrigation district.

(b) The Pump station must have a maximum utilization

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rate.for its equipment.

(c) The pump and its motor must be kept working at their maximum efficiency.

(d) The expense of the irrigation must be kept at its minimum (including basic construction capital and maintenance expenses.)

With regard to the large irrigation districts, the use of a single pump, or the use of several pump of different models must be avoided, because possible accidents may cause the water to be cut off if only one pump supplies the water for the entire district. If several models are chosen all at once, maintenance and repair work will be very complicated, and many different parts will have to be stored to service all the different pumps.

The height of delivery is generally clearly marked on the pump. If the pump is to perform with a regular maximum efficiency, it must be able to serve the specific requirements of the area. If the water level at the source of water is stable throughout the season, then, to determine the water pressure is a very simple matter. However, if the water level varies constantly, then, the average must be taken for the purpose of calculation, and the angle from the shaft axis must be adjusted in accordance with the variation of the water level at different times. If this is the case, then, a more versatile model should be chosen.

c. Reasonable Combination of Equipment

The pump must be accompanied with a motor of just the right size. If the motor is too small, the pump will not function properly. If it is too big, a waste of fuel and oil will be the result.(waste of electicity in case of an electric motor).

The pump must be operated with its specifications (that is in accordance with its volume of flow, the water pressure, and the permissible suction.). When the pump is installed, unnecessary height of delivery is to be avoided as much as possible so as not to lose pressure head. It is a common mistake to install the inlet of the pipe too high, with too many turns, and too long, with the result of losing pressure head unnecessarily, and adding the height of delivery to

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the pump.

3. SEVERAL SPECIAL TYPES OF WATER CARRYING EQUIPMENT [p 654]

(1) Pump Boat

In the T'ai-hu Region of Kiangsu and Chekiang, there are many rivers and streams, all of which are connected. The masses put pumping equipment on a boat and send it to wherever it is needed. This practice has a history of more than 10 years, and its advantages are numerous.

a. It is extremely flexible. It may come to the rescue of areas suffering from drought or flood. The extemely large and extended areas benefit by this equipment and helps to raise the utilization rate.

b. Due to its mobility, there is no need of constructing permanent pipes, the cost is greatly reduced. The efficiency of the pump is not affected by the water level.

c. During the off-season, the boat and its equipment may be easily utilized for manufacturing and transporting products of agricultural supplementary industries.

This type of pump boat may navigate in ordinary streams. A high speed diesel engine of 20 to 30 horsepower (the old steam boats usually have low speed diesel engines) with a 30 cm inlet centrifugal pump are all that are needed.

(2) Hydraulic Pump

This is a new pumping tool of a combination of water wheel and water pump. It is simply constructed, and easily installed. The maintenance is very low, and the equipment is long lasting. Compared with a motor driven pump, a hydraulic pump requires no operator, fuel, or machine oil. It operates entirely under water, and is lubricated by water only; therefore, the cost of irrigation may be greatly reduced. Of course, it is necessary that there are certain hydrodynamic conditions. There must be swift flowing water, tide, or waterfall, so that the hydrostatic head is concentrated at one point to be utilized to operate the pump.

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The hydraulic pump was experimented with successfully in 1954 by the Comprehensive Experimental Station of Fukien. After being popularized in the province of Fukien, it has been expanded to the provinces of Chekiang, Szechwan, Hunan, Kansu, Shansi, and Hopei. It is used not only to pump water, but also to generate electricity. At present, the hydraulic turbine designed in Fukien has a wheel diameter of 20 to 100 cm. The hydrostatic and the pressure head are in the proportion of 1.2 to 5.

(3) Internal-combustion Pump

This is a type of pump which makes use of the energy of the combustion of gas in the gas chamber, which directly raises the water pressure. The ordinary piston, and cylinders, etc. are omitted, and the structure is very simple. A great deal of steel may be saved by this design, and it may be considered as a great revolution in the desing of pumping tools.

In 1958, a double-chamber and a single-chamber internal-combustion pump were successfully tested and manufactured in Peking and Tientsin. In June of 1958, and March of 1959, the related ministries of the central government called meetings for the exchange of experience regarding the internal-combustion pump. These meetings started a national movement of study and experiment. At present, there are more than 10 successful models in the provinces of Kiangsu, Fukien, Chekiang, Hunan, and Yunnan. The size of the chamber varies from 2 m to 4 m, and the volume of water flow varies from 100 tons to 400 tons.

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SECTION 5. HARVESTING MACHINERY [p 655]

In the major rice growing areas of our country, the paddies are small, but the unit yield is very high. At the harvest time, the plants and the soil contain a great deal of moisture. The harvest is often done when the water is not completely drained. Moreover, there is a tradition in this country of making use out of everything. The harvest is done so very carefully that many use the stalk and every other part of the plants. Therefore, the imported harvesters can only be used in the northern parts of our country. In the south, they are not at all usable.

A few mechanized or semi-mechanized harvesters have been designed in our country. There are still problems to be solved, but, much experience has been accumulated in the process to form a good foundation for future mechanization of the harvest of rice. The following is a description of the major models:

1. HARVESTING MACHINERY [p 656]

(1) Quick Reaping Tool

The quick reaping tool may be used as an improved sickle (Figure 23-7). With regard to the loss in fallen seeds, the quality of this reaping tool is not much worse than the sickle. Only one person is needed to do the work, and more than two mou of rice may be harvested in one day; therefore, the work efficiency is two to three times that of the sickle. The worker needs not to bend down to operate this tool, therefore, the work is much lighter. It is simply constructed, easily made, low cost, and has many uses. Aside from rice, it may also be used to harvest wheat and potato stalks. It may be used on the plain, the hills, the large field, and the small paddies.

At present, in Hunan, the "chicken cage reaping tool" is quite popular. The Autonomous Region of the Chuang

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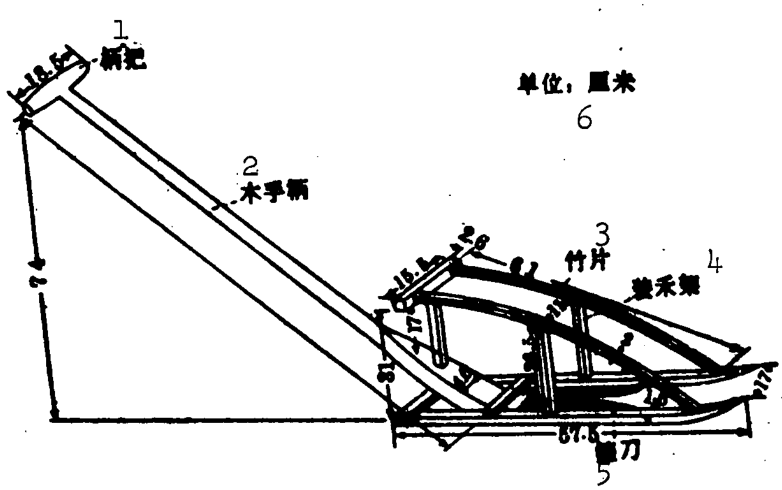
Nationality of Kwangsi has a Hsiang-kuei-59 Model reaping tool. In Shantung, there is a reaping tool which may be used to harvest either rice or wheat. The structure of the Chekiang reaping tool is also similar. The tool which is being used in Kwangtung, may be adjusted to the height of the stalk, or when the stalk has fallen. However, it is not suitable for those stalks that are soft because of the bending position.

Figure 23-7 The Quick Reaping Tool



1. Handle bar 2. the wooden handle 3. slit bamboo
4. the frame to hold the rice 5. the sickle 6. Unit: cm

(2) Harvesters Pulled by an Animal

The style and the theory are similar to the T'ai-ku Model wheat harvester. With wooden wheels, this tool is very simply constructed. After the rice is cut, the workers must gather and tie the stalks by hand; therefore, when this tool is being used, the ground must be dry. It is currently being tested in some parts of Kiangsu.

(3) Motorized Harvester

The harvester manufactured in our country in the

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past must have two animals to pull. It moves slowly, and slips easily in the rice paddy. Nanking Institute of Farm Machinery of China Academy of Agricultural Sciences redesigned it, and used a 20 horsepower tracdor to pull it instead of the oxen. It is able to perform even if the soil is very muddy. It may be used to harvest both rice and wheat, and can complete 50 mou a day.

At present, a small harvester is being tested together with a tractor most suitable for the wet paddies. It is designed to meet the demands of the high yield regions. The machine is to be light and flexible, and is suitable for the small paddies. The problem of laying the grain down after it has be cut is also being studied very carefully.

(4) The Capstan Driven Harvester

The Institute of Agricultural Machinery of China Academy of Agricultural Sciences is currently experimenting with a harvester driven by a capstan. It is designed to solve the problem of the southern rice paddies which are small and muddy during the harvest. The study is concentrated on the necessity of the moving power to be off the ground.

2. SHELLER [p 657]

(1) The Foot-operated Manual Threshing Tool.

This is one of the improved manual machines that are very popular today. It can accomplish more than 1,000 chin a day. In some areas, it may be set up in the paddy, to thresh as the grain is harvested. When a toothed board is attached, it may also be used to thresh wheat.

(2) Simple Motorized Threshing Machine

It is a step forward development of the foot-operated model. The grain is still held by hand, and the machine is operated by a diesel engine or a tractor. It is often set up for the use of a large sunning field.

The people's communes of Yen-chi-hsien,Kirin are currently experimenting with a combination harvesting machine,

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that can thresh, sift, and clean all in one operation. It is used with a four horsepower electric motor and is very efficient.

(3) Small Automatic Threshing Machine

The automatic threshing has a conveyor belt which feeds the grain to be husked. However, if the rice is too wet, the machine cannot operate. It is used with a three horsepower motor, and the productivity is more than 1,000 chin per hour. This machine is light, and easily moved. The stalk remains whole and unbroken after being husked.

(4) Large Automatic Threshing Machine

The large machine made in this country is very efficient. It is being used in many areas except the south, where the paddy is small and the transportation is not convenient, therefore, it is seldom used. Besides, in the south, the tradition demands that the stalk must be kept unbroken, therefore, this machine is not suitable.

3. COMBINED HARVESTING MACHINERY [p 658]

(1) The C-6 Combination Harvesting Machine and Its Adaptation

Since 1952 the state-operated farms of the north have been adapting the C-6 model combination harvester to harvest rice. For example, the state-operated Ch'a-ha-yang Farm of Heilungkiang uses the C-6 model to harvest more than thirty thousand mou of paddy rice every year. It may be used to reap after the frost has come, so that the harvest may be completed in a hurry to reduce loss. Under normal conditions, in the north, with this machine, the rate of loss may be reduced 2%, and the rate of broken seeds may be kept to below 1%. Before the harvest, the paddy must be drained and the temporary dikes eliminated.

The C-6 model was not originally designed for harvesting rice, therefore, it must be adapted to meet the condition of the damp stalk of rice. When the yield is about 600 chin per mou, the width of the blade must be reduced to 2.5 to 3 m. A board should be attached to cover the remaining portion

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of the blade.

When the rice is ready for harvest, the moisture content of the plants is very high. In the south, it is about 20%. The stalk is also higher than that of wheat. When the grain is being threshed , the rice seeds are easily broken. If effort is exerted to obtain a high rate of separation, the rate of broken seeds may increase also. In the Northeast, the yield is about 400 to 500 chin per mou, and the stalk is dryer. In the regions where the yield is higher, and the stalk is damp, the aforementioned machine cannot be used to thresh at all.

The rough grain of rice is not as smooth as that of wheat, and the specific gravity of the former is smaller; therefore, it is harder to separate the rice seeds from the grass. When the rice seeds are damp, it is even more difficult. According to the conditions of Huai-hai farm, when the soil moisture content is about 24%, 1,500 kg of pull is needed to move the adapted C.6 model in the rice paddy for harvesting. During the last few years, the efforts of the state-operated farms to convert the C-6 for rice harvest have helped to solve some production problems for some regions, and much valuable experience has been accumulated in the process. This experience are to be used as basis for further mechanization of our country's rice culture.

(2) The Study and the Conversion of the Automatic Combination Harvester

To use the automatic harvester, there must be a road for the harvester to move in the paddy. The state-operated Tseng-chia-pu Farm of Kiangsi and the Lien-hu Farm of Kiangsu converted the automatic harvester, and Huai-hai Farm converted the A-szu-400 model combination harvester to use them in the rice paddies. The cogged roller was used to replace the original threshing roller, and one more cogged roller was added. Caterpillar treads are used for the moving part. Ch'en-yang Farm Machinery Plant of Liaoning designed in 1959 an En-sau-k'o-tz'u-2.5 automatic combination harvester. The style of the double cogged rollers is adopted in this machine. It is currently in the process of being tested.

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CHAPTER 24. HARVESTING, INSPECTION, STORAGE OF RICE AND UTILIZATION OF BY PRODUCTS

[p 663]

Harvest is the last link of the chain of rice cultivation process. Harvest may also affect the yield and the quality of the rice crop. Timely harvest, careful threshing, timely sunning, and careful cleaning are also important steps in rice production. After the harvest, the rice must be inspected and graded before it is sunned to dry and stored separately according to the grades. In order to maintain the quality of the grain, it must be inspected periodically while in storage. The temperature of the warehouse and the grain, and the rules of the variation of the moisture content of the grain are all to be watbhed carefully in order to prevent the rice from deteriorate.

Meanwhile better storage methods for the preservation of the quality and the nutritional value of the rice are being constantly studied and improved. The disqualified grain the hulls, and the outer coats of the seeds are being utilized and processed to form various by-produts, all of which are intimately related to our people's daily lives. Polished rice has always been our people's major food, and considerable advancement has been made in the utilization of the rice by-products. In this chapter, we shall discuss these subjects one by one.

SECTION 1. HARVESTING RICE [p 663]

The harvest of rice in the state-operated farms of our country is being partially done with machines at present.

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Some people's communes are now also using machines for threshing and cleaning of the grain. The following is a discussion of these work procedures:

1. HARVESTING PERIOD AND METHODS [p 663]

(1) A Proper Harvest Time

The harvest time of rice is determined by the degree of ripeness of the seeds. If the seeds are harvested too early, threshing will be difficult; the grain is smaller; the yield is reduced; the seeds are easily broken; and rice borers may easily occur in storage. If the harvest is too late, the stalk has withered and is easily broken; the head is easily crushed; the seeds often have fallen by themselves; the hulls are thicker; the color of the seeds has changed; the broken seeds are numerous; the quality of the crop is bad; and the yield suffers greatly.

The proper harvest time is at the end of the wax-ripe stage. At that time, the plant has stopped sending nutrients to the seeds, and most (more than 95%) of the seeds have turned yellow. One third up, the stalk has withered. If the soil is fertile and the moisture content great, then the base of the head may still be green, otherwise, it has turned yellow also. In the north, with a short growing season, or in the double-seasoned regions of the Yangtze Valley, rice is harvested when the grain is yellow, but the leaves are still green. If a windstorm is likely, or there may be a possible flood, then the harvest may begin when the wax-ripe stage is 90% completed.

(2) The method of Harvest

When the rice is harvested manually, there are the procedured of cutting, tying, threshing, and bundling the stalks. These procedures must be planned ahead of time, and careful planning is also important for the quality of the harvest.

a. The method of cutting the plants

First cut the plants toward the direction of the wind. Sometimes, the plants are cut just above the soil so as to get rid of the overwintering borers and fungi, and to

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make it easier to prepare the land for the next crop. If forage legumes are to be planted, the the stalk is cut with a stubble of 5 to 6 ts'un in the soil.

The method of cutting varies in the different regions. For example, in the sandy soil regimn of the Pearl River Delta, both the early and late crop are cut with the two-stage method. The plants are first cut at a place 5 to 8 ts'un above the soil. When there is a handful, then the part from the tip of the head to about 5 ts'un down is cut down. The middle part is laid down first on the ground, then the part with the grain is laid on top of it. At about noon, the part with the grain is then gathered and brought to the yard to be threshed and sunned.

In the north, the winter air is dry. The grain is often left in the paddy for 2 to 3 days in the sun; then it is gathered from the ground and threshed right there. If the paddy is damp, then the grain is bundled after cutting and brought back to the yard to be threshed. If possible, it is often piled up to be threshed when there is less work to do in the field. During the harvest, there may be overripe plants, fallen plants, kernel smut and other damage to the yield. When the grain is being transported from the field, seeds may fall due to carelessness. According to surveys, the disease of kernel smut of Hua-nan No.15 caused a serious loss of 65 chin of grain from one mou of rice. This type of loss often occurs to the hsien subspecies, but not the keng subspecies. This is why the farmers say it is important "to harvest carefully and thresh carefully so that every kernel of the grain will go to storage."

b. Threshing

In the south, threshing is done either by a machine or by the ox driven thresher; in the north, threshing is mostly done by a mechanized thresher.

2. DRYNESS AND CLEANLINESS OF HARVESTED PRODUCTS [p 664]

After the rice is harvested, it must be sunned to eliminate the excess moisture on the surface and in the

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seeds. After the grain is sunned, all the foreign substance is to be cleaned out so that the grain may be stored or processed.

(1) Drying

When the rice is harvested on a clear day, the stalk contains about 60 to 70% of moisture, and the grain contains about 20 to 25% of moisture. Therefore, aside from the portion of the stalk that is to be turned under as fertilizer, the stalk and the grain have to be dried. The methods of drying the grain are mainly the following:

a. Sunning

When the dew on the yard has dried, the grain is laid on the yard, about one tan of grain on a sq.chang. It is turned every half an hour with a wooden rake. Toward noon, the wooden rake is used to pile the grain up, so that the accumulated heat in the grain will cause all the kernels to dry evenly.

In Canton, on a clear summer day, the temperature is about 31°C, while the temperature on the surface of the yard is about 38°C, and the temperature of the surface of the grain pile is about 44°C. The center of the pile is about 38°C, the bottom part is about 34°C, and the average temperature in the pile is about 39°C. Therefore, the grain should be totally dry in a day. Generally speaking, if the moisture content of the kernels is 13.5 to 14.5%, they are ready to be stored.

The dryness of the kernels may be easily determined. A kernel must make a cracking sound when it is bit. The husk comes off easily when it is rubbed, and the rough rice has a shining surface. Then, it is just dry enough.

b. The oven drying method

The oven is often made of bricks, with a stove at the bottom. About 1,000 chin of grain may be dried in one hour. The temperature should be 70 to 100°C. When the temperature is high, the grain may pop. Therefore, when the kernels are very damp, high temperature is permitted. After they have been dried for a while, then, the temperature should be reduced so that not very many will pop.

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c. The Steam Drying Method

In the double-seasoned regions, when the early rice crop is harvested, it frequently rains, and the temperature is high. The grain may easily sprout or become rotten. The steam drying method is commonly used in Hu-chou, Chekiang, and in South China and the Southwest. A large steam barrel is used for this process. Each barrel should contain about 200 chin of rice. Add about 10% of water, and cover the barrel tightly. Then the barrel is cooked until full steam appears, and the rice is about 105°C. At that time, the moisture content of the kernels is about 22%. The kernels may also be soaked in water for about 5 minutes before being steamed.

According to the Institute of the Sciences of Grain Studies of the Ministry of Food, after the steamed kernels are dried in an oven of below 45°C, the moisture content is about 16.5%. When this rice (hsien or keng) is used for cooking, the cooked rice contains more vitamin B_2, two to three times more than the rice processed with other methods. The steamed kernels takes more water to cook, and contain more fat, protein, and cellulose. They are not as easily broken because they are harder. The embryo and the husk are not as easily broken off, and this is the reason for their higher nutritional value. Therefore, this method may be adopted when it rains at the harvest time, or just to improve the quality of the rice.

Table 24-1 Chemical Analysis of Steamed Rice of the Hsien and Keng Subspecies

(1) 品种类型	处理 (4)	水分 (5) (%)	灰分 (6) (%)	脂肪 (7) (%)	蛋白质 8 (%)	纤维 9 (%)	10 钙 (微克/100克)
籼稻 (2)	对照 (11)	15.43	0.794	0.972	9.10	0.354	8.49
	烘干蒸 12	13.83	0.992	1.134	9.23	0.525	8.36
	烘浴 13	14.75	0.965	1.079	9.20	0.550	8.62
	晒干蒸 14	14.15	0.939	1.127	8.15	0.448	5.50
粳稻	对照 11	15.82	0.634	0.746	7.10	0.480	9.69
	烘干蒸 12	14.55	0.846	1.207	7.38	0.645	9.64
	烘浴蒸 13	14.27	0.825	0.990	7.33	0.630	9.11
	晒干蒸 14	14.89	0.838	1.207	7.71	0.390	8.98

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1. Subspecies 2. Hsien 3. Keng 4. Treatment 5. Water
6. Carbon 7. Fat 8. Protein 9. Callulose 10. Calcium
11. Control Group 12. Steamed and oven dried
13. Soaked for 5 minutes, steamed, and oven dried
14. Steamed, and sunned to dry

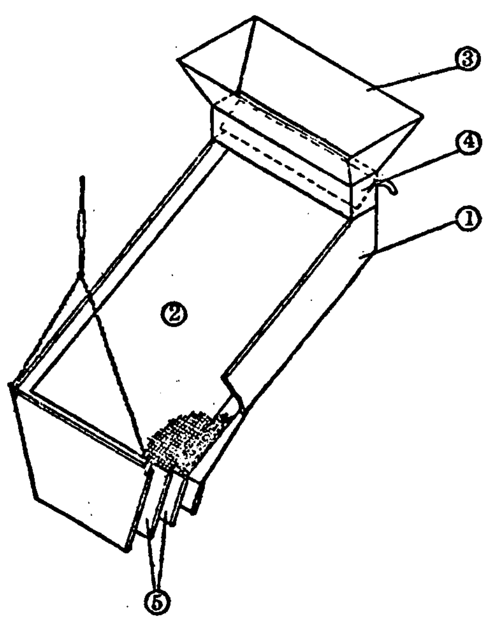
(2) Cleaned

After the rice is dried, the foreign substance such as mud, sand, bits of coal, glass, pièces of metal, stalk, leaves, hulls, weeds, seeds of other plants, and dead insects must all be cleaned out. This is a necessary process for safe storage. If the cleaning process is not done, the quality of the rice will be seriously affected, and further processing will be difficult. This process may be done with various types of tools. The ones currently used in China are as follows:

a. The Tilted Sieve

With this tool, the separation of the rice and the foreign substance depends primarily upon the size of the perforation. The tool is stationary, and has a slanted surface. Taking advantage of the theory that all substance falls downward, this tool may be very serviceable if the size of the perforation, and the slope of the perforated surface are just right for the particular variety of rice; therefore, it must be adjusted to meet the demands of the various varieties.

Figure 24-1 The Tilted Sieve



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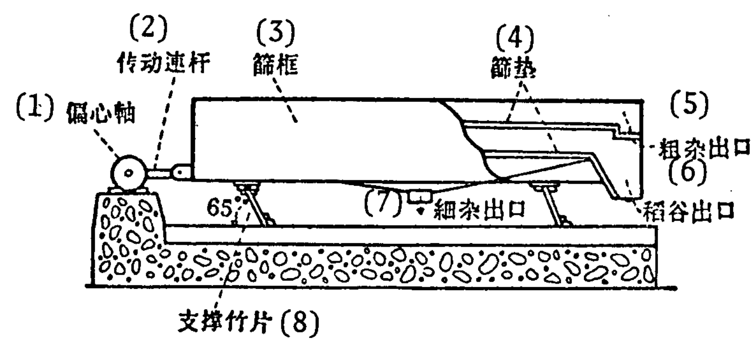
1. The frame of the sieve 2. perforated mesh 3. Intake funnel 4. Movable shutter 5. Outlet

(2) Hand Operated Sieve

This is shifting device without the vacuum cleaning attachment. A titled axle, or an automatic balancing mechanism is used to make the sieve move back and forth. The rice seeds are dropped into the upper layer, and the large foreign substance is pushed out of the outlet; then, the rice seeds, which have passed through the perforation of the upper layer come out of the center outlet, while the fine foreign substance, such as fine sand and seeds of Penicum crus galli passes through the finer perforation of the lower layer and comes out of the center outlet. (Figure 24-2)

Figure 24-2 Hand-operated Sieve



1. Titled axle 2. Motion transferring arm 3. Frame of the sieve 4. The perforated mesh cushions 5. Outlet of the large foreign substance 6. Outlet of the cleaned rice 7. Outlet of the fine foreign substance 8. Slit bamboo support

c. The Vibrating Sieve

This device makes use of the sieve and the air motion to separate the rice from the foreign substance. Its motion depends upon an automatic balancing mechanism. The rice

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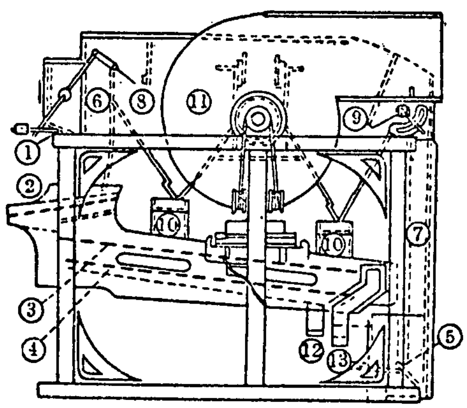
is dropped in the first layer, then, it passes through the first and the second layer to be separated from the large foreign substance. The third layer separates it from the fine foreign substance. Meanwhile, the bellow blows air currents to clean out the hulls. (Figure 24-3)

Figure 24-3 The Vibrating Sieve



1. Adjustable inlet 2. The first layer of perforated mesh 3. The second layer of perforated mesh 4. The third layer of perforated mesh 5. The outlet 6,7. The air passages 8,9. Settling chambers 10. Slanted passage 11. Bellow 12. Outlet for fine foreign substance 13. Outlet

d. A Wooden Bellow /A Wooden Windmill/

This is our country's old tool for cleaning the grain. It takes the advantage of the difference of the specific gravity of the various foreign substances and that of rice, and separates them with strong air currents.

Besides the aforementioned devices, there are also other tools which make use of vacuum cleaning action and the magnet. The blowing action of a bellow is also used to remove the small stones which are about the same size as the grain.

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SECTION 2. INSPECTION OF RICE [p 668]

1. INSPECTION STANDARDS [p 668]

The standard of inspection is the basis upon which to grade the quality of rice. When the state purchases rice, a different price is awarded to a different quality. Due to the difference of natural conditions, cultivating techniques, and the varieties, the quality of the rice produced from the various regions is different; therefore, at present, there is no uniformed nation-wide quality standard for the purpose of state purchases. The standard is set locally by the various rice growing areas. There are two kinds of methods currently practiced by the local authorities for judging and grading the quality of rice:

a. Price increase and decrease method with partial grading

This is a transitional standard that is being practiced by most areas at present. It is based upon the rate of polished rice obtained from the rough rice (this is the grading part of the system), and on this basis, the moisture and foreign substance content of the rice is judged for the purpose of increase or decrease in prce. For example, as regulated by the Ministry of Food, for each 1% of increase in moisture, the price is reduced 1.2%, and for each 1% of reduction of moisture (as compared with the standard moisture content), the price is increased 1.2%. The same method is used to treat foreign substance. However, this standard is not as reasonable as the method of combining all items for the purpose of judging quality.

b. Basic standard (price is fixed in accordance with the quality of rice which is judged by combining all relevant items.)

This method of judging rice is gradually being adopted throughout the country in the place of the one we just described. For example, in Chekiang Province, this method is currently used to fix the price in rice purchases.

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For the purpose of state purchase, there is first a division of the three categories of the types of rice, the varieties, and the technical index. The rice is first divided according to its botanical types of the keng, the hsien, and the nou. Then, the difference of the various varieties is described in five different ways: :

(a) The grain is pointed and thin, transparent, with very little powdery outer covering.

(b) The rice is basically transparent, but with some powdery outer covering.

(c) The rice is only semi-transparent, with some dead white outer covering, and a dead white center.

(d) The rice is slightly transparent, but mostly white.

(e) The rice is not at all transparent. It is in a powdery white color or pink color.

There is also a standard of 14% of moisture content, 1% of foreign substance content, and the three different types of rice should be separated; the mixture of one in the other should not exceed 10%. If the rice is found to exceed the standard in any of the specified items, the price is to be reduced accordingly.

The primary item which affects the quality of the rice is the rate of polished rice to be obtained from the rough rice, and the moisture and foreign substance are the secondary items.

The rate of polished rice is the amount of polished rice obtained after the outer seed-coats and some of the embryo are removed by rubbing. The broken seeds are included in the rough rice.

Foreign substance is defined as the substance that may pass through a.I.5 perforated sieve. It may be inorganic such as soil, sand, coal, metal; or organic, such as plant roots, stem, leaves, live or dead insects, hulls, rotten rice, rice beard, seed of Penicum crus galli, and other plants.

The broken seeds include the following types:

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The seeds that are not completely ripened, with an appearance of dead white color. They are sometimes called dead green rice, and are more or less edible.

The seeds that have been partially eaten by insects.

The seeds that have spots due to the disease of the rice plant.

The seeds that are moldy.

The seeds that have sprouted.

The seeds that have turned yellow due to faulty storage.

The seeds that are discolored or give an offensive odor.

2. INSPECTION PROCEDURES AND METHODS [p 669]

(1) The Sample Taking Method

The first step of rice inspection is to take a sample from of the lots which are being inspected. A separate sample should be taken of each unit while the amount of rice taken as a sample depends upon the requirements of the inspection process. The methods of taking a sample are as follows:

a. Taking a Sample from the Warehouse

If the rice is stored in piles in the warehouse, then, according to the volume, the pile or piles are to be divided first into the five points of the center and the four corners. Then, the pile is again divided into layers. Then, an instrument (it is called a grain detector) shaped like a stick, is used to penetrate through the various points to the various layers and to bring up a sample from each of the locations.

b. Taking a Sample from Packaged Rice

If the rice is stored in sacks, then 7 to 10%

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of 100 sacks, 4 to 7% of 1000 sacks, or 3 to 4% of 10,000 sacks should be used to take samples. The sample taking instrument should be inserted from the opening of the sack diagonally to reach the opposite corner of the bottom of the sack and take sample seeds in the process.

c. Taking a Sample from Round Storage Bins

The method of taking a sample from round storage bins is similar to taking a sample from a pile of grain. First, the points of the center and two points toward the edge should be determined for the purpose of inserting the grain detector. Then, the bin is also divided into several levels, so that the sample may be a fair representation of the rice of the entire bin. If the diameter of the bin is over 7 m, then more than three points should be chosen on the surface.

(2) To Mix the Samples

The samples taken from the various points are to be mixed for the purpose of inspection. The mixed sample is called the "average sample". As soon as the samples are mixed, the actual inspection should proceed immediately. If for some reason or another, the average sample cannot be inspected immediately, then it should be sealed with a detailed inscription, and be kept in a safe place.

(3) Quality Inspection

In our country, quality inspection is done with the two methods of direct inspection and instrument inspection.

a. Direct Inspection

This method is the method of judging the quality of rice with the normal human sense organs. Generally, the inspector looks at the shape, color, and size of the seeds, and judges the number or percentate of broken seeds. He puts the seeds in his palm to judge the dampness, the weight, and the temperature. He smells the seeds to detect odor; he bites the seeds to judge the hardness, and to listen to the sound when the seed cracks.

b. Instrument Inspection

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Various instruments may be used to judge the quality of rice. This method is by far more accurate.

(a) The inspection of foreign substance

Take one kg of the average sample. After weighing, use hands to pick out the large foreign substance, and weight the remaining rice again. The following formula may be used to figure out the percentage of the large foreign substance:

$$\text{Large foreign substance (\%)} = \frac{\text{weight of large f.s.}}{1{,}000} \times 100$$

Then, for inspecting the small foreign substance, the three sizes of 3.0, 2.5, and 1.5 mm perforated mesh are used to shift the sample for one minute with the speed of 110 to 120 shifts per minute in a clockwise motion; then, shift another minute with the same speed in a counterclockwise motion. Then, pick out the foreign substance thus separated from the three sieves, and figure out the percentage with the following formula:

$$\text{Small foreign substance (\%)} = \frac{\text{Weight of s.f.}}{\text{weight of the sample}} = 100$$

If the sample contains both large and small foreign substance, then the following formula should be used:

Content of foreign substance (%)

$$= \frac{\text{wt. of large f.s.} + (1{,}000 - \text{wt. large f.s}) \times (\text{wt. of small f.s} \div \text{sample})}{1{,}000} \times 100$$

(b) The Inspection of the Rate of Polished Rice

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Take 20 g of rice sample, from which the foreign substance has been removed, and put it in a hand-operated husking machine to remove the husk and obtain the rough rice. Then, use a hand mill to rub off the outer seed-coats, and weigh. The formula for calculating the percentage is as follows:

$$\text{Rice (\%)} = \frac{\text{total wt of rice} - \text{broken seeds} \div 2}{\text{wt of sample}} \times 100$$

Each sample should be tested twice, and the difference between the two tests should not exceed 1%. The average of the two test results is the rate.

(c) The method of Determing the Moisture Content

The moisture content of the rice of the sample is tested by an electric oven with a constant temperature of 105°C. The dry substance of the grain will not be harmed under this temperature, and the result is very accurate.

Take 15 g of rice seeds from the average sample, and rub them until not less than 60% are of a diameter of 1 mm, and not more than 5% are of a diameter of 2 mm, then, use a spoon, take one spoonful from each of the sizes of seeds, and each portion must weight more than 5 g. Then, weigh the two portions before putting in the electric oven for about 3 hours. Then, weigh them again after they are cooled off. Then, put the seeds back into the oven for another half an hour before taking them out to cool and be weighed again. Repeat the process, until the weight of the seeds before and after half an hour in the oven differs no more than 0.002 g. Then, calculate the moisture loss with the following formula:

$$\text{Moisture (\%)} = \frac{\text{wt.of sample before drying} - \text{wt.of s.after drying}}{\text{wt. of sample before drying}} \times 100$$

The method of using an electric oven of 130° and drying the seeds for 40 minutes may also be adopted, and there

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are also other instruments for testing the moisture content quickly.

For testing the moisture content, each sample is tested simultaneously in two ovens, and the results must not differ more than 0.1%. When other methods are used, the results must not be more than 0.5% different, and the average of the two results is considered the moisture content of the sample.

(4) The Inspection of Insects

Take 2 chin of rice seeds from the sample, and put them in the three sizes of 2.5, 1.5, and 1.0 mm sieves and shift, then inspect the substance that passes through the sieves. The rate of the insect content is calculated from the number of live insects; however, dead insects and insects in hibernation should also be noted. If the temperature of the sample seeds is less than 10°C, then they should be kept in an environment of 20 to 30°C for 13 to 20 minutes before inspection.

Again, take 5 g of rice seeds from the sample, then, count the number of grains, before using a knife to cut open each grain to inspect and to find any insect, egg, moth, or larva, and figure out the number of them for each kg of rice.

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SECTION 3. STORAGE OF RICE [p 673]

In the process of storage, the nutritional value, the quality of the processed product, the rate of utilization vary with the condition and the duration of the storage.

The quality of the rice does not change much under normal storage conditions. If the rice is stored improperly it may become heated or moldy, or there may be insects. If the rice is stored properly, the duration of storage also makes a difference. (Table 24-2)

Table 24-2 Changes in Nutritional Content and the Duration of Storage

成 (1) 分	(4) 出产年份及贮藏时间		
	1958年新稻 (贮藏約一个月) 5	1957年收获 6 (贮藏一年)	1955年收获 7 (贮藏三年)
粗蛋白 2	9.45%	9.00%	8.65%
粗脂肪 3	2.25%	2.20%	2.02%

注：湖南省醴澧县花林坪仓库不同贮藏期限，胜利籼与晚儿粘混和的稻谷。 8

1. Content 2. Protein 3. Fat 4. Year of production and duration of storage 5. New rice of 1958 (stored about one month) 6. the harvest of 1957 (stored about one year)
7. The harvest of 1955 (stored about three years)
8. Note: Stored in Hua-lin-p'in Warehouse of Ling-li-hsien, Hu-nan. The rice is a mixture of Sheng-li-hsien and Wan-erhchan varieties.

The newly harvested rice is not very hard, and the seeds break easily while being processed. In the cooking process, much of the nutritional content is lost in the cooking liquid, and the cooked rice is very sticky. Since it does

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not absorb much water, the volume of the cooked rice is small. These characteristics improve, after the newly harvested rice has been stored for the short period of time. However, if it is stored for too long a period, then, the cooked rice loses its color and flavor, as well as its stickiness. It is no longer very palatable.

1. FACTORS AFFECTING QUALITY CHANGES OF RICE DURING STORAGE PERIOD [p 673]

The chief factor which affects the quality of rice during storage is the activity of life (respiration) and the attacks of the microorganisms which are attached to the seeds.

(1) The respiration function of the rice seeds

Just like any other needs of grain plants, the respiration function of the rice seeds is a biological process of oxidation of the carbohydrates and other nutrients. The respiration may be divided into the aerobic and the anerobic. The aerobic respiration releases heat and produces carbon dioxide and water. The anaerobic respiration produces heat and also acetic acid, lactic acid, alcohol, or carbon dioxide depending upon the nature of the respiration. The amount of heat released by anaerobic breathing is far less than aerobic breathing.

The respiration decomposes the nutrients of the seeds and they are lost in the water and carbon dioxide which are released into the air. Thus the dry substance of the seed is gradually reduced. Under normal storage conditions, the respiration of the seeds is very weak, and the reduction in dry substance is almost beyond detection. If the rice is stored improperly, the respiration action of the seeds is increased, and the heat released by the respiration is accumulated in the pile of rice, which becomes increasingly warmer. The weight of 1,000 seeds drops sharply, and the seeds cannot sprout any more. They may even become rotten, or not edible.

The factors that affect the breathing of the rice seeds are as follows:

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Table 24-3 The Relationship between the Temperature of Rice and the Thickness of the Carbon Dioxide in the Air of the Storage Place (Kwangtung Provincial Food Studies Laboratory, 1959)

粮 (1) 温(°C)	2 囤内空气中二氧化碳浓度 (%)	增 (3) 长 (%)
10—20	0.6446	100.0
21—30	1.1873	184.2
31—40	2.3224	360.3

1. The temperature of the grain (°C) 2. The density of the carbon dioxide in the air of the storage bin (%) 3. Increase (%)

a. The Moisture Content of the Seeds

The respiration of the dry kernels is weak. If the moisture content is between 10 and 11%, then the amount of the carbon dioxide released by the breathing action cannot be detected by ordinary methods. As the moisture content increases, so does the respiration. When the moisture content reaches 14.5 to 15%, then the respiration increases very rapidly.

b. The Temperature of the Storage

When the temperature of the storage is low, then the respiration of the rice seeds is weak. As the temperature rises 10°C, the respiration is doubled. A test conducted in Yang-chiang-hsien, Kwangtung proved that there is a relationship between the temperature of the storage and the density of the carbon dioxide (Table 24-3).

c. Ventilation

The oxygen and the carbon dioxide content of the storage affects the intensity of the breathing action. If the moisture content is low, the seeds may be stored tightly,

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with no ventilation. When the oxygen content is reduced due to lack of ventilation, carbon dioxide increases, and the accumulation of carbon dioxide hinders respiration. However, if the moisture content of the kernels is high, then if the storage is poorly ventilated, the effect of the anaerobic respiration may be even more harmful.

Besides, the respiration of the kernels that are not completely ripened is higher than the normally ripened kernels; that of the broken kernels is higher than that of the whole kernels. The respiration of the newly stored kernels is higher than that of the kernels that have been stored for a prolonged period of time.

(2) Microorganisms

Such microorganisms as the fungi, bacteria, molds, and yeasts can all be found on the stored rice kernels. The types of microorganisms attached to the rice kernels are very complicated; they vary with the local climate, and the condition and duration of storage.

The various fungi on the kernels have different effects on the safety of the kernels. A test conducted by Wu-han Institute of Microorganisms of Academia Sinica on the fungi of the stored keng kernels with 15 to 16% of moisture, in the seven different warehouses of T'uan-p'u People's Commune of Hsi-shui-hsien, Hupei proved that the most numerours fungi on the rice kernels are Thizopus nigricans, Mucor, Saprolegnia, Plasmopara, and Phytophthora, and they are considered to be quite dangerous to the rice kernels in storage.

These microorganisms may secrete all kinds of enzymes to decompose the protein, carbohydrates, and fat content of the kernels in order to obtain nutrients and produce heat. When these fungi multiply rapidly, the heat they produce may cause the temperature of the kernels to rise. The kernels that have been harmed by these microorganisms, have a dark color, and smell moldy, alcoholic, or sour. Some of the microorganisms may produce poisonous substances which may harm people or animals who eat the rice. The factors in grain storage which affect the growth and reproduction of the microorganisms are as follows:

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a. Temperature

There is a definite temperature limit for the growth and reproduction of each type of microorganism . As shown in Table 24-4, the microorganism multiplies 80 times faster within a three-month period when the kernels are stored in a ventilated place of 35°C temperature, with the moisture content of 19.6%, compared with the kernels stored under 15°C temperature conditions.

Table 24-4 The Number of Fungus Spores Attached to the Rice Kernels of Various Moisture Contents Kept in Storage for Three Months

(4) (单位: 1,000个)

稻谷水分 1 (%)	2 通风贮藏			3 密闭贮藏		
	15°C	25°C	35°C	15°C	25°C	35°C
13.8	3	4	3	3	2	5
15.2	7	10	20	5	5	5
17.2	30	200	1,440	4	4	3
19.6	100	1,000	8,000	10	10	2

1. Moisture content of the rice kernels (%)
2. Ventilated storage 3. Tightly closed storage
4. Unit: 1,000 spores

b. Relative Humidity and the Moisture Content of the Rice Kernels

The relative humidity most suitable for bacteria and yeast is 100%. The lowest moisture content under which they may reproduce is 16 to 18% of the rice kernels. The fungi do not demand as much as the bacteria and yeast with respect to relative humidity and the moisture content of the kernels. However, they grow best under the conditions of 60 to 75% of relative humidity and no less than 14 to 15%. This is why stored grain is more often damaged by fungi than bacteria and yeasts.

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c. Oxygen

The amount of oxygen content in the air may affect the growth and reproduction of the microorganisms. Many of the fungi can reproduce only when there is oxygen. However, some microorganisms can grow in either aerobic or anaerobic conditions. Since there are many kinds of microorganisms on the rice kernels, the removal of oxygen from the air with tightly closed storage methods cannot stop the reproduction of all the microorganisms. As indicated in Table 24-4, when the kernels are kept in tightly closed storage, the growth of the fungi is controlled, but the kernels are damaged by yeasts, and various degrees of alcoholic odor may be detected.

(3) Stored Rice Pests

Some 50 species of insects have been found in our country infesting stored rice, and more than 14 species of mites have been discovered in grain storage. It is a very important responsibility to keep the stored rice from being damaged by these pests. Major rice growing areas of our country, which are south of the Yangtze river, are particularly bothered by these pests due to the warm temperature. When the kernels have been damaged by these insects, the quality of the rice drops, and sometimes, it may not even be edible. In 1951, the rice milling plant of Li-chia-t'u of Ch'ung-ching milled some insect infested rice, and only 52 chin of polished rice was obtained from 100 chin of rough rice. Without the insect damage, 72 chin should have been the case.

The occurrence of pests is related to the following factors:

a. Temperature

The reproduction of the stored grain pests is related to temperature. The Chu-ku-tao [a species of the saw-toothed grain beetle] takes only 18 days to produce a new generation if the temperature is 35°C; if the temperature is 30°C, it takes 20.7 days; if the temperature is 25°C, it takes 30.3 days; if the temperature is 20°C, it takes 69.1 days. When the temperature reaches the highest or the lowest

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limit, the pests hibernate; and if this temperature condition continues for a certain period of time, the pests die. Therefore, it is possible to use the oven, or the sunning process, or a cold storage method to kill all the pests.

b. Moisture and Temperature

The moisture of the body of the pests comes mainly from the grain. Generally speaking, all stored grain pests like high humidity and warm temperature. Some cannot multiply when the moisture content of the grain is lower than 10%. Others cannot live only when the moisture content is above 8%. There are also some, which will only hatch when the relative humidity is above 70%.

c. The Whole Kernel of Rice

Some pests cannot bore into a whole kernel of rice. They eat only the broken ones. Therefore, to separate the broken kernel from the whole ones is one way of keeping the pests out of the grain storage.

2. RELATIONSHIP AMONG TEMPERATURE, MOISTURE CHANGE AND CARE OF STORED RICE [p 677]

As we have just mentioned, the physiology of the rice kernel, the harmful microorganisms, the insects,and the mites are all closely related to temperature and moisture of the storage. Therefore, the variation of temperature and moisture is the key to safe storage.

(1) The Variation of Temperature of the Stored Rice

The temperature of the stored rice is mainly affected by the temperature of the external atmosphere (we may call it the "external temperature".) and the various biological activities within the pile of grain. The importance of these factors is determined by the concrete conditions. When the moisture content is high, then the temperature of the kernel is determined mainly by the biological factor. If the moisture content is low, then, the temperature of the kernels is affected mainly by the external

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temperature. Therefore, the temperature of the kernels is at its lowest in February and March, and at its highest in August and September.

In view of safe storage, the first variation of temperature, i.e. caused by the biological factor, is very dangerous. The kernels may be easily damgged. Every effort should be exerted to prevent this kind of temperature variation.

Although the normal temperature of the stored rice varies with the season, the condition of the warehouse and the piles of rice are also closely related to the normal variation of temperature. When the warehouse is well insulated, then the highest temperature of the kernels is not as high as the kernels stored in warehouse that is not insulated.

The size of the grain pile also affects the temperature. The larger is the pile, the less is the effect of the external temperature on the kernels which are inside the large pile. However, since the kernels inside of a large pile are not affected by the external temperature, they have a tendency to remain warm after the external temperature has dropped. This condition creates a favorable temperature for the multiplication of the pests. Therefore, the larger piles are more difficult to be safely maintained.

If the kernels are tightly packed when they are being piled up, they are easier to be heated. Ventilation directly affects the exchange of heat between the grain pile and the atmosphere. If the pile of grain is well ventilated, then the temperature of the kernels drops faster in the winter, and rises faster in the summer too.

(2) The Variation of the Moisture Content of the Stored Rice

a. The Balance between the Moisture Content of the Rice and That of the Air

Just like any other kind of grain, the surface of the kernel and its interior are connected with capillaries of the diameters of 10^{-4} to 10^{-7} cm. At present, the physical and chemical mechanism with which the kernel absorbs the moisture from the air is not yet wholly understood, but, it is

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generally agreed that the vapor in the air is absorbed by the kernel through these capillaries, and moisture of the interior of the kernel is also evaporated through these capillaries.

Under certain temperature and humidity conditions, the moisture content of the kernel is called balanced when the seed of its moisture absorption equals the moisture it evaporates. The relationship between the moisture content of the kernel and the relative humidity of the air is as follows:

When the relative humidity remains constant, as the temperature rises, the moisture content of the kernel drops; as the temperature drops, the moisture content of the kernel rises. When the temperature remains constant, then, the moisture content rises as the relative humidity becomes higher; it drops, as the relative humidity becomes lower.

b. The Meaning of Moisture Balance in Relation to Grain Storage

Due to this characteristic of balancing moisture, if the rice kernels are stored in a place with relatively stable temperature, and a humidity condition separated from the atmospheric humidity outside the storage, then, the moisture content of the kernels determines the relative humidity of this closed environment. In other words, the moisture content of the kernels inside a pile of grain is closely balanced with the relatively humidity there. Thus, the relative humidity of the air within a grain pile is almost the same as the moisture content of the kernel. Since the relative humidity determines the speed with which many microorganisms multiply, the moisture content of the stored grain is very important to the safety of the grain stored.

c. The Variation of the Moisture Content of the Stored Rice

(a) The daily and the Yearly Variation

The kernels which are on the surface of a pile are in direct contact with the air, and their moisture content changes very fast. On the 2nd of June, 1955, the moisture content of the surface kernels was observed in

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K'un-shan, Kiangsu. It was noted that withi 24 hours, the highest moisture content was 14.2% from 2 to 4 A.M., then it began to drop to the lowest of 11.95 at 4 to 6 P.M. The difference of the highest and the lowest is as much as 1.25%.

Aside from the surface layer, the moisture content of the kernel of other areas inside of a pile does not vary much during a day. Some of the kernels have been observed to have constant moisture content within a month's time.

When the humidity of the air changes from season to season, the moisture content of the kernels changes also, but the variation is different with the kernels of the various layers of a pile.

If the rice is piled loosely, with a small area in contact with the air, then, the average variation of moisture content of the kernels of the entire pile is small. This is why if the moisture content of the rice kernels is small it is wise to pile them loose in a tightly closed storage room, so that they will not absorb moisture from the atmosphere.

(b) The Transfer of Moisture

The moisture of the various areas of a grain pile is noted to transfer from one area to another. In the autumn, the moisture content of the kernels in the center of a pile is often transferred to the kernels on the surface. Sometimes, a thick layer of kernels on the surface become moldy or rotten due to too much moisture. The larger is the pile, the more serious is this problem. This moisture transfer is due to the temperature difference between the air and the center of the pile. In the fall, when the external temperature drops, the temperature of the center of the pile becomes higher than that of the surface. The air reaches the center of the pile and becomes warmer due to the higher temperature there, then, when it returns to the surface of the pile, the cool temperature turns it into a vapor, which condenses into moisture and is abosrbed by the kernels near the surface of the pile.

Due to the same reason, the moisture of the kernels near the surface is transferred to the kernels of the lowest position in the pile when the external temperature rises

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in the spring and summer.

However, the transfer of moisture within a pile of grain in storage is not as fast as the transfer of moisture between the air and the kernels, therefore, the threat to the safety of the stored grain is not as great in case of the transfer within the pile.

(c) The Relative Safe Moisture Content of the Stored Rice

Even if the moisture content of the kernels is high if they are stored in a certain low temperature environment, they may be kept from becoming moldy. On the other hand, if the moisture content is very low, they may still be damaged if they are stored in a high temperature environment. The so-called relative safe moisture content is the moisture content in relation to the temperature.

The relative safe moisture content of stored rice under various temperature conditions is given in Table 24-5.

Table 24-5 The Relative Safe Moisture Content of Stored Rice

温 (1) 度 (°C)	水 (2) 分 (%)	备 (4) 注
35	13 以下 (3)	
30	13.5以下 (3)	
20—25	15 以下 (3)	
15	16 以下 (3)	
10	17 以下 (3)	
5	18 以下 (3)	只能保持短期安全 (5)

1. Temperature (°C) 2. Moisture content (%)
3. Below --- 4. Note
5. May be kept safe within a short period of time only.

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The climate of the various regions makes the relative safe moisture content different from one place to another. For example, in the southern parts of Kiangsu, if the moisture content of the rice kernels is 14%, they may generally be stored safely through the summer. In Kwangtung, however, if the moisture of the stored rice kernels is as much as 14%, they will become heated and spoiled in May. Actually, due to moisture transfer, leaking warehouse, and other reasons, even if the moisture content of the rice was very low when it was stored, constant inspection is still necessary to insure safety.

3. RICE SOTRAGE METHODS [p 680]

(1) Preparation Before Storage

a. Warehouse Preparation

The warehouse must be inspected, and measures taken to prevent dampness, heat, and rats. If necessary, the eaves should be made longer, the walls thicker, and the cracks between the ground and the walls filled, and the windows repaired.

b. The Preparation of the Tools

The mats, the sacks, and the bins should all be carefully inspected for rats, insects, holes, dampness and so forth. They must be thoroughly washed, sunned, or otherwise cleaned and disinfested.

c. Disinfect the Warehouse

The cleanliness of the warehouse, inside and outside, is one of the methods to keep away the pests. After the warehouse is thoroughly cleaned and swept, it must be disinfected with drugs. Normally, it is sprayed with a 6% 666 solution. After spraying, the doors and the windows should be shut for several days. Afterwards, the drug

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residue should be cleaned out, and fresh mats be laid on the ground. If possible, lime water may be used to paint the interior over, and the room should be left to dry for several days before it is ready to store the rice.

Besides, certain medicine may also be used to smoke the warehouse for disinfection. Certain disinfecting rolls are being tested in Kiangsi currently. It is said to be very effective for disinfecting the warehouse with the smoking method. The procedure is considerably easier.

d. Quality Inspection of the Rice to Be Stored

The rice kernels to be stored in a warehouse should be inspected for moisture content, insect infestation, etc.and measures should be taken accordingly before they are admitted to the warehouse.

(2) The Method of Storage

a. Dry Storage

This is the most basic method and the safest. Normally, the kernels are sunned first. However, due to the limitation of climate they are sometimes dried in an oven. If a drying oven is used, it is important not to use too high a temperature, which may cause the kernels to break. According to the experience of Kiangsu, for drying rice, a hot air device of about 70°C is quite sufficient. The kernels are heated not over 40°C, and the rate of broken seeds is about 12 to 14%. If the original moisture content is especially high, then, the kernels may have to be dried more than once.

To store dried rice, it is important to keep the doors and windows closed so that the moisture of the air will not be absorbed by the grain.

b. Tight Storage

With tight storage, the dried grain is tightly separated from the external atmosphere. In a closed environment, the oxygen is soon exhausted by the respiration of the kernels, and carbon dioxide increases with the result of weakened biological activity of the kernels. All the aerobic fungi and pests are controlled or dead. Therefore, this is a very good method of storing grain.

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However, with this method, the kernels must be dried to the extent that the moisture content is below safety level. In areas of the Northwest and other places, where the ground water table is low and the soil is very dry, people dig holes in the ground to store grain. These underground cellars are very serviceable; however, they are seldom large enough to hold a great quantity of grain. If necessary, grain elevators may be built to provide tight storage space. The local grain storage official created a method of using sand, husks, ashes, and fire bricks to cover the surface of a grain pile. This method is also quite useful for keeping dried grain from absorbing external moisture. However, before this method is adopted, it is absolutely necessary to make certain that the moisture content of the kernels is below 13.5 to 14%; otherwise, they may become heated and spoiled.

c. Low Temperature Storage

Under low temperature, all the biological activities come to a halt, therefore, low temperature is very beneficial for stored grain. Even though the moisture content of the kernels may be high, low temperature may preserve their wholesomeness longer.

To bring low temperature to the storage, one method is to open the doors and windows when the outside temperature is low, to let the cool air reduce the temperature of the warehouse.

When the weather is cold, the kernels may be laid in the open air to cool. The grain may also be sifted in the wind, or a cooling device may be installed in the transport vehicle to cool the grain before it reaches the warehouse. When the grain is cooled during the winter, measures should be taken to preserve the low temperature as long as possible, to prevent the temperature of the grain from rising suddenly when the season changes.

d. Mechanical Ventilation

Cool air may be pumped into the storage room to keep down temperature. According to the test conducted in Wu-han by the Bureau of Food, when a mechanical device was used to bring cool air into a warehouse for 96 hours, the 1,800,000 chin of rice stored in the warehouse was cooled

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from 11.6°C to 2.7°C.

If a cool air device is operated properly, it may reduce the moisture content of the kernels also. According to the Bureau of Food of Szechwan Province, when the moisture of the upper layer of the rice kernels in storage was 14.6%, that of the middle layer 14.3%, and that of the lower layer 14.4%; after the warehouse was artificially ventilated 10 times, the moisture content of the upper layer or grain was reduced to 11.2%, that of the middle layer and lower layer to 11.1%; while the kernels of the control group which was not ventilated artificially showed no change in their moisture content. This is why mechanical ventilation is a very useful method for treating the stored grain that has begun to show signs of being heated. The mechanical device used for this purpose is mainly a fan or an air circulator which must generate a certain amount of air current for the size of the warehouse.

e. Chemical Storage

There are various drugs which may be used to control or to kill the stored grain pests or microorganisms. These drugs have various degrees of affect on the kernels themselves. They may destroy the biological functions of the kernels and make them incapable of sprouting.

The effects of chloropicrin [nitrotrichloromethane] used as a grain preserver are as follows:

(a) It may destroy the stored grain pests and control or kill the microorganisms attached on the kernels.

(b) It functions to reduce temperature of the kernels, so that when the external temperature rises, the temperature of the kernels rises slower, and when the external temperature drops the temperature of the kernels drops faster.

(c) Its effect on the sprouting rate of the kernels depends upon the moisture content of the kernels. According to the studies of Kiangsi Institute of Food, conducted in 1958, if the moisture content is below 12%, then the use of chloropicrin has no effect on the kernels with regard to sprouting. According to the studies of Kuo Ying-wen (6753 5391 2429) and co-workers in Szechwan, if the moisture content

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of the kernels is about 14%, the use of chloropicrin has definite effects on the kernels with regard to sprouting.

(d) Only a small amount of chloropicrin is needed, about 15 to 25 g for each m^3 of the warehouse, or 32 to 35 g to each m^3 of stored grain; therefore, this is an inexpensive method.

In our country, the use of chemicals for the preservation of grain has just begun. More studies are needed to determine their effects and effectiveness.

F. Hot Grain Storage Method

With this method, the kernels are put into the warehouse when they are still hot from the sun or the drying oven, so that the very high temperature of the kernels will remain constant for a certain period of time to kill the harmful pests and microorganisms. This has been one of the storage methods of the masses. Its important aspects are as follows:

(a) When the kernels are sunned, they should be turned very frequently and remain in the sun for only a short while. When they are put in the warehouse, their temperature should be 40 to 50°C.

(b) If the high temperature of the kernels is kept for 7 to 15 days, the pests may be killed. After that, the temperature should be brought down as quickly as possible.

(c) When this method is used, the moisture content of the kernels should be below 11%, so that the high temperature of the kernels in storage will not affect the quality of the kernels.

According to the experience of the various areas where this method is being practiced, it is very effective for keeping the pests out of the warehouse and it is not harmful to the quality of the kernels.

Although this is a good method, its application is nevertheless limited, because, after the period of 7 to 15 days is over, it is rather difficult to bring the temperature down quickly. If kernels are left in such a high temperature for

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a prolonged period of time, their quality will definitely be affected. The sunning method cannot always be practiced everywhere, because it is necessarily limited by the weather. If oven drying method must be used to dry the kernels until the moisture content is below 11%, the cost will be prohibitive. Due to these reasons, this method is not extensively adopted at present.

4. PREVENTION OF INSECT PESTS [p 684]

It is important to prevent the occurrence of pests in the grain storage. If the kernels are infested with pests, it is urgent to kill them before they spread and damage the grain of the entire warehouse.

(1) Disinfestation of the Grain before it Enters the Warehouse

Such pests as the moth and mites may be brought from the field with the harvest. Many others sneak into the grain when it is being processed. It is important that all precautionary measures must be taken to inspect the tools and the location during the various processing procedures before the grain is brought to the warehouse. If insects are discovered, they should be eliminated immediately.

(2) Preventing Infestation after the Grain is Stored

First of all the grain storage must be thoroughly cleaned and maintained clean. Outside of the building, the walls and the walks may be sprayed with 666 solutions to keet the environment sanitary.

(3) Mechanical Extermination

There are four ways of exterminating the pests physically:

a. Sunning

Sunning in the summer is very effective for exterminating the pests that have already infested the rice kernels.

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According to the experience of Kiangsi Bureau of Food, the kernels should be laid on the yard to about one ts'un thick. When the temperature in the sun is about 44°C, the kernels should be exposed to the sun for about 6 hours, then the eggs, larva, and adult moths which are hidden in the kernels may be 95.21% killed. If the temperature in the sun is 50°C, then, the killing effect may reach 100%.

b. Mechanical Drying

If the infested kernels have a high moisture content, they may be put in a drying mechine with a temperature of 80 to 100°C, until the temperature of the kernels reaches about 50°C. Under this kind of high temperature, the pests die quickly.

c. Low Temperature Method

When the temperature is as low as 15°C, the stored grain pests go into hibernation, and reproduction stops. If the temperature is reduced to 5°C, then, some of the pests will die.

To use this method, the infested grain may be laid on the yard in the winter. The pile should be constantly and regularly turned so that all the kernels will be cooled evenly. Afterwards, the grain is put back in storage, and the low temperature is maintained for a certain period of time. After the pests have either died or gone into hibernation, the kernels may be shifted through a sieve so as to eliminate them. This method has been proven effective even for the regions where the temperature in the winter is not very low.

d. Mechanical Extermination

At present the mechanical tools used for exterminating the pests are the blower and the sieve. They are generally used when the extent of damage is light. The blower may separate the pests from the kernels. With the sieve, due to the fact that the size of the pests is different from the grain, if various sizes of sieves are used, the pests may eventually be separated from the kernels with success.

These tools are more effective for the pests that remain outside the kernels, but not for those that are hidden

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within the kernels. Generally speaking, the extermination can seldom be thorough.

(d) Chemical Exterminators

The chemical exterminators most frequently used in this country today are chloropicrin (CCl_3NO_2), Ethylene chloride ($C_2H_4Cl_2$), Methyl bromide (CH_3Br). The advantage of chloropicrin is the fact that it is very penetrating and a small amount can be very effective. There is no danger of inflammation or combustion. Its disadvantage is its low boiling point (112.4°C) and therefore it is not easily evaporated. It remains on the kernels for a prolonged period of time, and therefore, if the moisture content of the kernels is high, the sprouting capacity of the kernels may be seriously damaged.

With chloropicrin, the poison enters the pests' body through their respiratory system and destroys their cells. Ethylene chloride attacks the pests' nervous system and the fat-like substance. It is inflammable. Methyl bromide is a gas under normal temperature conditions. It is very penetrating and evaporates very fast. However, it is odorless and colorless, and people may be poisoned without being aware of its presence.

These drugs may be applied with the following methods:

a. Temperature Aside from methyl bromide, the others may be applied only when the temperature of the grain is no less than 12°C, and the average temperature of the atmosphere is no less than 10°C.

b. Dosage When used to exterminate insects, the following amount should be applied:

Table 24-6 The Amount of Chemicals used for the Extermination of Stored Grain Pests

药剂名称 (1)	部 (6) 位	(10) 用药量 (克/立方米)
氯 2 化苦	空间体积 7	20—30
	粮堆体积 8	35—70
二氯化乙烯 3	空间体积 7	300
	粮堆体积 8	450
氯化苦、二氯化乙烯混合剂 4	空间体积 7	二氯化乙烯 74—83,氯化苦 6—7 11
	粮堆体积 8	二氯化乙烯 203—280,氯化苦 17—20 12
溴代甲烷 5	空间和粮堆体积平均 9	15—30

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1. Name of chemical 2. Chloropicrin 3. Ethylene chloride 4. a mixture of chloropicrin and ethylene chloride 5. Methyl bromide 6. Area applied 7. Cubic measure of space 8. Cubic measure of the pile of grain 9. The average between the cubic measure of space and that of the grain pile 10. Chemical used (g/cubic meter) 11. Ethylene chloride 74-83, chloropicrin 6-7 12. Chloropicrin 17-20, ethylene chloride 17-20

c. Method of Application

The warehouse must not leak air. For chloropicrin and ethylene chloride, the chemicals may be put in a container hanging in the warehouse, or it may be sprayed. With these two methods, the operation is done inside the warehouse, and many difficulties arise. During the recent years, many areas adopted the method of connecting a tube and applying the chemicals from outside. This method of application has been found to be very successful. If chloropicrin and ethylene chloride are applied, the warehouse should be tightly closed for no less than 72 hours; if methyl bromide is used, it should be closed tightly for 24 to 72 hours.

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SECTION 4. UTILIZATION OF RICE BY-PRODUCTS [p 686]

Various procedures are required after the rice is harvested, before it is processed into polished rice ready for cooking. Many by-products are obtained during these processing procedures. For example, the weight of the husks is about 18 to 20% of the weight of the kernels, and the weight of the outer seed-coats is about 6 to 8% of the rough rice. These proportions vary with the varieties and the growth condition of the current year. (Table 24-7) In the past, the by-products of rice were not considered very valuable. Since the great leap forward of 1958, they have been processed and utilized, with great success. The following is a discussion of the many uses of the by-products of rice.

Table 24-7 The Rate of Husks, Seed-coats, and Rice of the Various Varieties

品 (1) 名	产地 10	出糙率 (%) 20	谷壳率 (%) 21	精白率 22 23	24 出白率 (%)		25 出糠率 (%)		26 出碎率 (%)	
					对糙米 27	对稻谷 28	对糙米 27	对稻谷 28	对糙米 27	对稻谷 28
2 南特号	安徽 11	78.18	21.70	标一	90.74	70.84	8.43	6.59	0.8	0.62
2 南特号	湖北 12	77.81	21.20	标一	87.30	69.50	10.47	8.15	1.7	1.32
2 南特号	江西 13	77.31	21.10	标一	88.67	68.55	9.08	4.98	1.53	0.18
3 光明籼	四川 14	78.87	19.87	标一	87.90	69.33	10.91	7.56	0.79	0.62
4 清水早	福建 15	76.70	22.63	标一	90.01	69.02	9.12	6.99	0.48	0.36
5 393	广西 16	78.43	21.19	标一	90.50	70.98	8.27	6.48	0.95	0.74
6 青森5号	吉林 17	81.04	18.73	标一	90.30	73.18	8.77	7.11	0.46	0.37
7 水原300粒	河北 18	80.23	18.31	标一	90.82	72.88	8.73	7.0	0.23	0.18
8 412	江苏 19	79.61	20.01	标一	91.11	72.26	7.80	9.81	0.31	.0.24
9 牛毛黄	江苏 19	81.43	18.28	标一	88.31	71.91	11.01	8.96	0.55	0.44

29 注：上述数据系试验室脱壳机及试验精米机进行砻谷及碾米试验的结果。前6种系籼稻，后4种系粳稻。

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1. Varieties 2. Nan-t'e-hao 3. Kuang-ming-hsien 4. Ch'ing-shui-tsao 5. No.393 6. Ch'ing-sen No.5 7. Shui-yuan 300 8. No.412 9. Niu-mao-huang 10. Producing area 11. Anhwei 12. Hupei 13. Kiangsi 14. Szechwan 15. Fukien 16. Kwangsi 17. Kirin 18. Hopei 19. Kiangsu 20. Percentage of rough rice from the whole kernels 21. Percentage of husks from the whole kernels 22. Percentage of polished rice 23. See the related item 24. Percentage of polished rice 25. percentage of rough rice , 26. percentage of broken kernels 27. With regard to rough rice 28. With regard to the whole kernels.

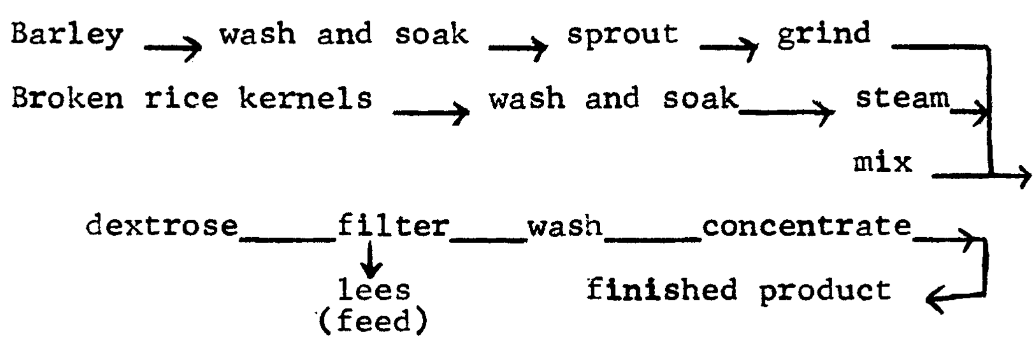
29. The aforementioned figures are obtained from the husking and polishing mechines of the laboratory. The first six varieties belong to the hsien subspecies, and the last four varieties belong to the keng subspecies.

1. UTILIZATION OF LOOSE RICE [p 687]

The broken rice kernels are called Mi-hsi in Kiangsu and Chekiang. The chemical content is similar to that of the whole kernel, containing a great deal of starch. They may be used to manufacture syrup , starch, various wines, wine lees, and feed.

(1) To Manufacture Syrup

When broken rice kernels or other starch is made into a sweet tasting dextrose, it is called syrup, which is very digestible and is a necessary raw material for confectionaries. When the syrup is made of broken rice kernels, it is of very pure quality. The process of making the broken kernels into dextrose is very easy, and about 10% of barley may be saved. The manufacturing process is as follows:



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(2) To Manufacture Starch

A glassy and very high quality starch may be obtained when broken rice kernels are used as raw materials. This starch is suitable for the use of the textile industry and for the drug industry to make glucose. According to the experience of Lung-an Milling Plant, about 140 chin of starch and 30 chin of dregs may be obtained from 100 chin of broken rice kernels. The manufacturing process of that plant is as follows:

Broken rice kernels → cleaning process → soak in water → add water and grind → shift through a sieve (add water to the dregs, and grind again, repeat two times, before using the remaining dregs for feed) → let it settle → take out the water → wet starch → dried in the sun → Dry starch

2. EXTRACTING OIL FROM RICE CHAFF AND COMBINED UTILIZATION [p 687]

The oil obtained from rice husks may be used as a substitute for soap manufacturing to save edible vegetable oil. Rice husk oil after being refined is also edible. The experiments of obtaining oil from rice husks conducted in Shanghai, Tientsin, Wu-han, and Canton since 1954 have been very successful. It has been proven that rice husks oil is one of the solutions to the problem of the increased demand of fats and oils for industry and for food.

The dregs after the oil has been taken from the rice husks may be directly fed to animals, or it may also be made into raw materials for many other products.

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Comprehensive Utilization of Rice Husks

- Rice husks — oil
  - rice husk oil
    - idustrial use
    - refined
      - edible oil
      - husk wax
      - soap
  - husk dreg cake
    - pig feed
    - white wine — alcohol (dreg for feed)
    - syrup — food coloring (dreg for feed)
    - yeast
    - vinegar
    - vegetable lime (a raw material for drug manufacturers)
    - glue (for wood)

Due to the difference of the refining process and the varieties of rice, the chemical elements of the rice husks are different. (Table 24-8) According to Wu-hsi Vegetable Plant, the husks of the hsien varieties contain more oil than those of the keng varieties; more oil in the late varieties than the early varieties; more oil in the single-seasoned varieties than the double-seasoned varieties.

(1) Obtaining oil from Rice Husks

To obtain oil from rice husks is no different from obtaining oil from other vegetables. The husks may be pressed by a machine press, or they may be soaked to obtain oil. In the later method, a solution is added to dissolve

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the fat content of the husks, and the refine the liquid to obtain oil.

Table 24-8 A Chemical Analysis of Rice Husks

来源 1	名称 5	水分(%) 10	灰分(%) 11	脂肪(%) 12	蛋白质(%) 13	无氮浸出物(%) 14	粗纤维(%) 15	淀粉(%) 16	多缩戊糖(%) 17	分析单位 18
2 上海建成米厂	粳米糠 6	13.30	8.39	17.18	12.89	—	7.18	21.50	8.07	食品科学研究所 19
3 上海第一米厂	籼米糠 7	9.63	9.82	19.01	12.92	—	8.71	12.33	8.71	食品科学研究所 19
2 上海建成米厂	晚籼米糠 8	10.12	9.08	22.14	13.22	—	9.72	18.16	8.68	食品科学研究所 19
4 军粮城米厂	米糠 9	10.51	8.31	21.90	15.88	37.33	6.07	—	—	华北农业科学研究所 20
—	米糠 9	13.5	9.40	18.20	14.80	35.10	9.00	—	—	东北农业科学研究所 21
—	米糠 9	11.89	10.62	19.85	13.35	36.11	8.18	—	—	华中农业科学研究所 22

1. Source 2. Ch'ien-ch'eng Mill, Shanghai 3. First Mill, Shanghai 4. Chun-liang-ch'eng Mill 5. Varieties 6. Husks of keng rice 7. Husks of hsien rice 8. Husks of late hsien 9. rice husks 10. Moisture content 11. Lime 12. fat 13. Protein 14.non-nitrogen substance 15. cellulose 16. starch 17.Pentose 18. Name of the scientic unit which analyzed the husks 19. Institute of Food 20.Hua-pei Institute of Agricultural Sciences 21.The Northeast Institute of Agricultural Sciences 22. Hua-chung Institute of Agricultural Sciences

After the rice husk oil has been stored for a certain long period of time, the oil dissolves into fatty acids and glycerol. This is why fresh husks produce more oil than the husks that have been stored for any length of time. If the husks are to be transported before processing, it is best to dry them in temperatures from 95 to 110°C for 15 minutes, until the moisture content drops to below 6%, so as to keep the oil content.

At present, the machines used in our country for pressing rice husks are the wooden press, the hydraulic press, and the motorized press. Normally about 10 to 14% of oil may be obtained from fresh husks. The soaking method has also

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been successfully practiced in production. A higher rate of oil may be otained with this method.

a. The Process of Obtaining Oil with a Wooden Press

Rice Seed-coats → select through a sieve → steam → make into cakes → press → oil
↘ residue cake

b. The Process with a hydraulic press

Rice seed-coats → select through a sieve → grind → heat until soft → steam → press into cakes → press → oil
residue cakes
(the cakes are presses again for oil)

c. Motorized Press

Rice seed-coats → select through a sieve → add water →

steam → press → oil
↘ residue cakes

The oil coming out of the oil press may contain numerous foreign substances, it should be refined before use. It may contain about 3 to 6% of wax, the melting point of which is about 70 to 80°C. This is a very useful product in industry as raw material for electircal insulators, carbon paper, stencil paper, floor wax, shoe polish, medical ointment, and cosmetic products.

(2) The Use of the Residue Cakes

The residue cakes after the oil has been taken out contain protein, fat, and non-nitrogen substance. They may be used to feed animals, to make wines, or as raw material for making syrup. The chemical analysis of the residue cakes is shown in Table 24-9.

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Table 24-9 An Analysis of the Residue Cakes

1 材料来源	水分 5 (%)	粗蛋白质 6 (%)	粗脂肪 7 (%)	粗纤维 8 (%)	无氮浸出物 9 (%)	灰分 10 (%)	分析单位 11
2 天津军粮城米厂	7.70	17.10	7.72	6.75	52.11	8.62	12 华北农业科学研究所
3 广州	17.50	15.30	9.93	10.10	37.30	10.47	13 广东省粮食厅
4 湖南	8.40	13.64	9.08	11.53	46.76	10.54	14 湖南省粮食厅

1. Source of material 2. Chun-liang-ch'eng Mill, Tientsin 3. Kwangtung 4. Hunan 5. Moisture 6. Protein 7. Fat 8. cellulose 9. non-nitrogen substance 10. lime 11. Name of the scientific unit which analyzed the material 12. Hua-pei Institute of Agricultural Sciences 13. Kwangtung Bureau of Food 14. Hunan Bureau of Food

a. Making Wine

Every 100 chin of residue cakes of rice seed-coats may produce 25 to 28 chin of 50% white wine, or 17 to 18 chin of 60% white wine, with 170 chin of wet wine lees. The production process is as follows:

Residue cakes of rice seed-coats → crush and grind → stir → steam → cool → aid fermenting agent → put in a jar to ferment → distill → white wine
→ wine lees

b. Feed pigs with the residue cakes or the wine lees

Although the rice seed-coats are more nourishing for the pigs, it is more economical to process them and feed the residue to the pigs than to feed them directly to the pigs. With comprehensive utilization, out of one ton of rice seed-coats, we may obtain 120 kg of oil, 160 kg of wine, and 1,700 kg of wet wine lees. The total economic value is six times the amount of the seed-coats. In order to make the dregs more palatable for the pigs, they are often mixed with other feed products for the pigs.

If the seed-coats are used to feed the pigs directly, due to the highly perishable fatty acid contents, the pigs sometimes become sick from it. If the pigs are fed too much rice seed-coats directly, the pig fat has a tendency to become soft, and this fact will reduce the quality of the pig.

The process of oil pressing causes the cellolus content of the seed-coats to become soft, and thus more digestible for the pigs. Aside from the oil that is removed, the oil pressing process does not remove any of the nourishment. The animals require very little oil, therefore, the residue cakes are better for the animals than the seed-coats.

The Animal Breeding Farm of Shanghai Municipal Bureau of Agriculture conducted an experiment on the 22nd of February to the 23rd of May, 1956, with 30 six-month old pigs. The pigs are divided into two groups for the experiment. The group of pigs that wasfed with residue cakes gained 1,264 chin in the 93 days of the experiment, while the group that was fed with seed-coats directly gained only 1,077 chin during the same period. The meat of the pigs that were fed with the residue cakes was better also. The same kind of test was conducted by Anhwei Bureau of Food with similar results.

The wine lees of seed-coat wine are also good feed for the pigs. An experiment was conducted by Fu-li Plant of Ch'ang-chou to feed rice seed-coats, residue cakes, and wine lees to three groups of 48 pigs for five months. The result proved that wine lees are not any worse then seed-coats. As far as cost is concerned, the wine lees are the cheapest.

c. Other Use of the Residue Cakes

The powdered residue cakes may be made into syrup, with the same process as making syrup from the seed-coats. About 50 chin of 35% Bé syrup and 180 chin of dregs may be obtained from 100 chin of powdered residue cakes. The syrup is dark colored, with a bitter and sour taste, and may be used to make food coloring, etc.

When powdered residue cakes are soaked in diluted sulfric acid, lime citrate may be obtained. When the product is filtered and crystallized, a dry butyric acid may be obtained. About 20 chin of this product may be obtained from 100 chin of powdered residue cakes.

Powdered residue cakes may also be used as a

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substitute for wheat bran for the manufacturing of yeast.

3. COMBINED UTILIZATION OF RICE HULL [p 691]

The husks of rice contain three major chemical elements: pentose, celloluse, and carbon. About 92 to 93% of the carbon is silicon dioxide. (Table 24-10)

Table 24-10 An Analysis of Rice Husks

样 1品来源	水分(%) 4	灰分(%) 5	苯醇提取物(%) 6	多缩戊糖(%) 7	纤维素(%) 8	木质素(%) 9	全氮 10
湖南长沙2	10.25	11.39	0.74	22	20.66	20.66	0.24
北京3	11.82	16.95	0.83	17	29.00	21.80	—

1. Source of sample 2. Ch'ang-sha, Hunan 3. Peking
4. Moisture 5. Carbon 6. Benzalcohol for distilling
7. Pentose 8. cellulose 9. Xylose 10. Whole nitrogen

Table 24-11 Chemical Analysis of the Carbon of the Rice Husks

1 样品来源	SiO_2(%)	Al_2O_3(%)	Fe_2O_3(%)	Na_2O K_2O(%)	CaO(%)	MgO(%)	烧失重(%) 3
天 2 津	93.48	1.72	0.24	0.74	1.42	1.11	1.22

1. Source of sample 2. Tientsin 3. Loss of weight through burning

To use rice husks as fuel is an old tradition of our country. The ashes may be used as fertilizer. It is

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indeed meaningful if rice husks are used to produce gas, which may serve as the much needed source of power for the rural areas. It is estimated that 1/6 of the rice husks harvested is sufficient to provide the power needed to process the rice of the harvest, while the remaining 5/6 may be used to provide power for other industries.

When rice husks are ground fine, they may be mixed with other feed for the pigs. With heat and pressure, rice husks may also be manufactured into ceiling tiles, or acoustic boards, for synthetic lumber. Besides, rice husks are good for packaging fruits and glassware. They are also used as fillers when wines are being distilled.

However, the best use of rice husks is to distill from them many raw materials of chemical industry. With hydrolysis, an aldehyde may be obtained from rice husks. When this is distilled, we may obtain gas, acetic acid, methyl alcohol, acetone, phenol oil, neutral oil, activated charcoal, sodium silicofluoride, and fillings for plastic objects. All these products do not contradict one another. With very little capital, all of them may be obtained from rice husks.

(1) Obtaining Aldehyde from Rice Husks

Although rice husks do not contain as much pentose as the husks of corn or cotton seeds, rice husks are plentiful in the cities and are very cheap. Aldehyde is one of the important raw materials of organic chemistry. It is used to make nylon 66, and synthetic rubber. It is also the raw material for resins and high quality glass. It is used to synthesize drugs and dyes. It may also be used to refine petroleum, oleoresins, and turpentine. Aldehyde may be directly used to disinfect seeds.

The pentose content of the rice husks may be converted into aldehyde in accordance with the following formula:

$$(C_5H_8O_4)_2 \xrightarrow[\text{Hydrolysis}]{+\ H_2O} nC_5H_{10}O_5$$

$$C_5H_{10}O_5 \xrightarrow[\text{dehydration}]{-\ 3H_2O} C_5H_4O_2$$

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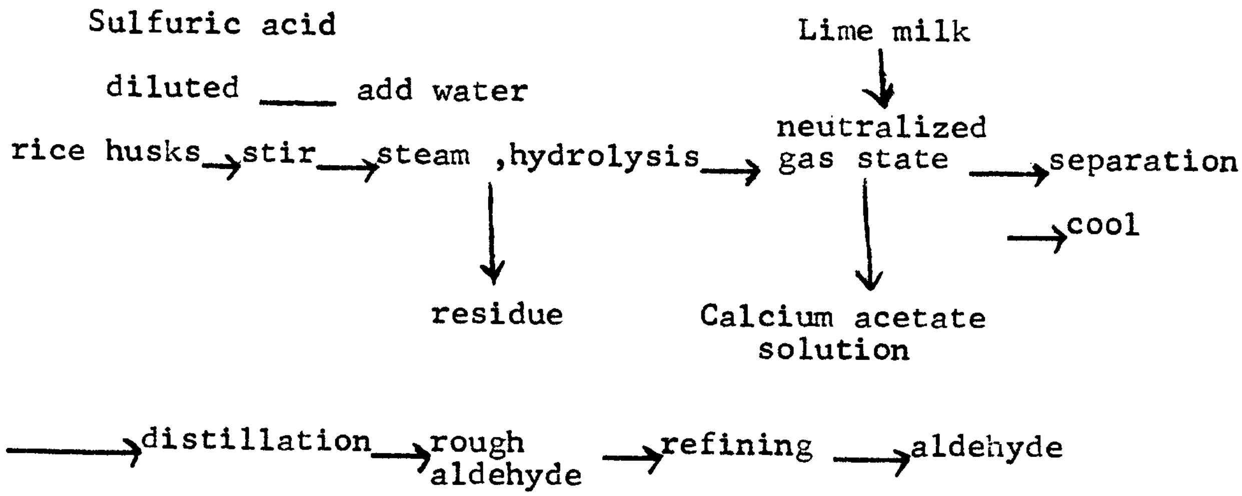
In our country, the manufacturing of aldehyde from rice husks began in 1956. At present, when rice husks are used, the production of aldehyde is as high as 5.5 to 6%, while the steam consumption has been down to below 30 tons for each ton of aldehyde, and the sulfuric acid consumption is down to 0.4 ton. The process is as follows:



(2) Dry Distilling of Rice Husks

When soil fuel is dissolved in a vacuum, the process is called dry distillation. The dry distillation of rice husks produces methyl alcohol, acetone, acetic acid, asphalt, activated charcoal, and gas. These products are very important raw materials for chemical industry. They may be used in medicine, dyes, textiles, leather, food, and construction.

The process is to deliver the rice husks from the mill directly to the dry distilling room, where they are heated, then cooled. After the cooled mixture settles, the top liquid is acetic acid, and the oil layer is the tar. The inflammable gas produced during the cooling process may be used as fuel for internal-combustion engines.

From acetic acid solution, we may obtain acetic acid, methyl alcohol, acetone, black wax, and sodium acetate. The contents of these are not constantly the same. They vary with

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the raw materials, the temperature and the duration of the distillation process, and the structure of the hearth.

The tar is a black liquid, with very complicated elements. It contains the ketones, the aldehydes, the esters, the alcohols, and the aromatics. Phenol oil, neutral oil, and asphalt may be obtained from the tar.

The carbon obtained from dry distillation of the rice husks contains silicon dioxide, which may be used to obtain activated charcoal, fillers for plastics, sodium silicofluoride, and pure silicon dioxide.

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APPENDIX

An accurate estimate of the yield of a rice paddy is important for the planning of labor, machinery, storage space, and transportation. It furnishes information for the state to formulate its purchase plans. If the area is large, it must be divided into sections for the purpose of making the estimate. For the estimate of an entire area, the various rice paddies are first arranged in a proper porportion, and classified into categories. Then, a certain number of paddies are selected to represent each category, before samples are taken for the purpose of the estimate.

The methods of taking samples may be divided into three:

(1) The Five-point Sample Taking Method:

This method is suitable for small paddies. First, make two hypothetical lines running diagonally from corner to corner. The center where the two lines cross each other is the first point. Then, four points on the lines are taken at a place 1/4 from the corner. These five points are where the samples are to be taken.

(2) The Eight-point Sample Taking Method:

This method is suitable for large paddies over 10 mou in size. First divide the length of the paddy into five equal parts, then, divide the width into three equal parts. Hypothetical lines are drawn from these points. The eight points where these lines meet are the places where the samples are to be taken.

(3) Random Method of Taking Samples

This method is suitable for large paddies more than 10 mou each. First, divide the length of the paddy into 10 equal parts; then, draw 10 hypothetical lines which divide the paddy into 10 equal parts. Then, one sample is to be taken on one point of each of these lines, but the point on the line is to be chosen at random to represent the various distances from the edges.

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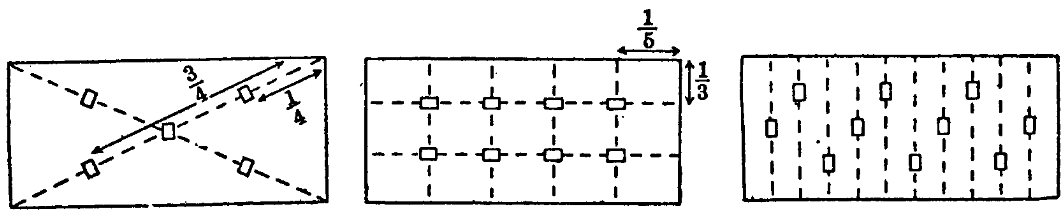
When the samples are taken, it is important that they should represent the entire paddy.

Figure 24-4 Methods of Taking Grain Samples from the Paddy



1 2 3

1. Five-point Sample Taking Method
2. Eight-point Sample Taking Method
3. Random Method of Taking Samples

The second step is to estimate the yield. This is generally done during the milk-rip period, before the grain is ready for harvest. The estimate is made in accordance with the factors that affect yield. The concrete method is as follows:

(1) At each point where the sample is to be taken, the space of 11 groups is first measured; then, divide the figure by 10 to obtain the average distance between the groups. Then divide 6,000 ch'ih^2 (or 600,000 ts'un^2) with the average space between the groups, to bbtain the actual number of groups per mou for that particular paddy. If this paddy was planted with a planting machine, then this calculation is not necessary.

(2) At each of the chosen points, pick five groups and count the total number of effectual heads. Then, pick another group from each point, and count the total number of seeds. Then divide the average number of heads with the number of seeds to obtain the average number of seeds per head.

(3) Dry the sample seeds, and clean them. Divide the seeds into four portions, and pick one liang of seeds from each portion. Count the number of seeds from each of the liang and obtain an average. This is the average number

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of seeds per liang. When this figure is multiplied by 10, the average number of seeds per chin is obtained.

(4) Multiply the average number of seeds per head by the average number of head per group, then multiply the figure again by the total number of groups per mou, to obtain the total number of seeds per mou. Divide this figure by the number of seeds per chin, to obtain the yield per mou for this paddy.

Then, based upon the condition of the empty hulls, and the fallen seeds, a discount of 85 to 90% may be made to obtain the estimated yield for the paddy. The method is as follows:

$$\text{Yield per unit area (chin/mou)} = \frac{\text{average no. of seeds per head} \times \text{average no. of hd per group}}{\text{no. of seed per chin}} \quad \frac{\text{total no. of groups per mou}}{} \times 85 \text{ or } 90\%$$

The second step is the actual testing of the yield. This is generally done during the wax-ripe stage, just before the harvest time. Samples are taken at several areas in order to calculate the yield per unit area. The area taken is generally 60 ch'ih^2 (i.e. 1/100 mou). When the sample is taken, the plants of this area are cut down completely. They are threshed, cleaned, weighed, and counted. The method of calculating the unit yield is as follows:

$$\text{Unit yield (chin/mou)} = \frac{\text{total yield of the area from which the sample is taken (chin)} \times 100}{\text{Number of areas where the samples are taken}}$$

The estimate and the test yield are both theoretical figures, the correctness of which is closely related to the fact that the points chosen are representing the general condition of the paddy. In production practice, the actual yield is often lower than the estimate and the test. This discrepancy is related to the fact that in actual harvest the procedures are not as carefully executed as the procedures of the sample taking.

END

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