GEOGRAPHIC INTELLIGENCE REPORT

AGROCLIMATIC EVALUATION OF THE SOVIET CORN PROGRAM

CIA/RR-GR-197
November 1958

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CENTRAL INTELLIGENCE AGENCY

ERRATA

In the legends of Figure 1, p. 6, and Figure 5, p. 25, "SSSR" should read "SSR."

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CONTENTS

Appendixes

Photographs

Maps

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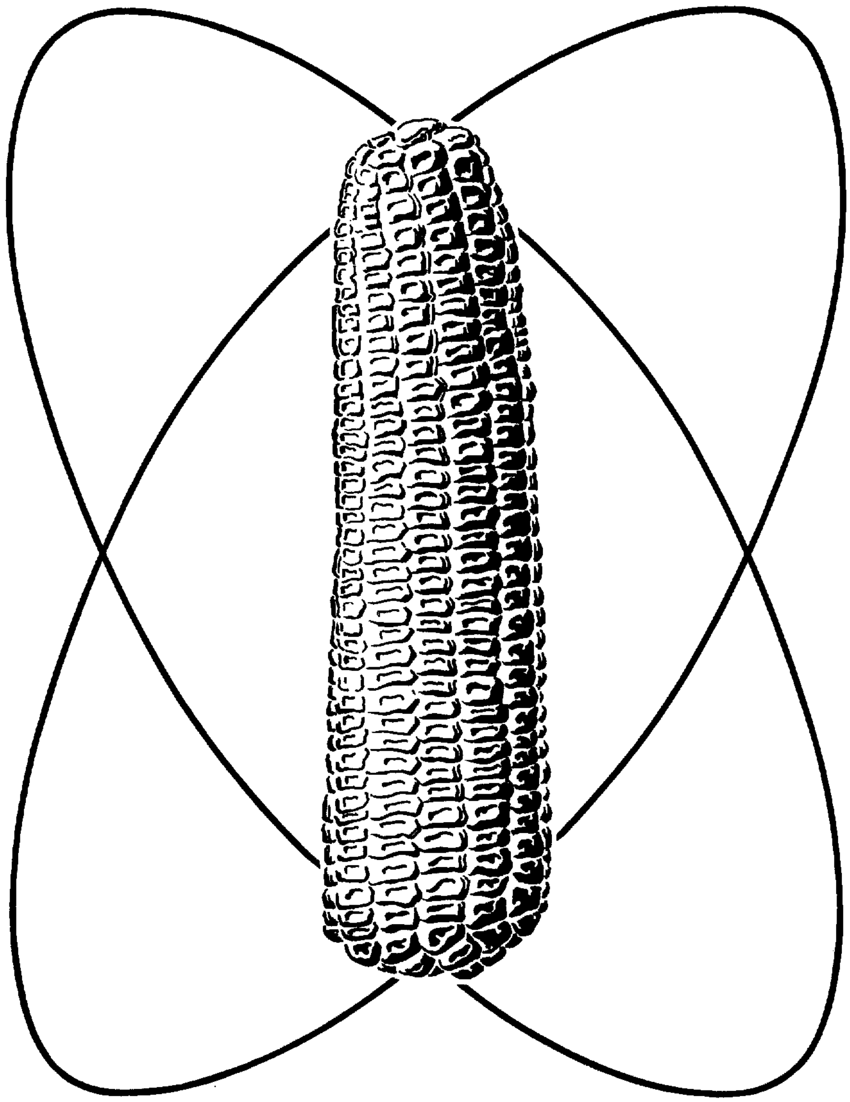
FRONTISPIECE



"SAUSAGE ON THE STALK"

. . . N. S. Khrushchev

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AGROCLIMATIC EVALUATION OF THE SOVIET CORN PROGRAM*

I. Introduction

The Soviet Corn Program is a manifestation of the strains and stresses that the rigid Soviet agricultural structure encounters when it is superimposed upon an unreliable set of natural conditions. The first significant changes in the lopsided and cumbersome agricultural structure came during the struggle for political power following the death of Stalin, when agrarian issues reached major proportions. Khrushchev, upon winning wide approval through the initial successes of his New Lands Program, ventured into other ambitious programs designed to increase agricultural production and bolster up the lagging Soviet agricultural economy. How successful such programs will be depends largely upon the vagaries of a climate that is both marginal and unpredictable.

The use of corn as a feed base to stimulate livestock production is the key to Khrushchev's new and radical agricultural policy. Although plans call for an increase in the production of corn for grain, greater emphasis is placed on the production of corn for silage in quantities sufficient to make each livestock-producing region self sufficient in fodder. In this way, Khrushchev hoped to exploit the high-yielding corn crop for two purposes, and so make good his claim that the Soviet Union would surpass the United States in the per capita production of milk, butter, and meat by 1961.

The purpose of this study is to determine on the basis of agroclimatic factors the potential distribution and the feasibility of corn production throughout the Soviet Union. This problem was approached through (1) examination of the distribution and intensity of Soviet corn production in recent years; (2) determination of the climatic conditions necessary for the growth of corn to be harvested as grain, silage, and fodder; (3) analysis of the climatic conditions within potential Soviet corn-growing regions; and (4) analysis and evaluation of the major regions in respect to their corn-growing and yield potential. No attempt was made to analyze or evaluate soil conditions, agricultural techniques, or hybridization in any of the Soviet corn regions.

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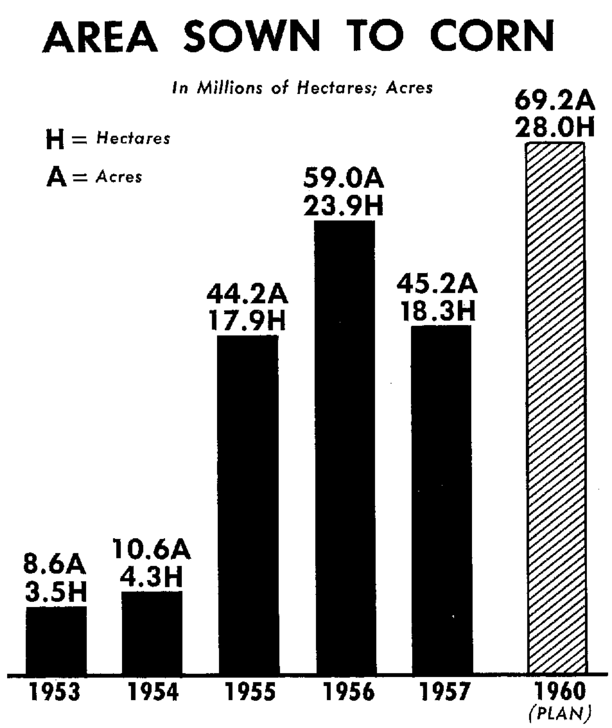
*The cut-off date for research on this report was 3 September 1958.

II. The Current Soviet Corn Program

The Soviet Corn Program was formally launched in January 1955 and had as its goal the sowing of 28 million hectares (69.2 million acres) annually by 1960. The program necessitated a tremendous change in Soviet corn production. Whereas previously nearly all of the crop was grown for grain, emphasis in recent years has been placed on corn as a fodder crop. Through increased production of fodder corn the Soviets hope to create a new feed base for their program for the rapid expansion of livestock production. Each livestock-producing region within the Soviet Union is expected to become self-sufficient in fodder. In view of the wide-spread distribution of livestock, the demand for fodder is great, particularly in the more humid areas north of the established corn growing regions. The recent and planned increase in the total areas sown to corn is shown on the following graph.



Prior to World War II, corn ranked sixth among the grain crops in the Soviet Union. In European USSR the northern boundary of the area in which corn was grown as grain follows a line drawn from west to east through Zhitomir, Kiev, Nezhin, Kursk, Voronezh, Syzran, Buguruslan, and Orenburg; in Asia the boundary followed a line through Orsk, Troitsk, Kustanay, the Minusinsk steppes, and southern

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Primorskiy Kray. 4, p. 25/* Before 1955, when the current program started, the greater part of the Soviet corn was produced in the Ukraine, the North Caucasus, and Transcaucasia. Significant amounts were also produced in the Central Chernozem and Middle Volga Regions of the RSFSR. Production of green fodder was on a much smaller scale. Since World War II, however, there has been a gradual shift to green-fodder production along the northern margins of the grain-corn area.

Under the impetus of the new program, the area sown increased sharply from about 4.3 million hectares (10.6 million acres) in 1954 to 17.9 million hectares (44.2 million acres) in 1955 and 23.9 million hectares (59 million acres) in 1956. During the 1955 and 1956 seasons, 67 percent of the corn was still grown as grain in the old, established corn regions of Moldavia, the Ukraine, the Caucasus, and the Middle and Lower Volga Regions. Farther to the north and east, in a wide band extending across the middle of the Soviet Union, corn is now being grown primarily for fodder and silage. From the Baltic Republics and Belorussia on the west, this broad band extends eastward through the Upper Volga Region, the New Lands Area of western Siberia and northern Kazakhstan, the piedmont regions of eastern Siberia, and into Primorskiy Kray in the Soviet Far East.

In 1955, corn was planted in nearly all areas with climatic and terrain conditions that might conceivably be regarded as suitable for the crop -- as far north as the Komi ASSR, in the remote alpine valleys of the Altay Mountains, and in the maritime region of the Far East. In many cases, however, the plantings proved to be essentially large-scale experiments conducted to determine the feasibility and productivity of specific varieties of corn under different conditions. Results of the experience gained in 1955 have been published and disseminated widely as an aid to subsequent corn production.

Corn planting reached its peak in 1956 (Map 1) when 23.9 million hectares (59 million acres) were planted. The greatest concentration was in Moldavia, the Ukraine, and the Caucasus region. About 30 percent of the total crop land in Moldavia was devoted to corn and 28 percent in the Georgian Republic. In the Ukraine, corn accounts for only 15 percent of the total cultivated land; but the republic produces over 53 percent of all the corn grown for grain within the Soviet Union. The overall 1956 distribution of Soviet

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*For serially numbered source references see Appendix D.

corn land in the country is also shown on Map 1. The distribution is based on figures reported for individual oblasts and republics, adjusted to local climatic and terrain conditions.

During the 1956 growing season, adverse climatic conditions reduced yields substantially. Throughout much of the fodder-producing area of European USSR, spring was cold and wet, and killing frosts were unusually early in the autumn. Frost damage extended as far south as the Central Chernozem Region and the northern Ukraine. Over extensive areas, corn planted for grain had to be hastily harvested for fodder.

In 1957, areas planted in corn amounted to only 18.3 million hectares (45.2 million acres) 46/, a sizable cutback from the preceding year.* This reduction was probably a reflection of the unsatisfactory results achieved during 1956, when early frosts prevented much of the grain-corn crop from maturing and reduced the value of the silage-corn crop. 37/ The general distribution and intensity of corn cultivation in 1957 was probably much like that for the 1955 season.

III. Climatic Requirements for Corn

With the launching of the Soviet Corn Program, corn production was extended into vast areas in which corn had never before been grown. The probable success or failure of the program in these new areas cannot be evaluated on the basis of past experience, but a fair estimate can be made by comparing the known climatic requirements and tolerances of corn with climatic conditions in the Soviet Union.

A. Thermal Requirements

Thermal conditions are of particular significance to the growing of corn. The date of corn planting is governed by average daily temperature in early spring, since specific temperatures are required before corn will germinate and grow. Optimum temperatures for germination are 28° to 30°C (82.4° to 86°F). 5, p. 13/ At temperatures of 8° to 10°C (46.4° to 50°F), corn kernels begin to germinate, but the progress is slow. At temperatures below 8°C (46.4°F), sprouts tend to turn yellow, and the development of the plant is greatly retarded; as a result the sprout is more susceptible than usual to attack by parasitic soil organisms. 10, p. 16; 35, p. 321/

*As in the case of preceding years, there is some disagreement on the amount of corn planted.

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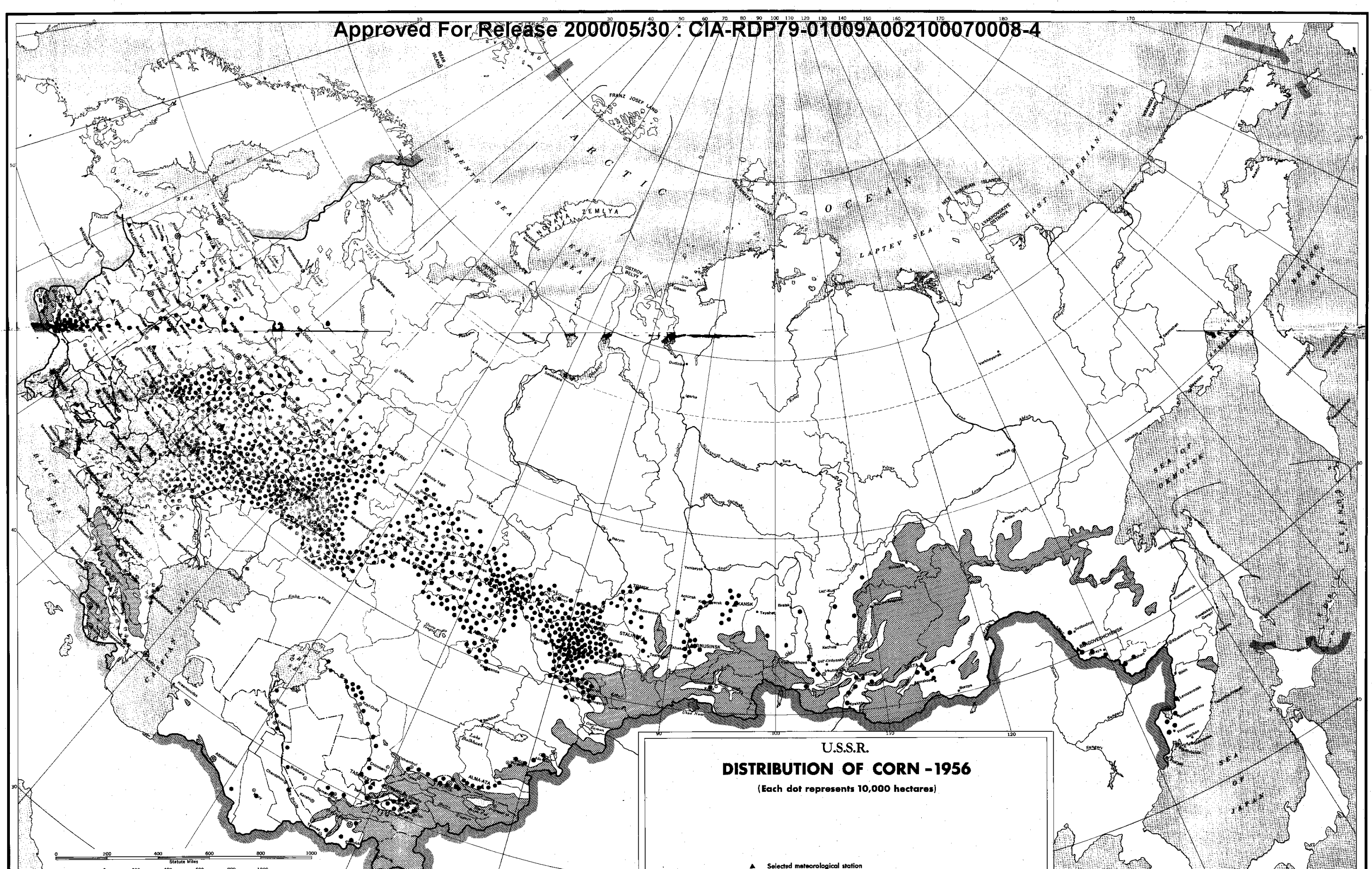

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MAP 1

Low temperatures also tend to lengthen the planting and emergence periods of seed corn. In moist soil, sprouts emerge about 4 to 6 days after planting when air temperatures are about 28° to 30°C (82.4° to 86°F), 5, p. 14-15/ but they require 8 to 10 days at temperatures of 15° to 18°C (59° to 64.4°F) and 18 to 20 days at temperatures of 10° to 13°C (50° to 55.4°F). 35, p. 319/

Although the young plants are relatively resistent to cold weather, late spring frosts are a critical factor in corn production. A minimum temperature of -2°C (28.4°F) usually constitutes a "killing frost", but some varieties are able to survive slightly lower temperatures.* Older plants -- 6 weeks old -- experience injury at somewhat higher temperatures. A plant exposed to temperatures of 0.5° to 5°C (32.9° to 41°F) for different lengths of time can recover and be capable of seed production provided less than 25 percent of the plant is injured. 35, p. 322/ However, if more than 50 percent of the plant is injured, it can seldom recover.

High temperatures may also be a major factor in limiting corn growth in the arid and semiarid regions. Observations show that seedlings 10 days old are very resistant to high temperatures. With increased age the plants become less resistant; 16 to 20 days after emergence, corn is particularly susceptible to damage from high temperatures. 35, p. 322/

The rate of corn growth was found to be correlated more closely with temperature than any other single climatic factor when temperatures above 10°C (50°F) were considered. Differences in temperature alone can account for 40 to 70 percent of the variation in the growth rate. 35, p. 322/ The greatest variation in growth rate occurs during the period between emergence and tasseling. Although the accumulation of temperatures prior to tasseling determine the date of tasseling; thereafter, heat plays a much less important role. Observations of a so-called 115-day variety of corn indicate that it takes 74 days to reach the tasseling stage at an average temperature of 20°C (68°F), but only 54 days at 22.8°C (73°F). 35, p. 323/ Cool nights increase the time needed to reach the tasseling stage. A difference of 4.4 degrees centigrade (8 degrees F) during the 60 days following planting, in one case, caused a variation of nearly a month in the date of tasseling (see Figures 1-4). 35, p. 324/

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*A "Minnesota 23" variety grown in northern Kazakhstan recovered from a frost of -3.1°C (26.4°F); see Source 11, p. 173.

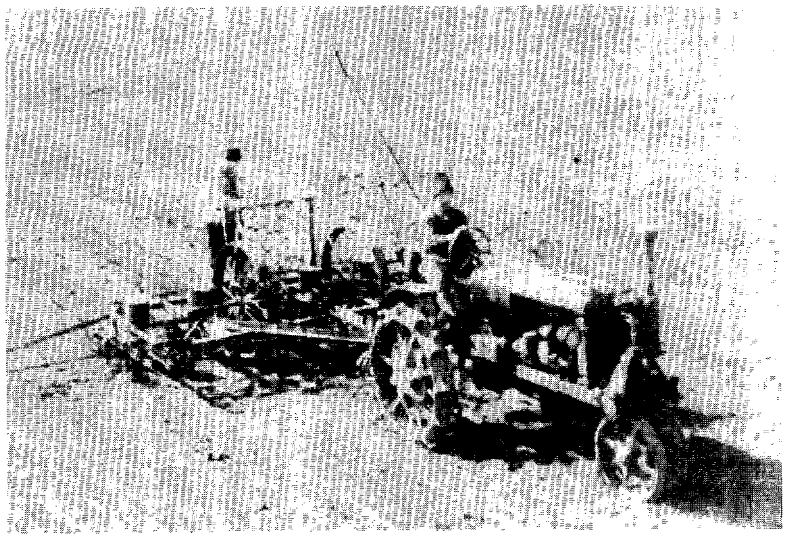

Figure 1. Corn planting in the Moldavian SSSR.

Figure 2. Corn at the beginning of the tasseling stage.

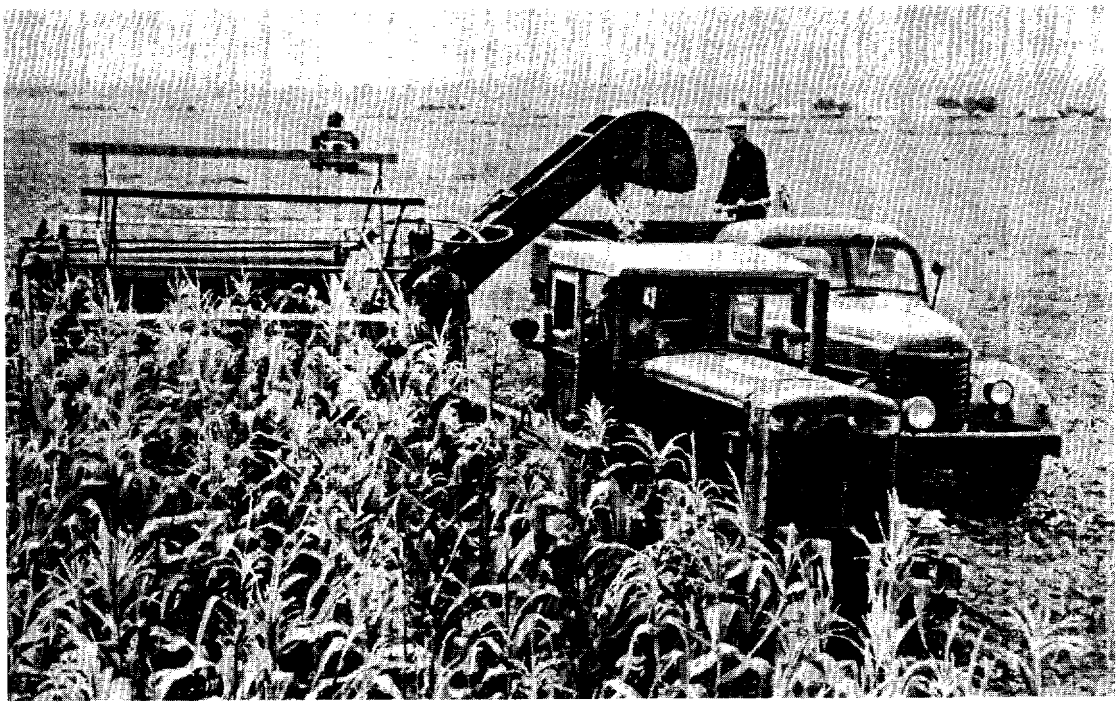

Figure 3. Corn in milk stage being harvested for ensilage.

Figure 4. Corn in fully ripened stage of maturity.

A convenient index for expressing the variations in thermal conditions affecting corn growth is the sum of temperatures or the accumulated heat above a specified base temperature. Sums of temperatures above 10°C (50°F) were found to provide a relatively precise gauge for the amount of heat needed to bring corn to specific stages of maturity. This method of measuring temperature requirements has proved successful in tests conducted jointly in the United States and the Netherlands. 3/ A slight variation of this method is used extensively in the USSR. The figure used by the Soviets is the sum of the average daily temperatures of all days during the growing season that have average daily temperatures of 10°C (50°F) or more. The use of data on the sums of temperatures is limited by the fact that it has not proved entirely satisfactory for determining the heat needed to bring corn from the milk-wax stage to maximum dry weight of full maturity.

Variations in temperature have a lesser effect on the rate of maturing during the period from silking to maximum dry weight than during the preceeding stages of development. Studies conducted in Iowa indicate that the biological development of corn during this period is relatively independent of weather conditions. 35, p. 324/ Although growth is not involved, the rate of drying of the corn plant is influenced by weather -- high winds, sunshine, and warm -- dry days tending to accelerate the ripening process.

Corn growth ends with the first killing frost (-2° to -3°C/ 28.4° to 26.6°F) in the autumn. This event usually coincides with the time when average temperatures fall below 10°C (50°F). Growth rate decreases rapidly as the temperature approaches the 10°C level. At lower temperatures, corn usually fails to ripen, particularly in the more northern latitudes where the autumns are moist and cloudy.

B. Moisture Requirements

Moisture conditions, like thermal, play a key role in the biological development of corn. The importance of moisture varies with the stage of development of the plant -- demands being lowest when the plant is young and greatest during the period of tasseling and the formation of the ear. Specific precipitation requirements for given periods of development are impossible to establish, since many other variables influence the effectiveness of the moisture. Air and soil temperatures, wind, evaporation, and humidity, as well as the surface water runoff and the moisture retentivity of the soil sharply influence the effectiveness of precipitation in a specific region. As a result, precipitation itself does not set sharp limits to corn growth, but decreasingly favorable moisture conditions (of which precipitation is a part) result in a roughly proportional reduction of yields below the normal.

Precipitation is seldom a critical factor during the early part of the growing season, since the rainfall is supplemented by moisture retained in the soil from the preceding winter. Furthermore, the moisture requirements of the corn plant tend to be relatively small during the initial stages of growth.

At planting time, a silt-loam soil that is at least 10 percent saturated provides moisture sufficient for germination 35, p. 319/, but the rate of germination is accelerated with an increase of moisture up to 80 percent saturation. Beyond this, an increase in soil moisture retards or may prevent germination.

For the first month of plant growth, moisture requirements remain relatively low -- roughly equivalent to 1.5 inches (38 millimeters) of precipitation. 35, p. 332/ Yields, however, cannot be predicted reliably on the basis of early seasonal setbacks, since the corn plant has tremendous recuperative powers during its early stages of growth.

Precipitation was found to be most important to successful corn growth during the tasseling-silking period. 35, p. 334/ In the United States corn belt, the 10 days following blossoming were found to be the most critical period. 35, p. 333/ In Central Iowa, precipitation of 1 inch (25.4 millimeters) or less in July resulted in below-average yields, and 1 to 3.5 inches (25.4 to 88.9 millimeters) of precipitation gave best yields if average temperatures were about 71°F (21.7°C). 35, p. 329/ Highest yields occurred when rainfall was 4 inches (102 millimeters) or more and temperatures were higher than 71°F (21.7°C). No consideration was given to the distribution of rainfall during the month. In the Soviet Union, the water requirements of corn are considered to be most critical during the period beginning 10 days prior to tasseling and continuing through flowering. During this period, covering about a month, the corn plant demands more than 75 percent of its total moisture requirements. 21, p. 6/

Other investigations indicate that drought near tasseling-silking time may have very adverse effects on productivity. Droughts may delay silking in relation to tasseling and result in infertility in the tassels and a high incidence of barren or nearly barren stalks. 35, p. 324/

Precipitation requirements remain relatively high from the silking stage to the time of maximum dry weight. In Central Iowa, 2.5 inches (64 millimeters) of precipitation in August gave normal yields; with smaller amounts, yields decreased and with greater amounts increased. 35, p. 330/

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During the ripening stage -- dent stage to maximum dry weight -- low precipitation is an advantage. Warm, dry days with considerable sunshine are believed to accelerate the rate of ripening.

C. Other Climatic Requirements

The amount of light received has a significant influence on the rate of corn growth. The period between planting to tasseling is reduced by short days and increased by long days. In the more northern latitudes, the long, bright days delay the time of tasseling, flowering, and ear formation. At Perm, USSR (58°N latitude), corn grown under normal light conditions was compared with that grown under experimental conditions with a 50 percent reduction in the length of daylight. The reduction of daylight from 18 to 9 hours over a 15-day period accelerated the planting-flowering time by an average of 1 week. 19, p. 12/ In another test of longer duration, corn subjected to an 8.5-hour day for a period of 34 days began flowering more than a month earlier than the same variety grown with the natural day length of about 14.5 hours. 1, p. 315/

Hail can also cause severe damage locally. The usual form of hail damage is the shredding of the leaves, and in severe cases the entire leaf may be ripped from the midrib. Yield reductions due to hail injury are roughly proportional to the amount of tissue lost, but vary with the plant's stage of development. When the plant is young, hail damage causes relatively slight reduction of yield. The effect of hail damage gradually becomes more pronounced, reaching a peak at tasseling time, thereafter the effect decreases again as maturity is approached. 1, p. 314/ Hail injury that causes complete defoliation when plants are 40 percent tasselled will result in almost total crop loss, and over 50 percent defoliation causes very severe reduction in yield. 35, p. 335/

IV. Climatic Limitations Within the Soviet Union

A. General

On the basis of climate alone, only a relatively small part of the Soviet Union is ideally suited for corn production. The rest of the country experiences various degrees of temperature or moisture deficiency that would reduce crop yields. The best areas climatically are the Caucasus Region, and the Carpathian Region. Although limited in extent, these regions account for some of the highest crop yields and greatest densities of corn planting in the Soviet Union. All of these regions are too small to contribute major amounts to Soviet grain or fodder production.

In the southern half of the Ukraine, thermal conditions are nearly ideal for the growth of corn as grain; but precipitation falls off sharply to the south toward the Black Sea coast and to the east toward the Lower Don Region, and droughts are frequent.

Northward and eastward from the center of the Ukraine, precipitation becomes more favorable; but the shorter growing season and the lower daytime temperatures are obstacles to the ripening of corn. Because of these less favorable thermal conditions, corn is grown for silage; or, if corn is to ripen as grain, one of the early-maturing, low-yielding varieties must be planted. The northern limit of practical corn growing is about 58°N latitude in European USSR. Farther north, limited heat and unpredictable frosts usually prevent corn from developing much beyond the tasseling stage.

In the New Lands Area of western Siberia and northern Kazakhstan, corn production is highly precarious, being severely limited on the north by the extremely short growing season and on the south by decreasing precipitation. Climatic conditions tend to be somewhat more favorable in the Altay Region; but in East Siberia and the Soviet Far East, climatic conditions are generally poor, and the ruggedness of the terrain limits corn production to small areas of only local significance.

The Soviets rely on three main groups of corn varieties to match the wide range of thermal conditions found in the Soviet corn-producing area.* The late varieties give the highest yields both as grain and silage,but their high thermal requirements restrict production to the southern part of the USSR. In the greater part of the corn area to the north, thermal conditions are less favorable; and reliance must be placed upon the lower-yielding average- and early-maturing varieties which, respectively, have about 70 percent and 45 percent of the yield of the late-maturing varieties under optimum conditions.

B. Temperature

The potential corn growing area of the Soviet Union includes a wide range of thermal conditions. To a large extent, local temperatures, however, dictate which kind of corn can be grown at a given latitude and the degree of maturity that can be expected.

*A list of specific varieties, subdivided into detailed groups on the basis of maturing rates, is given in Appendix A.

The dates of the last killing frost in the spring and the first killing frost in autumn set fixed limits to the growing season. In the Georgian Republic the last spring frost occurs about 1 April, and at 58°N in European USSR about 20 May, some 50 days later. In the New Lands Area (50° - 57°N) the last spring frost occurs even later -- roughly from 20 May to 1 June in western Siberia and northern Kazakhstan and between 1 and 10 June in the southern part of eastern Siberia.

In autumn killing frosts occur first in the more northern latitudes, and progressively later to the south. The first killing frost usually occurs about mid-September at the latitude of Vologodskaya Oblast' (59°N), about 5 October in Kar'khovskaya Oblast' (50°N), and as late as 1 December in coastal areas in the Georgian Republic. In the New Lands Area in West Siberia and northern Kazakhstan the average date of the first killing frost is between 10 and 20 September.

The frost-free season decreases from about 290 days in the subtropical region of Georgia to less than 100 days in the northern part of Kirovskaya Oblast' (about 60°N). In the established corn region of the central part of the Ukraine, the average frost-free season begins in the latter part of April and lasts until the beginning of November, a period of about 160 days. In much of the New Lands Area, the frost-free season is only 110 to 120 days in length, thus limiting corn growing to fodder and silage production.

In the northern half of the potential Soviet corn-growing area, lack of heat is the major limiting factor to corn production. Heat not only establishes the northern limit to the area where corn will ripen as grain, but it also determines the degree of maturity that can be attained where corn is grown as silage. The more mature the green corn becomes, the higher its nutritional value as fodder or silage. In addition, accumulative heat -- measured as the sums of temperatures above 10°C -- serves as a useful index for indicating the degree of maturity a particular variety of corn is likely to attain in a given region, despite the fact that its vegetative period may vary by a month or more in length from region to region. Average accumulated heat needed for corn in the USSR is shown on the following table. 14, p. 405/

Table 1

Average Sums of Temperatures Above 10°C a/
Needed by Selected Varieties of Corn to
Reach Specific Stages of Maturity*

Variety of Corn	Planting to Tasseling	Planting to Milk Stage of Grain	Planting to Wax Stage of Grain	Planting to Full Maturity
Very Early Maturing	1,100	1,700	1,900	2,100
Early Maturing	1,200	1,800	2,000	2,200
Average Maturing	1,400	2,100	2,300	2,500
Late Maturing	1,500	2,200	2,400	2,700

a/The sums of the average daily temperatures of all days during the growing season that have average daily temperatures of 10°C (50°F) or more.

*See Appendix A for a list of specific corn varieties which are subdivided according to maturing rate.

Information on corn grown in various sections of the Soviet Union illustrates the reliability of sums of temperatures as an index. In Table 2; two varieties of corn having different maturing characteristics are compared in respect to the length of their vegetative period and the accumulative heat (sums of temperatures) required to bring them to maturity. 30, p. 23/ For mature corn the vegetative periods vary by almost a month in length for either variety; the sums of temperatures required through the growing season remain relatively constant, varying by only 180 degrees centigrade for the early-maturing variety and by 270 degrees centigrade for the average-maturing.

Table 2

Length of the Vegetative Period and Thermal Requirements of Two Varieties of Corn in Various Parts of the Soviet Union

Location of Experiment Station	Early Maturing Variety (Spasovskaya)		Average Maturing Variety (Minnesota 13)	
	Length of Vegetative Period (in days)	Accumulative Temperatures a/ Required to Reach Maturity	Length of Vegetative Period (in days)	Accumulative Temperatures a/ Required to Reach Maturity
Tambov (Tambovskaya Oblast')	131	2,230	---	---
Balashov (Saratovskaya Oblast')	125	2,260	140	2,450
Voronezh (Voronezhskaya Oblast')	129	2,280	133	2,300
Bezenchuk (Kuybyshevskaya Oblast')	117	2,270	132	2,520
Saratov (Saratovskaya Oblast')	113	2,180	123	2,370
Kamyshin (Stalingradskaya Oblast')	106	2,120	119	2,350
Krasnokutsk (Khar'kovskaya Oblast')	105	2,150	121	2,360
Moldavia (Moldavian Republic)	118	2,200	138	2,570
Rostov (Rostovskaya Oblast')	106	2,220	113	2,370
Krasnodar (Krasnodarskiy Kray)	---	---	113	2,350
Yessentuki (Southern Stavropol'skiy Kray)	---	---	134	2,480
Ural'sk (Zapadno-Kazakhstanskaya Oblast')	114	2,300	121	2,430
Slavgorod (Western Altayskiy Kray)	119	2,230	---	---
Semipalatinsk (Vostochno-Kazakhstanskaya Oblast')	111	2,220	---	---

a/ Sums of average daily temperatures of all days during the growing season that have average daily temperature of 10°C or more.

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Accumulative temperatures expressed as the sums of temperatures for the potential corn-growing regions of the Soviet Union are shown on Map 2. The extreme southern part of the country has the greatest heat resources; toward the north, the heat resources diminish progressively. At about latitude 52°N in the northern Ukraine and at the southern end of the Urals, the accumulative heat is about half that of southern Central Asia, and at about latitude 60°N only one-third. The highly productive, late-maturing varieties requiring about 2,700 degrees accumulative heat will generally fail to ripen fully at latitudes north of 50°N in European USSR. Average-maturing varieties requiring 2,500 degrees of accumulative heat can be grown for grain only as far north as the northern Ukraine and the Central Chernozem and the Middle Volga Regions. The early-maturing varieties, requiring 2,200 degrees of accumulative heat, ripen as far north as central Lithuania, central Belorussia, and the southwestern parts of the Tatarskaya and Bashkirskaya ASSR's.

The limits for corn raised as silage and fodder are also restricted on the north by the accumulative heat required to produce a given stage of maturity. From the standpoint of yield, the average-maturing varieties are generally the most suitable for the limited heat resources of the more northern latitudes. These varieties require 1,400 degrees to reach the tasseling stage, when it can be cut as green fodder; 2,100 degrees to reach the milk stage of grain, when the plant is suitable for either fodder or silage; and 2,300 degrees to reach the wax stage, when the nutritional value as silage is particularly high.*

The extreme northern limit of practical corn growing for any purpose is roughly the 1,600-degree sums-of-temperatures isoline, since only varieties that mature very early will mature sufficiently to justify their cultivation even for feed at such latitudes.

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*A comparison of U.S. and Soviet data on the nutritional value of corn harvested at various stages of growth is presented in a recent article by D. Gale Johnson <u>Corn Production Possibilities in the Soviet Union</u> (pp. 1-5). Conclusions concerning nutritional yields depend on the criteria used to gage the nutritional value of corn. U.S. data indicate that corn produces the best silage when the grain is in the later part of the wax stage and beginning to dent. At this stage the amount of fat, protein, and dry matter is nearly as high as that for corn at full maturity. Soviet data indicate that corn yields more feed units per hectare in the wax stage than any other, including that of full maturity.

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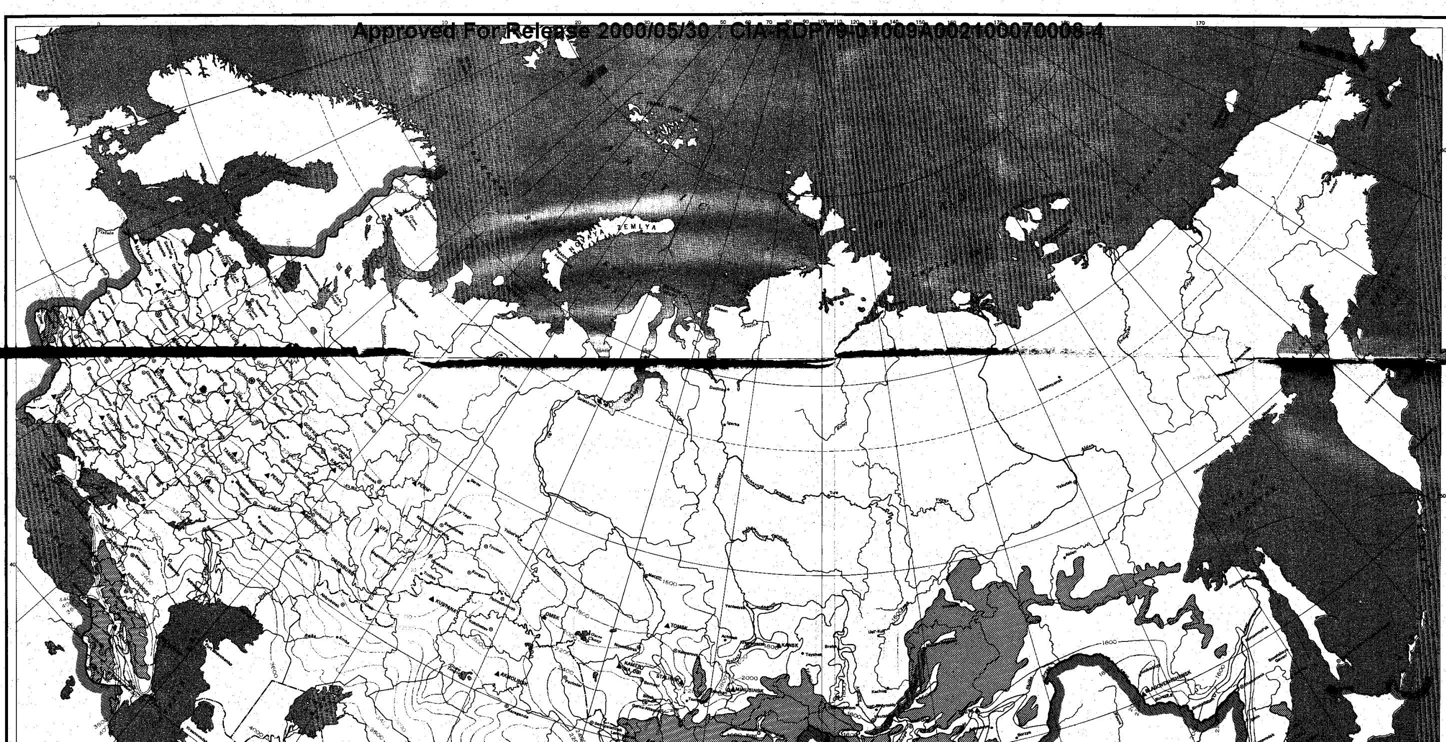
In the northern part of the Soviet corn-producing area, low daily temperatures during the beginning of the growing season retard germination and subject the seeds, roots, and the shoots of the young corn plants to attack by ground parasites and insects. 7, p. 1-3/ In this area heavy damage is caused by the wireworm. These parasites become active when soil temperatures reach 5° or 6°C (41° to 42.8°F). Corn, on the other hand, begins to germinate at 8° or 10°C (46.4° to 50°F). If the corn is planted earlier the seeds do not germinate or germinate slowly, which subjects the kernel, and later the slow-growing sprout and root, to wireworm attack. In the Tatarskaya ASSR and in Ryazanskaya, Moskovskaya, and Leningradskaya Oblasts, heavy damage was caused by wireworm in 1954 and 1955; and crop losses attributable to insects, especially the wireworm, in places amounted to 20 to 25 percent for the total planting. In addition, in the Leningrad and Moscow areas during the same period, the low spring temperatures retarded corn growth, which resulted in considerable damage by the Swedish fly.

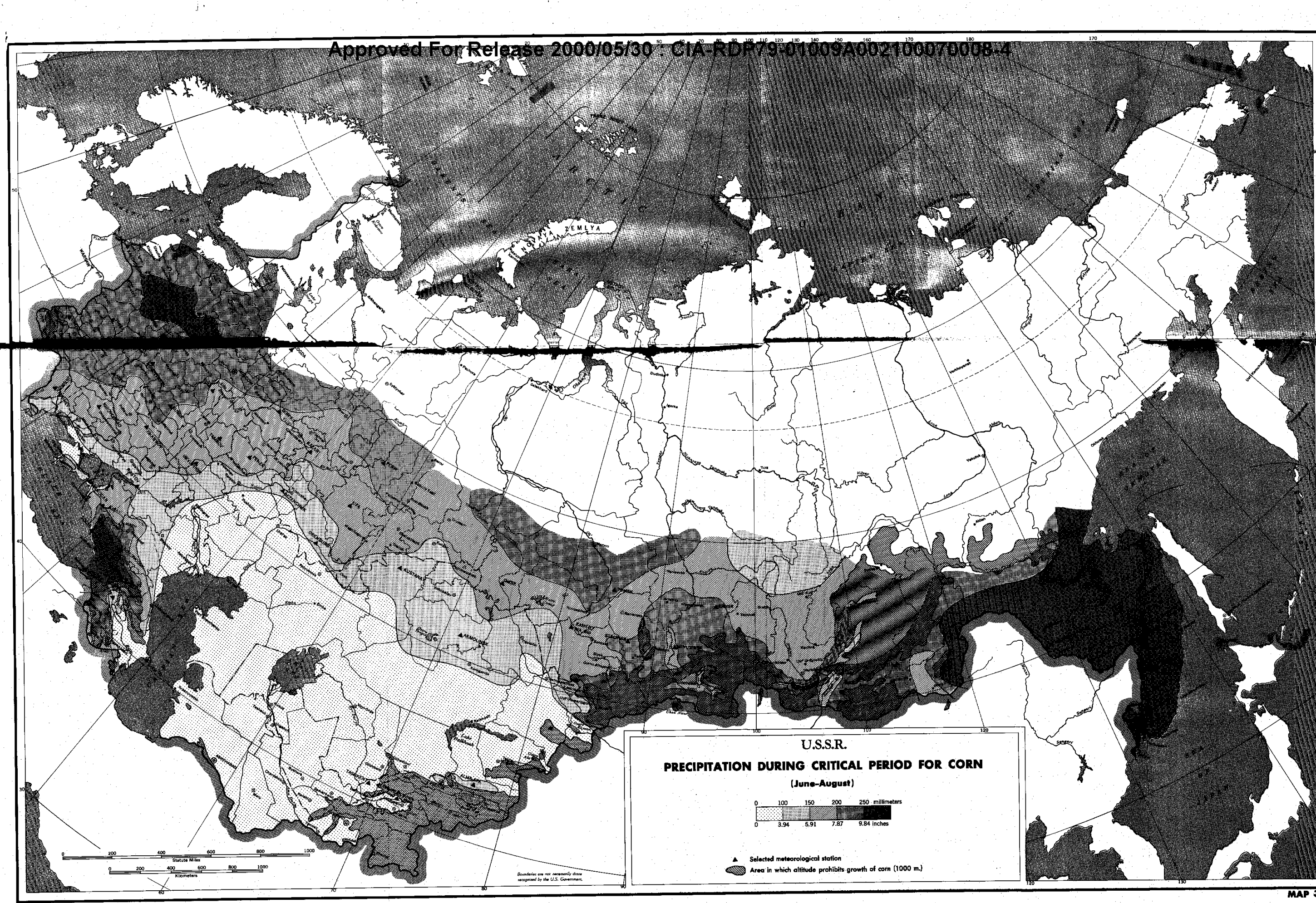
C. Precipitation

Precipitation varies greatly within the potential corn-producing area of the Soviet Union, and much of the land to the east and southeast is marginal from the standpoint of moisture. In the most favorable region, the western part of the Georgian Republic, the precipitation amounts to 2,000 millimeters (79 inches) or more per year. Another favorable area is the piedmont of the Northern Caucasus, which receives 650 to 800 millimeters (26 to 31 inches) of rainfall annually. In other potential corn growing regions, yearly precipitation ranges from about 300 to 650 millimeters (12 to 26 inches), the former being considered the minimum precipitation limit of corn production without irrigation. 18, p. 132/

Of greater importance than the total is the amount of precipitation that falls during the growing season of corn, especially when the moisture demands of the plant are the greatest (Map 3). If the period between the tasseling and milk stages of the grain is taken as the time when moisture is most essential, then the most critical period falls between June and August throughout the Soviet Union, but the exact dates vary considerably from place to place. Planting time and the rate of plant growth determine largely the date at which specific varieties reach the milk stage of development. Early-maturing varieties reach this stage about 10 July in the Lower Volga Region and in late August at the latitude of Vologodskaya Oblast' (59°N).

The major part of the established area of grain-corn growing receives between 150 and 225 millimeters (6 and 9 inches) of rain during the critical June-August period. For most of the silage- and


U.S.S.R.
SUMS OF TEMPERATURES
DURING THE GROWING SEASON
Sum of average daily temperatures of all days during growing season that have average daily temperature of 10°C or more
Selected meteorological station
Area in which altitude prohibits growth of corn (1000 m.)
Statute Miles
Kilometers
NOVAYA ZEMLYA
TOMSK
KANSK
MINUSINSK
STALINSK
ALMA-ATA
Boundaries are not necessarily those recognized by the U.S. Government.
26503 7-58
MAP 2


NOVAYA ZEMLYA
U.S.S.R.
PRECIPITATION DURING CRITICAL PERIOD FOR CORN
(June-August)
0 100 150 200 250 millimeters
0 3.94 5.91 7.87 9.84 inches
Selected meteorological station
Area in which altitude prohibits growth of corn (1000 m.)
Statute Miles
Kilometers
26602 7-58
MAP 3

fodder-producing areas, precipitation during the June-August period (see Map 2, following p. 15) ranges from 100 to 250 millimeters (4 to 10 inches). Areas with rainfall in excess of 250 millimeters (10 inches) are limited to most of the Georgian Republic, the piedmonts of the Caucasus and the Carpathian Mountains, the Belorussia-Smolensk Upland and the Soviet Far East.

D. Other Climatic Factors

Wind is a significant climatic factor in corn production chiefly in the less humid plains areas, where few physical barriers prevent the winds from sweeping in from the south and southeast. Throughout the steppe and forest-steppe regions, winds of gale force (over 51 kilometers/32 miles per hour) are common. In northern Kazakhstan, gales blow an average of about 14 to 26 times during the period from April through September. The frequency of gales decreases to the west (Kuybyshev, 5; Khar'kov, 4) and to the northwest (Kazan', 0; Gor'kiy, 6; Moscow, 9).

Of particular importance is the "sukhovey", a hot, dry wind that is common in the southern and southeastern parts of the corn area and contributes to crop dessication. At the time of the sukhovey, the flow of air becomes hot and dry, with speeds up to 64 kilometers (40 miles) per hour. If these winds occur during the flowering-silking stage of corn, they dessicate the delicate parts of the tassel and ear and reduce crop yields. The sukhovey also may cause severe wilting or permanent damage to the plant if it continues for an extended period of time.

As a climatic phenomenon, hail is of minor importance; but it can cause a considerable amount of damage to corn locally. Long-term Soviet observations indicate that hail is most frequent in the mountainous or upland regions where the air turbulence is the greatest. In the southern part of the USSR, particularly in the piedmont regions of the Caucasus, hail storms occur 7 or 8 times during the summer. In the remainder of European USSR, hail is less common. It occurs on only 2 to 3 days during the growing season on the Smolensk-Moscow Ridge and in the Valday, Central-Russian, and Pre-Volga Uplands; and on only 1 or 2 days in the flatter areas of European USSR. The area with least hail is the southeastern part of the RSFSR. In European USSR, over 60 percent of the days with hail occurs in May and June, the period of rapid corn growth prior to tasseling.

V. Phenological Aspects of Corn Distribution in the Soviet Union

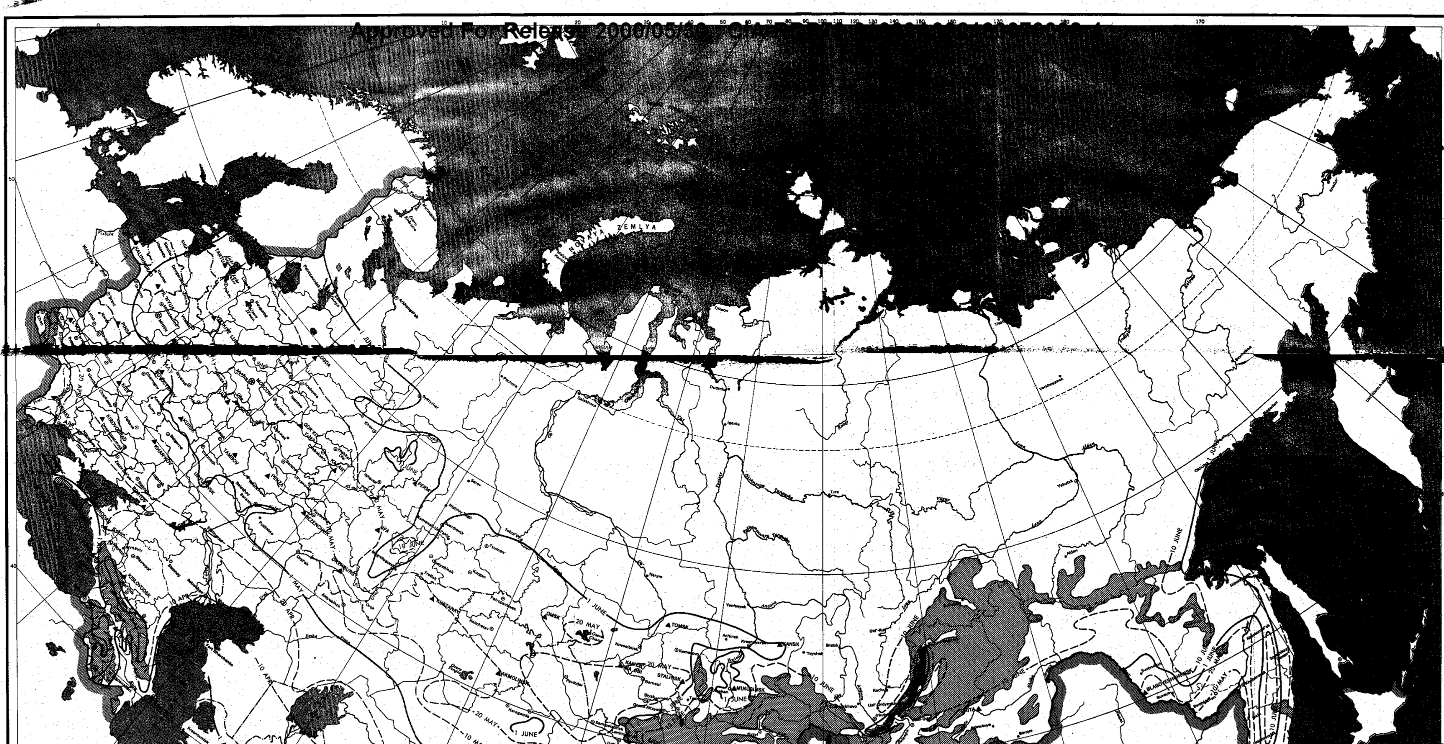
Phenological data, in which specific stages of plant growth are correlated with climatic conditions, have been used to establish the critical dates in the vegetative development of corn, such as the time of planting and harvesting and the dates on which major varieties of corn reach specific stages of maturity -- tasseling, milk stage of grain, and fully ripened grain. Maps 4 through 7 show the critical dates in the vegetative history of early- and average-maturing varieties of corn in the Soviet Union.

Planting dates are commonly set in one of three ways. The first and probably the most commonly used is the average date of the last spring frost. This method is useful for ascertaining the potential planting dates over a broad area and over a period of years. The second, which is somewhat more exact locally for any specific year, is based on soil temperatures. It is particularly well adapted to the northern parts of the Soviet corn area, where the growing season is short. Here corn is planted when soil temperatures reach 10° or 12°C (50° or 53.6°F) at a depth of 10 centimeters (3.9 inches). 33, p. 595/ The third method is based on air temperatures. Average air temperatures are fairly closely correlated with average soil temperatures. In a given year, however, the march of temperature may vary considerably from the average, which makes this method the least reliable of the three. Nevertheless, air temperature is a simple and useful guide to the time of planting, particularly where local factors other than climate must be considered.

Planting dates vary by more than 2 months in the Soviet Union, ranging from the beginning of April in the Georgian Republic to about 10 June in the southern part of East Siberia (Map 4). In the established corn regions -- Moldavia, the Ukraine, and the Kuban Region of the North Caucasus -- corn can be planted between 10 April and 1 May. At such latitudes the growing season is long enough to permit a delay of a couple of weeks in the time of planting. Farther north the date of planting becomes a critical factor because the short growing season permits no delay in planting.

The early-maturing varieties of corn, such as Spasovskaya, are best adapted to areas in which heat or moisture resources are marginal. Because of insufficient heat, these are the only varieties that can be grown near the northern limits of the potential corn-producing area. To the east and southeast, on the other hand, moisture is inadequate for other varieties at their critical growth periods. In the New Lands Area, for example, corn must mature before the droughty conditions of late summer set in.

Early-maturing varieties reach the milk stage of development in a relatively short time after germination -- by 10 July in the Lower Volga Region, and by 1 September at 58°N latitude in Yaroslavskya Oblast' (Map 5). In much of the New Lands Area, early-maturing varieties reach the milk stage of development between 20 and 31 August; in the Soviet Far East this stage is reached between 10 and 31 August. The early-maturing varieties also reach full maturity



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MAP 4

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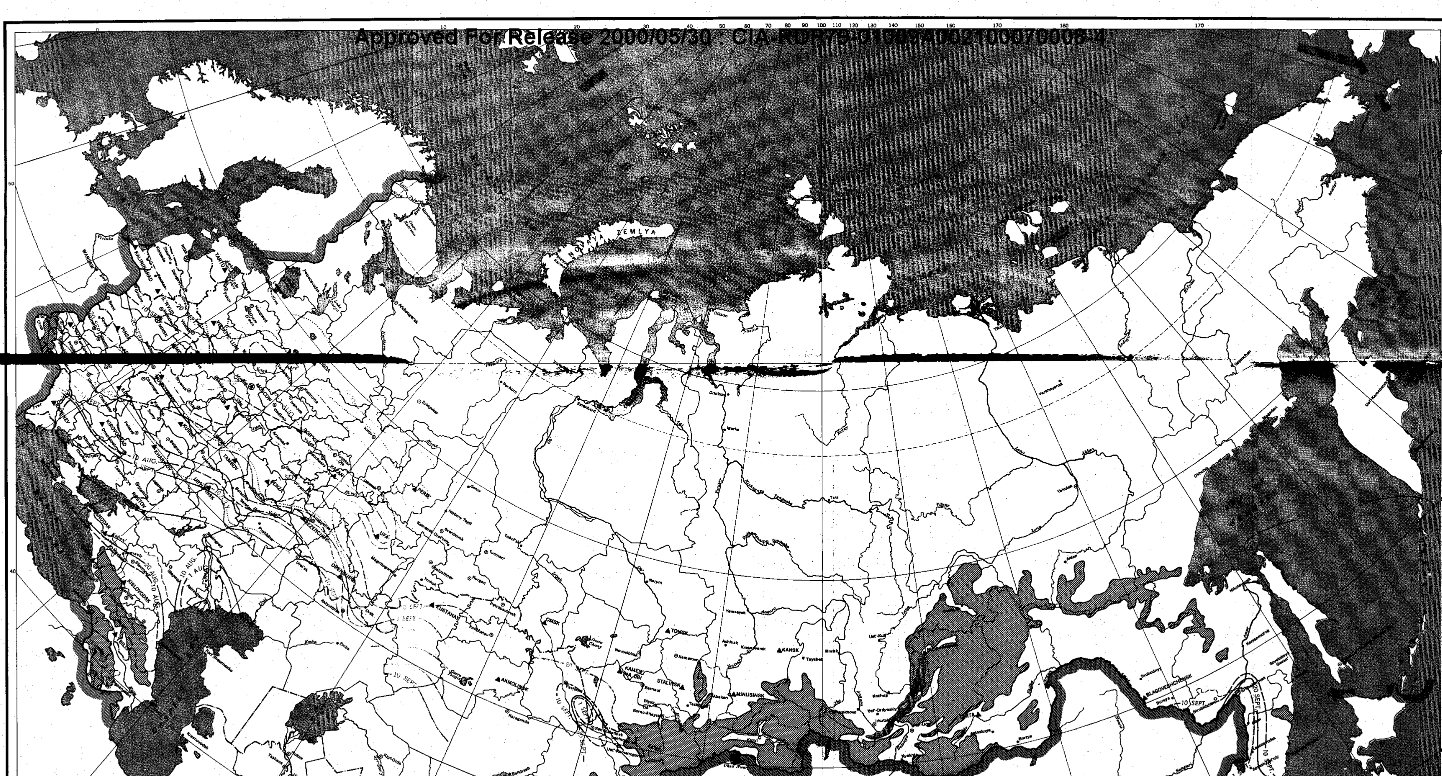
U.S.S.R.
PHENOLOGICAL DEVELOPMENT OF
AVERAGE-MATURING VARIETIES OF CORN
(Minnesota 13)
20 JULY Average date of tasseling
20 AUG. Average date when grain reaches milk stage of maturity
10 SEPT. Average date when grain ripens
Selected meteorological station
Area in which altitude prohibits growth of corn (1000 m.)
Statute Miles
Kilometers
NOVAYA ZEMLYA
TOMSK
KANSK
STALINSK
MINUSINSK
CHITA
ALMA-ATA
Boundaries are not necessarily those recognized by the U.S. Government.
25606 7-58
MAP 6

MAP 7

26607 7-58

in a shorter time than later varieties. The dates at which this stage is reached are 1 August at Odessa, 20 August at Khar'kov, and 20 September at Vladimir. In European USSR, south of the latitude of 52°N, early-maturing varieties can be expected to ripen nearly every year. At roughly the latitude of Moscow, however, the date of ripening is about the same as that of the first killing frost in autumn. In the New Lands Area, early-maturing corn ripens between 20 August and 10 September. In the lower Amur River basin in the Soviet Far East, the early-maturing varieties can be expected to ripen somewhat earlier, usually during the later half of August.

Compared with the early varieties, average-maturing varieties, such as Minnesota 13, require a longer time to reach each successive stage of development, and may fail to ripen in much of the area north of latitude 52°N (Map 6). Average-maturing varieties, however, are well adapted to these northern latitudes if they are cut for silage in the tasseling or milk stage of development.

Average-maturing varieties ripen fully only in the southern part of European USSR and in Central Asia. Dates of ripening vary from 10 August in the Lower Volga Region to about 20 September in the Central Chernozem and Middle Volga Regions. In both western Siberia and the Soviet Far East heat resources are too limited to ripen these varieties.

Tasseling of average-maturing varieties occurs between 10 July and 20 August in the greater part of central European USSR. Milk stage of the grain is reached about a month later in each area. Autumn frosts, however, generally prevent these varieties from developing beyond the milk stage north of the latitude of Moscow. In the eastern part of the New Lands Area and in the Soviet Far East, only the southern parts of the USSR have sufficient heat to develop the grain to the milk stage, when it is mature enough for silage of fair quality.

The vegetative growth for corn of all varieties (Map 7) ends with the occurrence of the first killing frost. The date is most important in the northern latitudes where corn is grown as fodder or silage. Here the harvesting must be completed before the onset of autumn frosts; otherwise the feed value of the corn will be reduced considerably by freezing. Vegetative growth ends about 10 September in the north and about 1 November in the southern part of European USSR and as late as 1 December in the coastal section of Georgia. In the New Lands Area of northern Kazakhstan and western Siberia, corn is subject to frosts between 10 and 20 September. In the Soviet Far East, autumn frosts occur somewhat later -- from 20 September to later than 1 October.

VI. Agroclimatic Adequacy Zones of the Soviet Union

On the basis of climatic adequacy, the entire Soviet corn-growing area has been divided into a series of overlapping zones, the northern boundaries of which form the northernmost limits for the growing of given varieties of corn for grain or silage (Maps 8 and 9). Except in the Lower Don Region, all of the zones have a common southern boundary which is determined by the frequency of drought. Each zone includes the area in which a specific variety can be grown with a high expectancy of success, the boundaries having been established on the basis of adequate heat in at least 9 years out of every 10. In the south those regions that have inadequate precipitation are also subject to frequent droughts. Regions in which the drought frequency during the vegetative period of corn averages 4 years out of every 10 have been considered as having inadequate moisture[1].

The best silage-producing areas of the Soviet Union are those in which late-maturing varieties will reach at least the milk-wax stage of ripeness. In European USSR the northern limit of this area is marked by a line that passes through the central part of the Ukraine, the southern part of the Central Chernozem Region, and the central part of the Volga Region. In the remainder of the Soviet Union, only the southern part of Central Asia is sufficiently hot for the production of silage from late-maturing varieties of corn.

Average-maturing varieties give lower yields but produce good-quality silage in areas farther north. The area in which average-maturing varieties reach the milk-wax stage of maturity is bounded on the north by a line that passes through the northern part of the Ukraine, and Tamboyskaya, Ul'yanovskaya, and Orenburgskaya Oblasts in the RSFSR. In the rest of the Soviet Union (excluding the southern part of Central Asia), the cumulative heat is sufficient to bring average-maturing varieties to the milk-wax stage of ripeness only in the northern part of Kazakhstan, the southwestern part of Altayskiy Kray, and the southern part of the Soviet Far East.

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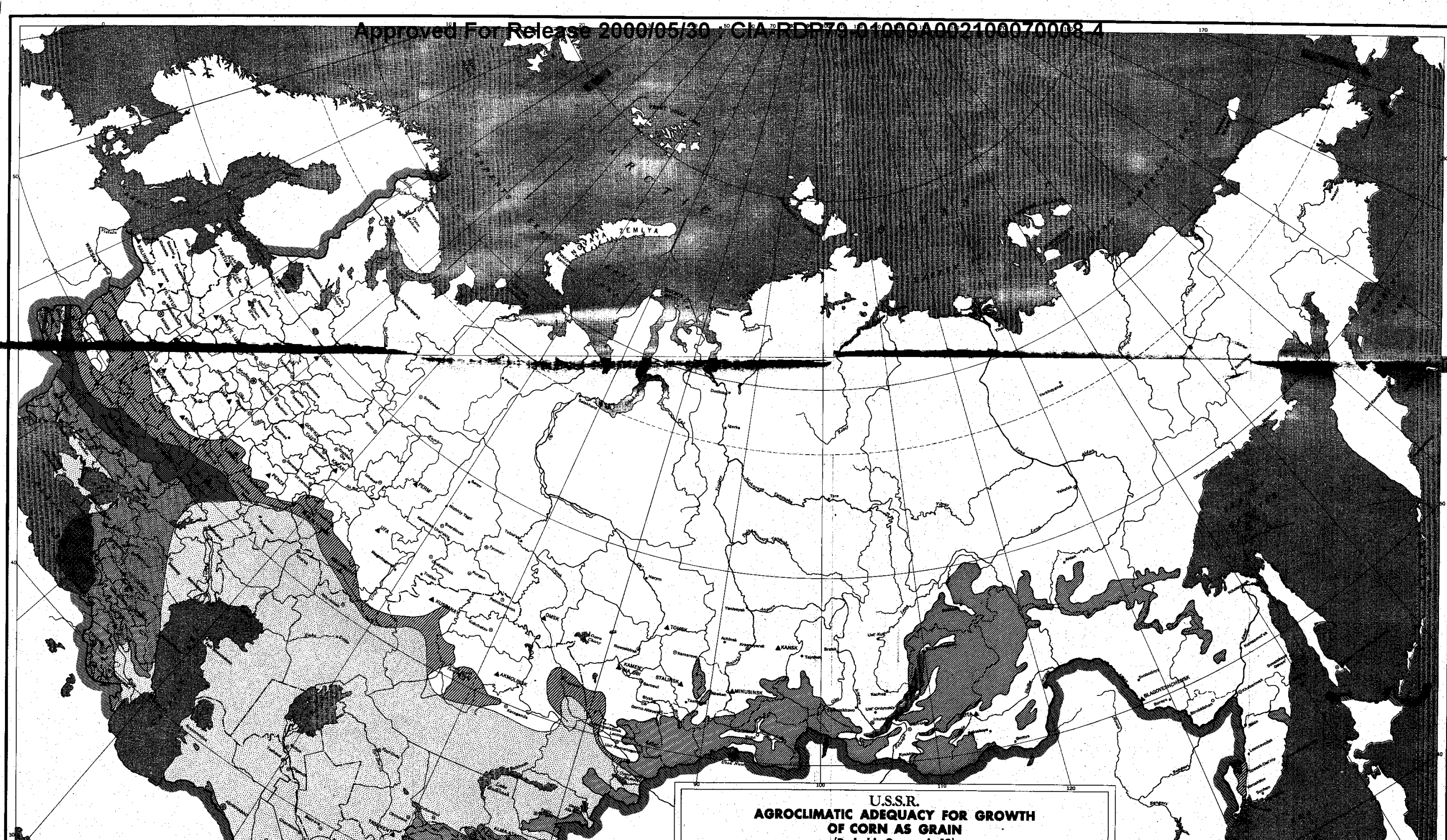
[1]The drought threshold for corn has not been clearly established, since corn is more susceptible to drought at some stages of growth than others. Furthermore susceptibility of corn to drought varies with the type of corn and the area in which it is grown. The southern boundary based on drought frequency appears to be valid, however. It generally coincides with the line of drought frequency for spring wheat based on a 20 to 25 percent reduction in yield from long-term averages in 4 years out of every ten. Since corn is more susceptible to drought than spring wheat, it is assumed that the reductions in yield of corn would be even greater.

U.S.S.R.
AGROCLIMATIC ADEQUACY FOR GROWTH OF CORN FOR FODDER OR SILAGE (Probable 9 years in 10)

- Early-maturing varieties reach tasseling stage
- Average-maturing varieties reach tasseling stage
- Late-maturing varieties reach tasseling stage
- Early-maturing varieties reach milk-wax stage
- Average-maturing varieties reach milk-wax stage
- Late-maturing varieties reach milk-wax stage
- Regions of insufficient precipitation (droughts probable at least 4 years in 10)
- ▲ Selected meteorological station
- Area in which altitude prohibits growth of corn (1000 m.)

MAP 8



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MAP 9

Corn can be grown farther north, but it reaches only the tasseling stage before the first killing frost, and as a result the quality of the silage or fodder is considerably reduced. Late-maturing varieties can be expected to reach tasseling stage as far north as the latitude of Moscow (56°N) in European USSR and average-maturing varieties as far north as the latitude of Vologda (59°N). In the New Lands Area, late-maturing varieties will reach tasseling stage in the area south of a line roughly joining Chelyabinsk, Omsk, and Novosibirsk. Average-maturing varieties can be expected to tassel in much of the remainder of the New Lands Area, as well as in scattered areas along the southern margins of East Siberia and in the Soviet Far East.

The northernmost limit of feasible fodder-corn production is about 60°N latitude in European USSR and 58°N in West Siberia. At these latitudes only the early-maturing varieties reach the tasseling stage of development before the first killing frost.

The best regions for the production of corn for grain (Map 9) are those which receive sufficient heat to ripen the high-yielding, late-maturing varieties of corn. These regions include the southern half of Moldavia and the Ukraine, and the Caucasus.

Average- and early-maturing varieties ripen to the grain stage at latitudes farther north. In European USSR, all of the areas as far north as the central Ukraine, the southern part of the Chernozem Region, and Orenburgskaya Oblast' receive enough heat to ripen average-maturing varieties. Early-maturing varieties will ripen farther north, but the grain yields are so low that it is more profitable to grow other varieties of corn for silage.

VII. Climatic Basis for Estimating Corn Yields in the Soviet Union

Estimating potential yields on the basis of climatic conditions is extremely difficult, since yields actually represent the end result not only of climate but also of many other interrelated factors. In the Soviet corn areas, however, climate plays a greater role in influencing yields than in any other major corn-producing area of the world. A larger part of the total area is marginal climatically, and weather conditions vary considerably and unpredictably from one year to the next. As a result yields fluctuate sharply, reflecting the year to year variations in the weather.

In a particular area the major climatic elements that affect corn yields act both individually and in combination. Accumulative temperatures dictate which varieties can be grown, thus determining the basic range of yields that can be expected. A number of other climatic factors, however, are simultaneously instrumental in affecting yields of the variety of corn grown.

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The actual usable moisture available for corn growth during given periods, for example, depends primarily on the total precipitation in a given year minus losses through evaporation and transpiration. Both of these losses, in turn, are functions of the prevailing air temperatures and wind velocities, as well as the growth stage of the corn plant. Moisture adequacy is a particularly critical factor during the period of rapid vegetative growth, when the moisture demands of corn are the greatest and the yield potential of the plant is established.

Soviet researchers, F. F. Davitaya and others, introduced the use of hydrothermal coefficients (GTK) as a means of indicating moisture adequacy during the critical periods of corn growth and estimating potential yields under given climatic conditions. 14, p. 407 and 414/ This index is based on the relationship between the total precipitation and the sums of temperatures for the June-August period.* Moisture adequacy as indicated by GTK values have been computed for various parts of the Soviet corn-producing area on the basis of long-term climatic averages (Map 10). Hydrothermal coefficient values computed range from 0.6 in the drier marginal areas to more than 1.8 in the most humid areas.

Yields of corn grown on a series of test plots have been analyzed on the basis of various degrees of moisture adequacy (Table 4). 14, p. 415/ In these tests, 33 varieties of corn were grown on 275 different but unidentified variety-testing plots in European and Asiatic USSR (the actual geographic location of these plots was not indicated). The varieties were broken down into three groups, depending on their rate of ripening. These varieties were compared on the basis of their average yields under various degrees of hydrothermal adequacy. The test yields represent the optimum under given climatic conditions, since testing plots receive much better care than the ordinary fields. No consideration was given to soil fertility or terrain.

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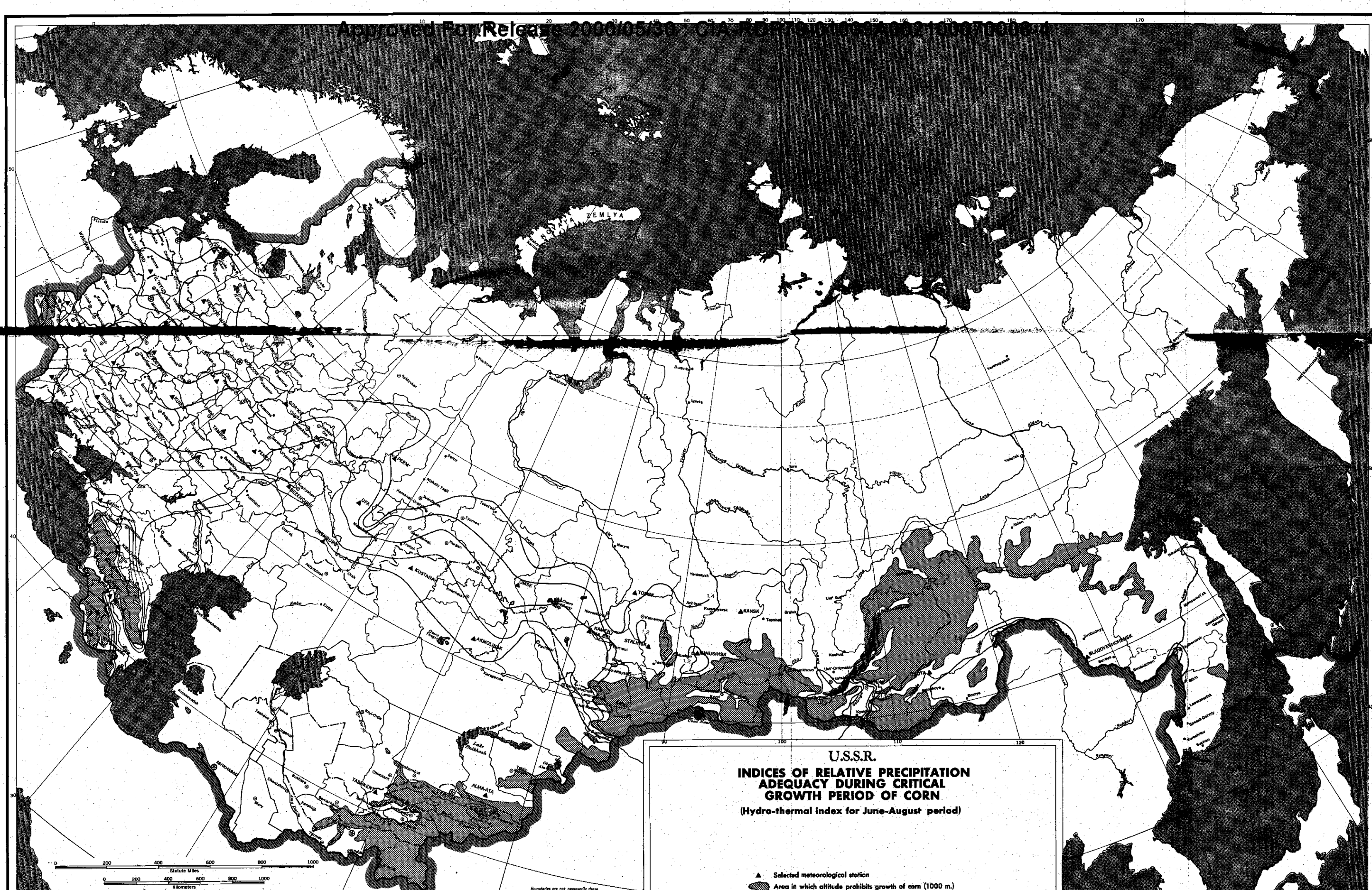
*The actual Hydrothermal Coefficients as applied to corn is derived as follows:

$$\text{Hydrothermal coefficient} = \frac{\text{Total precipitation in mm. (June-August)}}{\text{Sums of temperatures in } {}^{\circ}\text{C (June-August)}} \div 10$$



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MAP 10

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Table 3

Optimum Yields of Corn (in centners per hectare)
According to Groups of Varieties on the Basis of Moisture Adequacy
Between June and August

Early-Maturing Varieties			Average-Maturing Varieties			Late-Maturing Varieties		
Average GTK Value	Yield[a]	Number of Observations	Average GTK Value	Yield[a]	Number of Observations	Average GTK Value	Yield[a]	Number of Observations
				For Grain				
0.3	11	33	0.3	15	54	0.2	15	19
0.6	19	99	0.6	26	191	0.6	29	37
1.0	25	89	1.0	33	147	1.0	38	26
1.4	28	59	1.4	39	53	1.4	48	11
1.9	26	24	1.8	43	21	1.7	63	6
				For Silage				
0.3	43	11	0.3	145	5	0.3	125	4
0.6	147	22	0.6	175	24	0.6	212	47
1.0	160	29	1.0	208	17	1.0	249	54
1.4	152	24	1.4	279	12	1.4	330	28
1.9	208	12	2.0	388	4	2.0	454	28

[a]Yield in centners per hectare.

Table 4

Average Grain and Silage Yields
of Various Corn Groups

Early-Maturing Varieties		Average-Maturing Varieties		Late-Maturing Varieties	
Average GTK Value June-August	Percentage of Optimum	Average GTK Value June-August	Percentage of Optimum	Average GTK Value June-August	Percentage of Optimum
		For Grain			
0.3	17	0.3	24	0.2	24
0.6	30	0.6	41	0.6	46
1.0	40	1.0	52	1.0	64
1.4	45	1.4	62	1.4	76
1.9	41	1.8	68	1.7	100
		For Silage			
0.3	9	0.3	32	0.3	28
0.6	32	0.6	39	0.6	47
1.0	35	1.0	46	1.0	55
1.4	33	1.4	63	1.4	73
1.9	46	2.0	84	2.0	100

The data in Table 4 indicate that yields vary considerably between groups in relation to GTK coefficients. Under moderately favorable moisture conditions (1.4 GTK) the grain yields of the late-maturing varieties exceeded the yields of the average-maturing and early-maturing varieties by 23 and 71 percent, respectively. On the basis of moisture adequacy alone, yields of the late-maturing varieties become higher as the GTK coefficient increases -- averaging 63 centners per hectare (101 bushels per acre) at 1.7 GTK compared with only 15 centners per hectare (24 bushels per acre) at 0.2 GTK.

If the best grain yields* of the late-maturing varieties are considered as optimum for the Soviet corn areas, the yields of the other varieties under various degrees of moisture adequacy can be evaluated as a percentage of this optimum (Table 4). The silage yields of the various varieties were calculated in a similar manner in order to rate their relative productivity**.

The yields of both average- and late-maturing corn increase rapidly with increases in the moisture adequacy; the best yields of the average-maturing corn are only slightly more than two-thirds that of the late varieties. The early-maturing varieties are less than half as productive as the late-maturing varieties when grown as grain. For silage purposes, the various varieties show the same pattern of yields relative to the optimum as corn for grain purposes. The early-maturing varieties have a low level of productivity. Both the two other groups have considerably higher productivity even under the less favorable moisture conditions.

VIII. Regional Summary

The Soviet Union has been divided into nine major corn growing regions, the boundaries of which conform in general with the statistical reporting districts on the oblast level (Map 11). Each of these regions has distinctive capabilities for corn production, depending on its climatic conditions. Detailed climatic data for representative stations within each of these regions is included in Appendix B.

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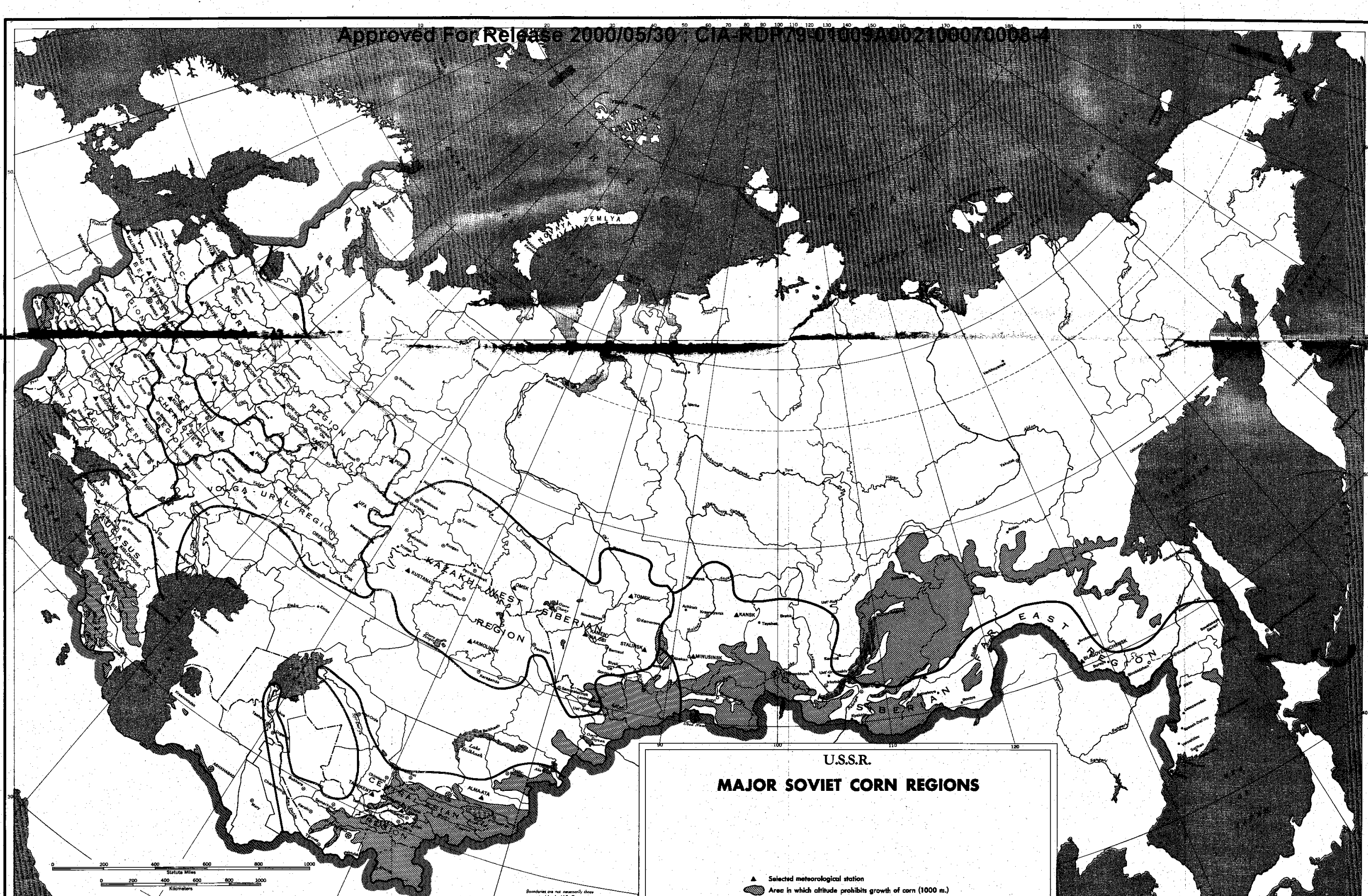
*These grain yields compare favorably with optimum yields for productive parts of the U.S. Corn Belt.

**Silage yields are difficult to appraise because of the unreliable Soviet methods for calculating yields. The optimum silage yield that was selected as the standard is 2.3 times the average U.S. silage yield between 1951 and 1954 or 203 centners per hectare (V.V. Matskevich p. 65).



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MAP 11

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A. Southwestern Region*

Long a center of corn cultivation, this region not only accounted for a large percentage of the entire Soviet corn crop in the past but also had a considerable increase in its corn acreage under the current agricultural program. During the 1955-56 period the region accounted for about 37 percent of the total corn acreage and about 62 percent of the corn grown as grain. In 1956, more than 5,800,000 hectares were planted to corn as grain, a 73 percent increase over 1950. This sharp increase in corn planting was achieved at the expense of fallow-land and other grain crops, principally winter wheat.

Climatic conditions favor intensive cultivation of corn (Figure 5). Thermal conditions become increasingly favorable from northwest

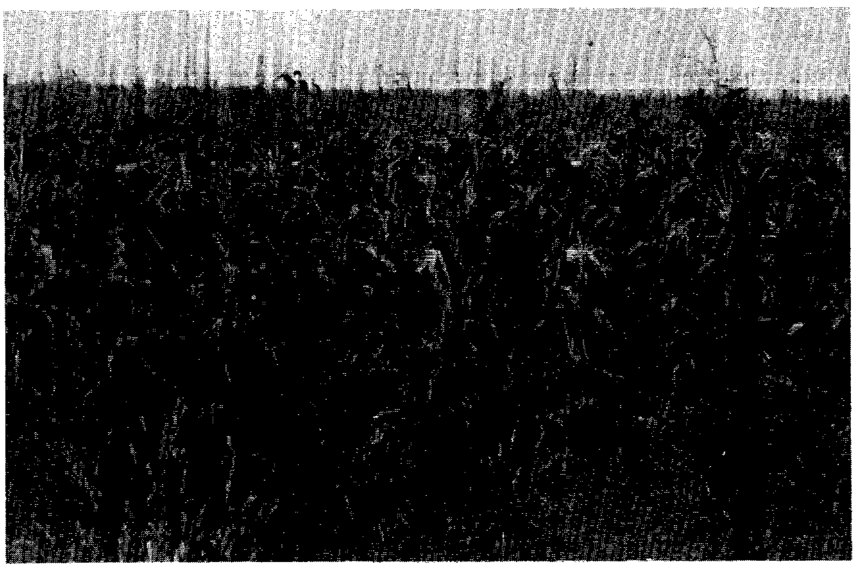

Figure 5. Cornfield in Ukrainian SSSR between Zaporozh'ye and Kar'khov.

to southeast -- average July temperatures increase from 18.8°C (65.8°F) at Lutsk to 23.7°C (74.6°F) at Rostov-na-Donu. The number of frostless days range from 122 days in the Transcarpathian region

*This region includes the administrative units of the Moldavian and Ukrainian Republics as well as the western half of Rostovskaya Oblast' as delimited in 1958, where the greater part of the corn production is concentrated.

to 212 days in southern Zaporozhskaya Oblast'. Except in the Carpathian region, however, precipitation decreases to the south and southeast -- toward the southern Ukraine and eastern Rostovskaya Oblast' -- during the critical growth period of corn. Precipitation during the June-August period ranges from more than 230 millimeters (9 inches) in the northwestern part of the Ukraine to less than 100 millimeters (3.9 inches) adjacent to and in the steppe region of the Crimean Peninsula. Droughts are common in both the southern coastal region of the Ukraine and eastern Rostovskaya Oblast', but irrigation is used in these areas to supplement the scant precipitation.

The parts of the region most favorable climatically for the production of corn as grain are the Carpathian piedmont, the northern half of the Moldavian Republic, and an area extending through southern Vinnitskaya, northern Kirovogradskaya, southern Poltavskaya, and central Khar'kovskaya Oblasts. Except in the alpine regions of the Carpathians, average-maturing varieties of corn ripen in all areas south of a line drawn through L'vov, Kamenets-Podol'skyy, Uman', Poltava, and Khar'kov. Late-maturing varieties ripen in nearly all of the southern half of the Ukraine, Moldavia and Rostovskaya Oblast'.

The northwestern part of the Ukraine also ranks as one of the best silage-producing areas in the Soviet Union. Nearly all of the Southwestern Region receives enough heat to produce good-quality silage, since average-maturing varieties generally reach the milk-wax stage throughout the area. Late-maturing varieties reach this stage of ripeness in the southern three-fifths of the region.

B. Caucasus Region*

Despite the preponderance of mountainous terrain, the Caucasus Region yields a significant part of the total Soviet grain-corn production. During the 1955-56 period, it accounted for about 10 percent of the total Soviet corn acreage and about 18 percent of the corn grown for grain. In the favorable piedmont and subtropical regions, cultivation is more intensive than in any other part of the USSR. In Northern Osetinskaya ASSR, over 42 percent of the cereal-grain area was devoted to corn in 1956, and in parts of the Georgian Republic the corn acreage amounted to 90 percent of the sown area.

*This region includes the Soviet administrative units of Armyanskaya SSR, Azerbaydzhanskaya SSR, Dagestanskaya ASSR, Kabardino-Balkarskaya ASSR, Krasnodarskiy Kray, Northern Osetinskaya ASSR, Checheno-Ingushskaya ASSR and the corn-producing areas of southern Stavropol'skiy Kray and southern Gruzinskaya SSR.

Thermal conditions in the region are excellent for the production of all varieties of corn. The frost-free season varies from about 170 days on the northern piedmont to more than 300 days in the Georgian lowlands. Precipitation, also, is favorable. Rainfall during the critical June-August period varies from 250 to 560 millimeters (9.8 to 22 inches) in the Georgian SSR, from 200 to 250 millimeters (7.9 to 9.8 inches) in the northern piedmont areas, and from 150 to 200 millimeters (5.9 to 7.9 inches) in the remainder of the region. In the Kura River lowland and the Pre-Caspian lowland; precipitation is insufficient for corn growing, and drought conditions are common along the northeastern margin of the region.

Any further increase in corn acreages in the Caucasus Region will require extension into the less humid steppe regions, chiefly in the northern parts of Krasnodarskiy Kray and Stavropol'skiy Kray and in much of Dagestanskaya ASSR. Here, increased irrigation will be needed to offset the lack of precipitation.

C. Baltic-Belorussian Region*

Corn is a relatively new crop in this region, and its production has remained very low. In the 1955-56 period the Baltic-Belorussian Region accounted for slightly more than 3 percent of the total Soviet corn acreage, with more than 92 percent of this planted for fodder or silage.

Despite the favorable precipitation and long growing season, temperatures are not high enough to ripen corn. The frost-free season varies from about 125 days in northern Estonia to 185 days in Kaliningradskaya Oblast'. Average July temperatures exceed 18°C (64.4°F) in parts of the Lithuanian-Belorussian Upland but fall below 17°C (62.6°F) in the cooler parts of northern Latvia and Estonia. During the critical June-August period, precipitation varies from less than 200 millimeters (7.9 inches) in the western parts of Lithuania, Latvia, and northern Estonia to more than 250 millimeters (9.8 inches) in the Lithuanian-Belorussian Upland. Most of the region receives 200 to 250 millimeters (7.9 to 9.8 inches) during the June-August period.

Thermal conditions are adequate for producing corn as fodder or silage only, since only the southern margin of the Belorussian Republic is hot enough to ripen even the early-maturing varieties.

*This region includes the Soviet administrative units of the Lithuanian, Latvian, Estonian, and Belorussian Republics as well as Kaliningradskaya Oblast' of the RSFSR.

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In the extreme southern part of the region, average-maturing varieties reach the milk-wax stage, but in the southern half of Kaliningradskaya Oblast' and in the Lithuanian and Belorussian Republics only the early-maturing varieties reach the milk-wax stage of ripeness. North of a line through central Latvia corn can be grown for fodder only, since it does not mature much beyond the tasseling stage.

D. North European Region*

This region, the northern-most region of corn cultivation in European USSR, accounted for 7 percent of the total corn acreage and about 13 percent of the corn planted for fodder or silage during the 1955-56 period. The greatest production is concentrated in the southern part of the region from the Smolensk-Moscow Ridge eastward to the Pre-Volga Upland. The northern boundary of the region marks the northernmost extent of feasible corn cultivation.

Climatic conditions for corn cultivation deteriorate rapidly as one progresses northward, mainly because of the unfavorable thermal conditions. The frost-free season ranges from about 150 days in Ryazanskaya Oblast' to about 100 days in the northern half of Kirovskaya Oblast'. Average July temperatures decrease from southeast to northwest -- exceeding 19°C (66.2°F) in Ryazanskaya Oblast' and Chuvashskaya ASSR, but falling below 17°C (62.6°F) in the northwestern part of the region in Novgorodskaya, Pskovskaya, Vologodskaya, and Leningradskaya Oblasts. Precipitation during the critical growth period of corn -- from June through August -- increases to the northwest, with the highest precipitation received in the Valday Hills where it ranges from 250 to 285 millimeters (9.8 to 11.2 inches) during the June-August period. Northwest of a line drawn roughly between Tula and Kirov, rainfall exceeds 200 millimeters (7.9 inches), and southeast of this line it ranges from about 175 to 200 millimeters (6.8 to 7.9 inches).

The North European Region is suitable only for the production of silage and fodder, since the grain cannot be relied upon to ripen at these latitudes. A small area, principally eastern Ryazanskaya Oblast' and the southern part of Chuvashskaya ASSR, receive enough heat to produce high quality silage, early-maturing varieties of corn reach the milk-wax stage. South of a line roughly connecting Velikiye

*This region includes the Vladimirskaya, Gor'kovskaya, Ivanovskaya, Kalininskaya, Kaluzhskaya, Krostromskaya, Moskovskaya, Ryazanskaya, Smolenskaya, Tul'skaya, Yaroslavskaya, Leningradskaya, Novgorodskaya, Pskovskaya Oblasts; Mariyskaya and Chuvashskaya ASSR's, as well as the southern half of Vologodskaya, Kirovskaya, and Permskaya Oblasts.

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Luki, Smolensk, Kaluga, Vladimir, and Yoshkar-Ola, late-maturing varieties reach the tasseling stage, at which corn is suitable for green fodder. North of this line only the lower-yielding, average- and early-maturing varieties develop to the tasseling stage. The value of corn grown along the northern margin of this region is extremely questionable, since none but the early varieties reach tasseling stage so far north. Also, the low temperatures common at the beginning of the growing season retard germination, which subjects the plant to attack by parasite and insect pests.

E. Central Chernozem Region*

This region in central European USSR accounted for about 9 percent of the total Soviet acreage in the 1955-56 period, with 62 percent of the acreage harvested for fodder or silage. Climatic conditions are relatively favorable for the production of silage. Thermal conditions become increasingly favorable to the southeast. Average July temperatures range from about 18°C (64.4°F) in northern Bryanskaya Oblast' to more than 21°C (69.8°F) in the southeastern part of Voronezhskaya Oblast'. The length of the growing season varies from 135 days in northern Penzenskaya Oblast' to about 165 days in the southeastern part of the region. During the June-August period, precipitation ranges from slightly less than 150 millimeters (5.9 inches) in the southeastern Voronezhskaya Oblast' to about 240 millimeters (9.4 inches) in western Bryanskaya Oblast'.

The Central Chernozem Region is most favorable for the production of silage, but average-maturing varieties will ripen fully in the southern half of Belgorodskaya and Voronezhskaya Oblasts. In the greater part of Kurskaya, Belgorodskaya, Voronezhskaya, and Tambovskaya Oblasts, average-maturing varieties reach the milk-wax stage; but in most of the remainder of the region only the early-maturing varieties reach this stage. All varieties reach the tasseling stage, at which corn is suitable for green fodder.

F. Volga-Ural Region**

Situated along the Lower Volga and the western flank of the Urals, this region accounted for about 13 percent of the total Soviet corn production during the 1955-56 period, with 80 percent of the corn grown for silage and fodder. In the Urals, corn growing is limited

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*This region embraces all the Oblasts and the Mordovskaya ASSR in the Central Chernozem Region in addition to Bryanskaya Oblast'.

**This region includes northeastern Stavropol'skiy Kray; Stalingradskaya, Saratovskaya, Ul'yanovskaya, Kuybyshevskaya, Orenburgskaya Oblasts; Tatarskaya and Bashkirskaya ASSR's; as well as the northern fringe of Zapadno-Kazakhstanskaya, and Aktyubinskaya Oblasts in western Kazakhstan.

by the rugged terrain and the cool climate; whereas, in the Lower Volga region to the southwest, corn production is restricted by scant precipitation, a high frequency of drought, and occasional dessicating winds during the period of critical vegetative growth. The length of the frost-free season varies considerably within the region -- from more than 150 days south of Saratovskaya Oblast' to less than 110 days in the Urals. Average July temperatures range from 25°C (77°F) along the Lower Volga to slightly less than 18°C (64.4°F) in the Urals. In the most productive area, temperatures range between 19°C and 22°C (66.2° and 71.6°F).

Precipitation during the critical June-August period is adequate in the northern part of the region -- Ul'yanovskaya Oblast', Tatarskaya ASSR, and Bashkirskaya ASSR -- where it exceeds 150 millimeters (5.9 inches). In western Saratovskaya Oblast' and the greater part of Kuybyshevskaya and Orenburgskaya Oblasts, however, precipitation is less favorable, ranging from 100 to 150 millimeters (3.9 to 5.9 inches) during the critical growth period. To the east and south of Saratov, corn cultivation becomes precarious because of frequent droughts and dessicating winds, such as occurred in 1957. Nearly all of the Volga-Ural Region is subject to drought about 4 years in 10, but irrigation is used in the Lower Volga-Lower Don area to supplement the precarious rainfall.

The Volga-Ural Region is suitable for growth of corn as either grain or silage. South of the latitude of Saratov (52°N) average-maturing varieties ripen as grain. In the greater part of Saratovskaya, Kuybyshevskaya, and Orenburgskaya Oblasts the relatively high yielding, average-maturing varieties reach the milk-wax stage of development, but in the more northern areas corn production is limited largely to fodder, since it does not develop much beyond the tasseling stage.

G. Kazakh-West Siberian Region*

The Kazakh-West Siberian Region is predominently an undulating plain which extends eastward from the Urals to the Kuznetskiy Altay. The northern boundary of the region marks the northernmost limit of corn growing as determined by thermal conditions; the southern boundary of corn growing, on the other hand, is the limit of moisture adequacy. The low temperatures of the region limit corn production mainly to silage and fodder, but in the 1955-56 period the region accounted for 14 percent of the total Soviet corn acreage.

*This region includes Sverdlovskaya and Chelyabinskaya Oblasts, the southern corn-growing regions of West Siberia, as well as the corn-growing areas of Northern Kazakhstan east of Aktyubinskaya Oblast'.

Climatic conditions in the Kazakh-West Siberian Region tend to restrict the corn-producing area. Toward the north the thermal conditions deteriorate sharply; and toward the south the precipitation is scant, and hot, dry winds, and drought are frequent. The frost-free season is 110 to 120 days long throughout most of the region. Average July temperatures vary from about 22°C (71.6°F) in vicinity of Semipalatinsk to about 17.5°C (63.5°F) along the northern margin of the region. During the critical June-August period, precipitation ranges from 150 to 200 millimeters (5.9 to 7.9 inches) in most of West Siberia, and from 100 to 150 millimeters (3.9 to 5.9 inches) in northern Kazakhstan and the western part of Altayskiy Kray.

The region is best suited to the production of green fodder; but along the southern margins of the region the thermal conditions are adequate to ripen early-maturing varieties of corn. In most parts of West Siberia that have sufficient precipitation, corn does not mature much beyond the tasseling stage. The best silage-producing area is the Kulunda Steppe, where both early- and average-maturing varieties reach the milk-wax stage. The Kustany and Akmolinsk regions of northern Kazakhstan receive enough heat to produce silage, but rainfall becomes increasingly precarious to the south. Expansion of corn acreages in the Pavlodar-Semipalatinsk area will depend upon the development of irrigation along the Irtysh River.

H. South Siberian-Far East Region*

This region contains relatively few areas suitable for corn growing. During the 1955-56 period, it accounted for only 3 percent of the total Soviet corn acreage, with most of the crop grown for silage. Production was centered mainly in the southern part of Krasnoyarskiy Kray and Irkutskaya Oblast'.

Climatic conditions restrict corn production largely to silage and fodder. The growing season is relatively short in East Siberia; about 100 days in the Minusinsk lowland, 98 days at Irkutsk, and 100 days at Chita. In the Soviet Far East, however, the growing season is considerably more favorable -- ranging from about 100 days in the Zeya River valley to about 150 days in the Ussuri River valley. The average July temperatures of the region are adequate for corn production -- 20.1°C (68.2°F) at Minusinsk, 19°C (66.2°F) at Yakutsk, 18.7°C (65.6°F) at Chita, and 20.2°C (68.4°F) at Khabarovsk. Accumulative temperatures during the growing season, however, are relatively low. Precipitation during the June-August period ranges from favorable

*This region embraces the southern parts of East Siberia and the Soviet Far East where the corn cultivation is concentrated.

to excessive -- from 137 millimeters (5.4 inches) at Ulan-Ude to more than 300 millimeters (11.8 inches) in most of the Soviet Far East.

Despite the general adequacy of precipitation, the ruggedness of the terrain and unfavorable thermal conditions restrict the extent of corn cultivation. Only scattered areas are suitable for the production of good-quality silage. These areas are located in the Upper Amur-Ussuri River valleys in the southern part of the Soviet Far East, where average-maturing varieties of corn reach the milk-wax stage. Average-maturing varieties reach the tasseling or green-fodder stage, in the Minusinsk lowland, in the Upper Angara River region, in the Chita and Ulan-Ude areas east of Lake Baykal, and in nearly all of the Upper Amur-Ussuri River basin.

I. Central Asian Region*

Situated on the flank of the Pamir Mountains, the Central Asian Region depends primarily on irrigation for its corn production. The region included only 3 percent of the total Soviet acreage during the 1955-56 period, but the fertile alluvial soils and long, hot growing season are conducive to high yields where irrigation is practiced (Figure 6). The greater part of the corn acreage is along the piedmont of the Kirgiz and Zeravashan Ranges, in the Fergana Valley, along the flood plains of the Syr-Dar'ya, Amu-Dar'ya, Chu, and Ili Rivers.

Thermal conditions are relatively favorable for corn growth; but at the peak of the growing season (during flowering and silking) the excessive daytime temperatures coupled with hot, dry winds from the desert may dessicate the corn plant. The long growing season -- 163 days at Kzyl-Orda and 234 days at Namangan -- permits the very-late-maturing, high-yielding varieties to be grown for grain or silage. In some parts of the region, corn can be grown for green fodder or silage as a second crop, following early vegetables or grains. Outside of the Alma-Ata--Frunze region, precipitation is extremely low. Increases in corn acreages, therefore, will be predicated on the extension of irrigation.

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*Statistically this region includes parts of the Turkmen, Uzbek, Tadzhik, Kirgiz Republics, and the southern tier of oblasts in the southern part of Kazakhstan.

Figure 6. Corn being grown in a mountain valley of the Pamirs in Central Asia.

IX. Conclusion

Although Khrushchev's "forced draft" Corn Program has been in progress for 3 years, it has not solved the problem of corn production satisfactorily. As of 1958, fodder production still fell far short of needs, as attested by Khrushchev's statement that fodder production must be increased four- or five-fold if the Soviet Union is to achieve its livestock and dairy goals. Furthermore, the Corn Program has met with resistence from both the farmers and elements within the party organization, who have criticised Khrushchev for pushing the program too rapidly, particularly in the more northern latitudes where corn is grown almost exclusively for fodder and silage.

The current Soviet Corn Program calls for (1) more intensive cultivation in the established corn areas of Moldavia, the Ukraine, and the Caucasus; (2) expansion of acreages in areas of marginal precipitation and drought in the southern Ukraine, the Lower Don--Southern Urals region and parts of Central Asia, all of which have sizeable areas under irrigation; and (3) considerable extension of corn production for fodder and silage into the European USSR north of 52°N. In the well established corn regions, increased acreages have been achieved at the expense of fallow land and other grain crops, principally winter wheat. The reduction in the acreages of other cereal grains, however, is being offset to some extent by their increased production in the New Lands Area of Northern Kazakhstan and West Siberia.

The current Corn Program has not introduced any radical shifts in the location of production, but rather has extended corn cultivation along the northern periphery of the old, established corn regions with the emphasis on fodder and silage. The most favorable regions for the production of corn as grain remain unchanged. The established grain-corn regions are also the regions most favorable for the growth of corn for silage. Among the regions capable of producing high silage yields are northern Moldavia, the northwestern and northern parts of the Ukraine, and the southwestern part of the Central Chernozem Region.

The Soviets are heavily committed to the Corn Program, particularly since it plays a key role in their even more ambitious livestock and dairy programs. The 1960 plans for corn production call for 28 million hectares of corn land, a 53 percent increase over the 1957 total. This planned acreage, though possibly attainable, is unrealistic since it necessitates further expansion into areas of increasingly marginal thermal and precipitation conditions. In such areas, corn yields can be expected to fluctuate sharply with the caprices of the weather -- which apparently were responsible for mediocre yields in the 1956-1957 seasons. Furthermore, many of these areas can produce only the low-yielding, early-maturing varieties of corn.

The greater part of future expansion in corn acreages will be for the production of fodder and silage. The most critical feed-consumming region of the country is the central part of European USSR and the Baltic-Belorussian Region. Here the fodder demands of the livestock and dairy industry are particularly high; but thermal conditions are limited, and only the early-maturing varieties of corn can be expected to ripen sufficiently for silage. Fodder and silage production also become increasingly precarious in the less humid southeastern areas that extend from the Lower Don region eastward through northern Kazakhstan. Any increases in corn growing to the southeast will depend largely on the extremes to which the Soviets are willing to go to achieve regional self-sufficiency in fodder and grain production.

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APPENDIX A

GROUPS OF SPECIFIC VARIETIES OF CORN GROWN IN THE USSR ACCORDING TO RATE OF MATURING

1. EARLIEST

    a. Beloyarnoye Psheno
    b. Kazanskaya 108
    c. Slavgorodskaya 270
    d. Chishminskaya 1

2. EARLY

    a. Spasovskaya
    b. Bezenchukskaya 41
    c. Voronezhskaya 76
    d. Chakinskaya Zhemchuzhina
    e. Severodakotskaya (North Dakota)

3. AVERAGE-EARLY

    a. Hybrid Donskoy
    b. Hybrid Bukovinskiy 1
    c. Khar'kovskaya 23 .
    d. Belaya Zybovidnaya Khar'kovskaya
    e. Dnepropetrovskaya

4. AVERAGE

    a. Hybrid VIR-25
    b. Minnezota 13 Ekstra (Minnesota 13 Extra)
    c. Hybrid Uspekh
    d. Hybrid VIR-42

5. LATE

    a. Hybrid Krasnodarskiy 4
    b. Hybrid VIR-50
    c. Sterling
    d. Hybrid Krasnodarskiy 1/49

APPENDIX B

CLIMATIC DATA FOR GROWING SEASON

Southwestern Region

Climatic Factors	L'vov 49°50'N 24°01'E	Kishinev 47°02'N 28°50'E	Kiev 50°27'N 30°30'E	Khar'kov 50°04'N 36°09'E	Rostov 47°13'N 39°43'E
Frost-free period					
Average					
First date	15 Apr	---	23 Apr	3 May	13 Apr
Last date	19 Oct	---	13 Oct	2 Oct	14 Oct
Duration (in days)	186	---	172	151	184
Extreme*					
First date	12 May	---	15 May	2 Jun	9 May
Last date	21 Sep	---	23 Sep	1 Sep	19 Sep
Shortest (in days)	145	---	146	113	154
Period with average temperatures above 10°C					
First date	26 Apr	20 Apr	28 Apr	26 Apr	19 Apr
Last date	7 Oct	16 Oct	3 Oct	6 Oct	15 Oct
Duration (in days)	165	180	159	164	180
Sums of temperatures of all days with average temperatures above 10°C	2600	3100	2600	2600	3300
Average temperatures					
April	7.5	9.0	6.8	7.0	9.0
May	13.3	15.5	14.5	14.3	16.8
June	17.0	19.3	17.4	18.1	20.7
July	18.8	21.9	19.2	20.3	23.7
August	17.9	22.1	18.2	18.9	22.8
September	13.8	16.2	13.6	13.2	16.5
October	8.8	10.3	7.2	7.0	9.8
Average precipitation					
April	46	31	46	33	35
May	65	51	51	41	44
June	107	69	74	71	66
July	104	61	79	69	52
August	71	41	56	51	32
September	53	32	46	31	32
October	51	28	48	41	35
Total: June-August	282	171	209	191	150

*Extreme dates of first and last frost do not generally occur in the same year.

Caucasus Region

Climatic Factors	Krasnodar 45°02'N 38°56'E	Sochi 43°34'N 39°46'E	Kislovodsk 43°54'N 42°42'E	Tbilisi 41°43'N 44°48'E
Frost-free period				
Average				
First date	13 Apr	26 Feb	22 Apr	22 Mar
Last date	21 Oct	12 Dec	9 Oct	14 Nov
Duration (in days)	190	288	169	236
Extreme				
First date	23 May	5 Apr	6 May	27 Apr
Last date	21 Sep	2 Nov	6 Sep	20 Oct
Shortest (in days)	132	238	140	---
Period with average temperatures above 10°C				
First date	12 Apr	28 Mar	30 Apr	4 Apr
Last date	27 Oct	30 Nov	8 Oct	3 Nov
Duration (in days)	199	248	162	214
Sums of temperatures of all days with average temperatures above 10°C	3600	4400	2600	4000
Average temperatures				
April	10.6	11.3	7.2	11.9
May	16.7	15.4	13.1	17.0
June	20.4	19.3	16.5	20.8
July	23.7	22.3	19.1	24.1
August	22.9	22.8	18.8	24.0
September	17.6	19.4	13.8	19.3
October	12.2	16.3	8.7	13.7
Average precipitation				
April	42	97	46	58
May	64	74	103	90
June	64	84	112	80
July	57	101	96	47
August	56	71	68	36
September	42	148	48	44
October	54	117	26	43
Total: .June-August	177	256	276	163

Baltic-Belorussian Region

Climatic Factors	Stations: Kaliningrad 54°43'N 20°30'E	Wilno 54°41'N 25°18'E	Tartu 58°23'N 26°43'E	Pinsk 52°07'N 26°06'E	Mogilev 53°54'N 30°20'E
Frost-free period					
Average					
First date	21 Apr	1 May	8 May	23 Apr	3 May
Last date	24 Oct	13 Oct	3 Oct	8 Oct	30 Sep
Duration (in days)	185	164	147	168	149
Extreme					
First date	15 May	26 May	29 May	23 May	24 May
Last date	3 Oct	19 Sep	7 Sep	11 Sep	5 Sep
Shortest (in days)	153	115	111	118	---
Period with average temperatures above 10°C					
First date	9 May	4 May	15 May	3 May	---
Last date	2 Oct	27 Sep	18 Sep	25 Sep	---
Duration (in days)	147	147	127	146	---
Sums of temperatures of all days with average temperatures above 10°C	2200	2200	1800	2300	---
Average temperatures					
April	5.8	6.0	3.7	6.9	5.3
May	11.8	12.8	10.4	13.8	12.8
June	15.5	16.1	14.5	17.6	16.1
July	17.5	18.1	17.1	19.0	18.0
August	16.2	16.6	15.0	17.7	16.4
September	12.8	12.2	10.5	13.1	11.5
October	7.7	6.6	4.9	7.0	5.4
Average precipitation					
April	38	38	35	49	46
May	48	59	55	51	63
June	62	65	65	77	80
July	83	106	83	94	73
August	85	87	86	57	79
September	76	57	74	46	59
October	60	54	61	40	59
Total: June-August	230	258	234	228	232

North European Region

Climatic Factors	Stations: Velikiye Luki 56°21'N 30°31'E	Vologda Molochnoye 59°18'N 39°40'E	Tula 54°12'N 37°35'E	Gor'kiy 56°20'N 44°00'E	Perm' 58°01'N 56°16'E
Frost-free period					
Average					
First date	7 May	21 May	10 May	8 May	23 May
Last date	29 Sep	17 Sep	28 Sep	30 Sep	19 Sep
Duration (in days)	144	118	140	144	118
Extreme					
First date	2 Jun	18 Jun	10 Jun	4 Jun	7 Jun
Last date	13 Sep	15 Aug	1 Sep	4 Sep	25 Aug
Shortest (in days)	92	72	105	121	93
Period with average temperatures above 10°C					
First date	3 May	16 May	4 May	8 May	15 May
Last date	20 Sep	10 Sep	21 Sep	17 Sep	11 Sep
Duration (in days)	139	116	139	131	118
Sums of temperatures of all days with average temperatures above 10°C	2019	1675	2192	1997	1791
Average temperatures					
April	4.6	2.4	4.2	3.0	2.2
May	11.9	9.8	12.7	11.6	10.0
June	15.4	14.5	16.5	15.8	15.6
July	17.7	17.1	18.6	18.1	18.0
August	15.7	14.6	16.8	16.2	15.3
September	10.8	9.0	11.3	10.4	9.2
October	5.1	2.7	4.9	3.2	1.6
Average precipitation					
April	31	29	33	29	28
May	47	48	48	40	51
June	72	67	63	61	66
July	84	71	78	74	79
August	82	69	55	58	72
September	51	65	48	59	64
October	43	48	44	51	53
Total: June-August	238	207	196	193	217

Central Chernozem Region

Climatic Factors	Stations: Kursk 51°45'N 36°12'E	Tambov 52°44'N 41°28'E	Uryupinsk 50°48'N 42°03'E	Penza 53°13'N 44°57'E	Novozybkov 52°31'N 31°51'E
Frost-free period					
Average					
First date	29 Apr	7 May	25 Apr	8 May	30 Apr
Last date	9 Oct	1 Oct	5 Oct	27 Sep	6 Oct
Duration (in days)	162	146	163	141	158
Extreme					
First date	29 May	1 Jun	17 May	5 Jun	30 May
Last date	22 Sep	5 Sep	26 Sep	1 Sep	11 Sep
Shortest (in days)	122	111	129	105	116
Period with average temperatures above 10°C					
First date	29 Apr	29 Apr	24 Apr	1 May	29 Apr
Last date	26 Sep	24 Sep	2 Oct	20 Sep	26 Sep
Duration (in days)	149	147	160	141	149
Sums of temperatures of all days with average temperatures above 10°C	2395	2435	2799	2231	2246
Average temperatures					
April	5.4	5.1	6.7	4.1	5.1
May	13.8	14.1	15.5	13.2	13.1
June	16.9	17.8	19.1	17.1	16.0
July	19.0	20.0	21.6	19.4	18.2
August	17.8	18.1	19.7	17.3	16.6
September	12.2	12.0	13.7	11.2	11.7
October	5.8	5.2	6.6	4.4	5.9
Average precipitation					
April	42	32	23	28	41
May	54	44	33	49	49
June	75	51	58	58	69
July	72	50	53	62	90
August	56	48	46	54	65
September	43	46	34	44	49
October	47	45	33	46	45
Total: June-August	203	149	157	174	224

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Volga--Ural Region

Climatic Factors	Kazan' 55°47'N 49°08'E	Ufa 54°45'N 56°00'E	Bezenchuk 52°59'N 49°29'E	Orenburg 51°45'N 55°06'E
Frost-free period				
Average				
First date	3 May	6 May	6 May	4 May
Last date	2 Oct	28 Sep	25 Sep	29 Sep
Duration (in days)	151	144	141	147
Extreme				
First date	1 Jun	2 Jun	5 Jun	4 Jun
Last date	8 Sep	1 Sep	6 Sep	7 Sep
Shortest (in days)	120	112	101	114
Period with average temperatures above 10°C				
First date	2 May	4 May	29 Apr	30 Apr
Last date	21 Sep	20 Sep	25 Sep	27 Sep
Duration (in days)	141	138	148	149
Sums of temperatures of all days with average temperatures above 10°C	2285	2202	2568	2679
Average temperatures				
April	3.1	3.3	4.5	4.3
May	12.1	12.6	14.3	14.7
June	17.4	17.5	18.8	19.7
July	19.4	19.4	21.4	22.0
August	17.2	17.1	19.2	19.8
September	10.5	11.1	12.5	13.1
October	2.8	3.1	4.6	4.7
Average precipitation				
April	26	28	23	21
May	34	42	36	36
June	57	60	41	45
July	52	69	40	37
August	49	51	43	32
September	47	46	38	26
October	43	53	35	31
Total: June-August	158	180	124	114

Kazakh-West Siberian Region

Climatic Factors	Stations: Kustanay 53°13'N 63°37'E	Akmolinsk 51°08'N 71°25'E	Omsk 55°01'N 73°23'E	Kamen'-na-Obi 53°48'N 81°20'E	Tomsk 56°27'N 84°59'E	Stalinsk 53°46'N 87°11'E
Frost-free period						
Average						
First date	---	13 May	28 May	25 May	26 May	20 May
Last date	---	21 Sep	19 Sep	19 Sep	16 Sep	20 Sep
Duration (in days)	---	129	115	118	114	122
Extreme						
First date	---	3 Jun	13 Jun	30 Jun	13 Jun	19 Jun
Last date	---	26 Aug	27 Aug	28 Aug	19 Aug	5 Sep
Shortest (in days)	---	87	90	89	86	77
Period with average temperatures above 10°C						
First date	7 May	8 May	13 May	---	24 May	17 May
Last date	22 Sep	20 Sep	17 Sep	---	11 Sep	17 Sep
Duration (in days)	139	134	126	---	109	122
Sums of temperatures of all days with average temperatures above 10°C	2200	2300	2000	---	1600	2000
Average temperatures						
April	0.7	0.8	-0.1	0.0	-0.6	0.8
May	13.0	13.2	10.4	10.8	8.4	9.9
June	17.3	18.6	16.2	17.3	15.3	16.7
July	19.9	21.1	18.4	19.2	18.1	19.0
August	18.0	18.5	15.5	16.7	15.8	16.6
September	11.2	11.8	10.0	10.6	9.2	10.3
October	2.2	2.2	1.2	1.9	0.6	1.5
Average precipitation						
April	15	17	17	14	27	28
May	28	24	28	27	46	53
June	37	40	56	46	66	69
July	48	47	70	65	77	63
August	34	34	53	48	71	71
September	25	24	34	33	48	51
October	26	24	22	26	48	38
Total: June-August	119	121	179	159	214	203

South Siberian--Far East Region

Climatic Factors	Minusinsk 53°42'N 91°42'E	Kansk 56°12'N 95°41'E	Chita 52°03'N 113°29'E	Blagoveshchensk 50°10'N 127°38'E
Frost-free period				
Average				
First date	24 May	27 May	3 Jun	9 May
Last date	13 Sep	13 Sep	4 Sep	28 Sep
Duration (in days)	113	108	94	141
Extreme				
First date	19 Jun	14 Jun	22 Jun	22 May
Last date	29 Aug	22 Aug	7 Aug	13 Sep
Shortest (in days)	78	84	64	126
Period with average temperatures above 10°C				
First date	13 May	21 May	24 May	15 May
Last date	14 Sep	10 Sep	9 Sep	22 Sep
Duration (in days)	123	111	107	129
Sums of temperatures of all days with average temperatures above 10°C	2100	1800	1700	2300
Average temperatures				
April	2.2	-0.1	0.0	2.3
May	10.4	8.6	7.9	10.3
June	17.3	16.0	15.8	17.3
July	20.1	19.0	18.8	21.2
August	17.2	16.0	15.3	18.8
September	10.1	8.8	8.2	12.1
October	1.0	-0.8	-1.8	2.3
Average precipitation				
April	14	13	10	20
May	33	31	28	41
June	54	43	51	84
July	59	56	94	124
August	57	56	94	117
September	35	36	36	69
October	18	23	10	20
Total: June-August	170	155	239	325

Central Asia Region

Climatic Factors	Tashkent 41°20'N 69°18'E	Namangan 41°00'N 71°41'E	Alma-Ata 43°16'N 76°53'E
Frost-free period			
Average			
First date	31 Mar	15 Mar	18 Mar
Last date	24 Oct	5 Nov	9 Oct
Duration (in days)	206	234	173
Extreme			
First date	28 Apr	21 Mar	8 May
Last date	3 Oct	23 Oct	19 Sep
Shortest (in days)	167	226	148
Period with average temperatures above 10°C			
First date	27 Mar	24 Mar	17 Apr
Last date	27 Oct	26 Oct	5 Oct
Duration (in days)	213	215	170
Sums of temperatures of all days with average temperatures above 10°C	4300	4400	3000
Average temperatures			
April	14.3	16.0	9.6
May	19.9	21.2	15.4
June	24.7	25.2	19.6
July	26.8	26.5	22.1
August	24.6	24.8	20.8
September	19.1	20.2	15.3
October	12.1	13.0	7.2
Average precipitation			
April	51	20	97
May	29	20	90
June	12	8	60
July	3	8	35
August	1	3	29
September	5	5	27
October	26	20	49
Total: June-August	16	19	124

APPENDIX C

GAPS IN INTELLIGENCE

Adequate information was lacking for a number of the phases of the Soviet Corn Program, despite the voluminous amount of literature that has been written on the subject. Detailed statistical data were lacking on the specific geographic distribution of corn and on the relative proportions of plains, rolling and hilly lands, or the individual soil types devoted to the crop. Reliable statistics concerning the corn area harvested and yields were also lacking. Such information would have made possible a better evaluation of the Soviet Corn Program.

Information on many climatic factors was meager. No data were available on the frequency or intensity of droughts for some parts of the corn-growing area, and no information at all is available on evaporation-transpiration rates. The climatic requirements and limitations of the corn plant are far from complete. Especially needed is fuller information on the complex relationship between climatic factors and plant development, particularly in respect to yields.

APPENDIX D

SOURCE REFERENCES

The sources used for this study were extensive but spotty in topical and regional coverage. Nearly all the information was derived from unclassified sources -- primarily Soviet and U.S. scientific texts, periodicals, and maps -- but some intelligence reports and documents also proved useful.

The list of sources given is selective and does not include all the individual items used for background information. Among those omitted were some general articles in Soviet and U.S. newspapers and periodicals, FBIS reports, and FDD summaries. Because of the propaganda value attached to the Soviet Corn Program, all accounts of it had to be carefully screened and compared with others in order to determine their accuracy.

The sources used in this study are generally reliable, as of the date of publication. Soviet books and periodicals dealing with subjects of an academic nature were generally found to be free of "ideological bias." Press and radio reports, however, contained many accounts of doubtful reliability and were carefully screened before any data they contained was incorporated into the report.

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