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NEW POSSIBILITIES IN THE DOMAIN OF GREEN MANURE UTILIZATION

In addition to producing forage grasses (mostly clover and alfalfa), the ability of legumes to fix nitrogen from the atmosphere must also be utilized by growing them as green manures. As such lupine is of the greatest importance for a good growth of it can accumulate, by the time it is plowed under in preparation for autumn grain sowing, about 160 kilograms of nitrogen per hectare, that is, not less than are contained in 30 - 35 tons of manure. It was estimated that in the European portion of the USSR alone, (in the non-chernozem area) green manure can be utilized yearly on an area of 2.5 million hectares. A wide field for utilization of green manures is also available in Siberia, where fallow precedes spring wheat, and hence a green cover crop can be plowed under later than it is done in preparation for autumn sowing. Within the sub-tropics, growing of legumes as green manure is also achieving great importance.

Sowing of legumes as green manure results in more rapid effect than the sowing of clover and alfalfa (see above). These measures must now be given especially great consideration in the rehabilitation of agriculture in regions devastated by the war so as to raise soil fertility in spite of manure shortage.

The use of green manures was previously restricted mainly to sandy soils, but now it <u>should find the widest application</u>, since it substitutes for manure shortage <u>in any soil</u> (even in the chernozem belt, if used from autumn on in preparation for spring grain). But in this we encounter the obstacle of <u>seed shortage</u>.

In combating this evil, selection of the plant acquires

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great significance, and preference must be given to legumes producing small seeds. Since they require less seed per hectare and provide better opportunity for sowing the nitrogen-gathering plants in admixture with other crops, thereby obviating the necessity of allocating a separate field to them in the spring (they are sowed together with a grain crop).

Unfortunately, up to now, we have grown mostly narrow-leaf lupine, which produces large seeds. This makes it necessary to raise the amount of seed used to 160- 200 kilograms per hectare, which is expended to obtain only one mowing of green plants, so that the expenditure must be repeated each year. Moreover, north of Moscow, where the seeds of this lupine do not ripen, there arises the necessity of meeting further costs and providing organizational measures in connection with the transportation of seeds.

Therefore it is also necessary, without giving up development of seed production of the annual lupine, to utilize the perennial lupine having small seeds in the production of which the ratio between the amount of seed and that of green plant material obtainable therefrom is 35 to 45 times more advantageous than in the case of the annual lupine. In the case of the former, one hectare requires about six times less seed (30 kilograms per hectare), while the period of hay mowings is about 6 to 8 times longer (sometimes even 10 times). In addition perennial lupine can yield in one summer from two (near Leningrad) to three (near Chernigov) hay harvests, so that the above-referred to ratio in the case of perennial lupine is found to be about 100 times more advantageous than that attained in the case of the annual lupine.

Naturally the first year of growth of perennial lupine, the same as in the case of clover, is not a period of utilization. Sown in the spring it develops only a leaf cluster, while the bloom, a very early one, appears only on the second year, but despite this, the problem of seed supply can be solved more readily and in less time by using the perennial lupine, especially since its propagation factor is much higher than that of the annual lupine. According to data of the Volokamsk Experimental Station, lupine, when sown in wide rows and hoed, can be planted at a rate of 4 kilograms of seed per hectare and [redacted] will yield a crop of 4 to 9 centners, i.e. the propagation factor may reach values of the order of 100 (and even 200). Moreover, its first year of growth can be greatly reduced in its vegetative period, since it is possible, even near Leningrad, to sow this lupine not only in the Spring but also in July. Furthermore, since its seeds can be harvested before winter grain, it is entirely feasable, for instance in southern Belorussia, to sow seeds harvested during the same year. In so doing not a single summer is wasted in preparation for a lupine hay stand of the following year, and expansion of acreage cropped to lupine can be accelerated. Also in the case of this lupine, it is possible to combine seed harvesting with plant material utilization as fertilizer, by reaping with sickles the tall flower-bearing stems, extending high above the leaves within that portion of the field where seed is harvested. (this is done in July in the North and June in the South), after which the plants are mowed and transferred to the field which is to be fertilized.

Since perennial lupine yields matured seeds as for north as Arkhangel'sk, local seed production is possible every-

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where.

In addition to being a source of seed and of green plant material, perennial lupine can constitute an important soil improvement agent in poor northern areas. Not only a 7 - 8 year period of growing lupine as a green fallow crop, but even one of 3 years duration, substantially increase land fertility. Thus, at the Sudogodak Experimental Field, a sector that had previously been abandoned because of low fertility, was made to produce for 2years lupine crops for use as fertilizer and thereafter gave a 222 centner yield of potatoes. In this instance no additional fertilizers were used. If, however, ground phosphate rock and potassium salt are applied, then by means of perennial lupine, reclamation can be attained not only of large areas of podsolized soils (heather barrens), but also of poor sandy soils, of which we have such vast areas, from the "sand sea" which covers an extensive region in the north (Shenkurskiy Rayon) down to the famous Aleshkin sands in the south. By stabilizing the latter with lupine, about 200,000 hectares of vineyards could be established, and their fertility sustained by inter-row cultivation of the same lupine, similarly to what is done abroad where they grow pines in conjunction with lupine on poor sandy soils.

While we are short of perennial lupine seed, its main utilization should be restricted to cultivation on adjacent plots outside the rotation system, as a source of seed and green plant material as fertilizer for the nearby fields. But when more seed becomes available, growing of lupine as part of the rotation system can be adopted, with one-time utilization by plowing under

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the lupine fallow during the blooming period as a fertilizer for winter rye, the lupine being sown in the spring of the foregoing season under the oats preceding the fallow. This procedure was successfully tested at the Sudogodsk Experimental Field (Ivanova Oblast'). In the Northeast, according to results obtained at the Solikamsk Experimental Station, it is not always successful, but west of the Moscow Meridian it produces very good results. Thus, in experiments conducted over a three-year period by agronomist Kondratov in Smolensk Oblast', yields of rye on perennial lupine were higher than with 18 tons of manure, and approximated those attained with 36 tons. In addition a substantial after effect was observed on potatoes which followed the rye.

These are the average figures for the three year period (1936, 1937 and 1939).

	Winter Rye (centners/hectare)	Potatoes (Aftereffect) (centners/hectare)
Control	8.4	87.4
Perennial Lupine	15.0	176.8
Manure (36 tons)	15.9	168.3
Manure (18 tons)	12.3	151.6

Even more beneficial results were obtained at the Ural Zonal Station (Molotov Oblast') where the effect of lupine was considerable even on the third crop (in centners per hectare):

	(1) Rye	(2) Flax After Rye		(3) Barley After Flax
		Straw	Seed	
Control	7.0	11.0	2.5	6.0
Lupine, Turned Under in Bloom	19.1	21.2	5.3	12.1
Only Crop Residues Plowed Under	16.6	19.9	4.7	10.9

The next problem at present is intensive production of perennial lupine seed. To meet it I have proposed that seed collected on small plots in July and August 1944 in the North (Ivanovo, Moscow, Smolensk, Kalinin oblast's) be sown in August or September in the Kuban' region. It was assumed that there would be a new crop of seed (100 - fold or higher or sowing 4.5 kilograms in wide rows) in the early summer of 1945, and by autumn a second blossoming and fruit formation was expected in the South. Then as early as 1946 the original supply of seed shipped from the north could be increased 10,000 times (or by 1947 one million times), so as to provide seed in first priority for areas deprived of livestock during the war period, and therefter strive to replace in other areas as well, manuring of fallow, by lupine, and to use the manure for fertilization of potatoes and of other crops.

(Actually this plan was somewhat disrupted by the extremely dry weather prevailing in the south during the autumn of 1944. The lupine did not germinate, and germination of the sowed lupine occurred to an appreciable extent only in the spring of 1945. Hence no early seed crop was obtained during that year. In addition to further steps in this direction, one must, of course, develop by all means the production of perennial lupine seed locally in the northern areas. As an example of a successful solution of this problem, there can be cited the case of the Semenovskiy Rayon of Gor'kiy Oblast'.)

It must be pointed out that introduction of lupine cultivation on fallow fields throughout the entire Non-Chernozem area may also solve another very important problem: it greatly facilitates the labor-consuming operation of manuring. The fact is that if lupine (in conjunction with phosphates and potassium salts) were to fully replace manure, on more distant fields of the holdings, the manure would need to be used only on nearby fields (primarily for vegetables, but also for cereal grains), and if the average distance over which manure must be carted be decreased only one half, it becomes readily apparent what fuel cost savings would be attained in the performance of this laborious operation. Of course lupine fallow is suitable primarily for sufficiently humid areas, but the turning under of mowed lupine grown on an outside area will not produce the same drying-out effect obtained from growing the lupine on the field where it is plowed under.

(According to data of the Sudogodsk Experimental Station, it is necessary to replow the land after turning under the lupine fallow crop to prevent weed growth in the autumn sown crop.)

In the future rich sources of perennial lupine seed, may be found among timbering areas where pines are grown on sandy soil. Experience in the west has demonstrated quite clearly that inter-row growing of lupine for 5 - 6 years without any additional care is a good method of promoting tree growth (thus a 20 year-old pine tree attains the size of a 30 year-old one grown without the use of lupine), while the annual seed harvest derived from such inter-rows of lupine on young plantations is an additional source of income for the forestry enterprise, as well as an important source of supply of lupine seed for agriculture.

Besides the perennial lupine there are, of course, other nitrogen collecting plants having small seeds, but none of them can be utilized as widely in the northern half of our plain. Serradilla, for example when planted in rows, requires as little as 30 kilograms of seed (if the seed is scattered 45 - 50 kilograms are needed). It can be sown with grain crops and yields in the autumn a good mowing of green plant growth suitable for use as feed and as fertilizer. While this can be successfully practiced in the Cherrigov region and in Belorussia, even in the vicinity of Moscow the autumn season is too short to permit utilization of serradilla after the grain crop with which it had been sown has been harvested. However, serradilla should be given due consideration within a very wide area, and it affords substantial advantages in rapid growth. Thus, when sown with cereal crops, it can be mowed in the autumn (and the remainder plowed under as fertilizer), while clover and perennial lupine can be mowed only in the following year.

According to computations of Ye. K. Alekseyev, within Poles'ye and southern Belorussia there are approximately 1.5 million hectares where serradilla could be utilized (including sowing in conjunction with grains). Still larger areas within which growing of serradilla, in one manner or another, is possible are located between Belorussia and the southern portion of Gor'kiy Oblast'. There is no point of estimating their size, however, at present, since there is a huge discrepancy between the required amount of seed and the quantity available. It is important to increase this quantity, but here we can see the difference between annual plants, the growing of which as green manure conflicts with growing for seed production, and the perennial lupine, which is adapted to give a seed harvest and still yield a crop of green plant growth for use as fertilizer.

Among the other small-seed annual legumes suitable for sowing with grain crops the following may be of interest: hop-like alfalfa frequently grown in Germany; crimson clover which is found growing in France and Switzerland, and the annual variety of sweet clover developed in the United States. These plants have been tried in this country to a lesser extent than lupine and serradilla. We should obtain, however, more seed than has been possible hitherto, in order to test them on a large scale.

The fact that we are stressing the great importance of perennial lupine and serradilla does not mean that annual lupine is not worthy of our attention. It still retains its significance, and possesses certain advantageous features which are lacking in perennial lupine. Thus annual lupine can be sown on harvested rye fields in southern Belorussia and in the Sherrigov area; it is also of interest as a seedcrop legume, especially the "sweet" lupine which yields valuable nutritive feed. At the same time root residues remaining after the lupine seed crop has been harvested ensure good yields of potatoes planted thereafter.

We must point out that it is entirely inadequate for such a large country as ours, to have available but one western located source of lupine and serradilla seed. We must create new sources in the central portion and in the eastern part of the country. As such, we believe to be suitable primarily for such a purpose the huge area of sandy soils extending southward from Murom along the right bank of the Oka and the Tsna to Morshansk and Tambov. Here can be found conditions suitable for the production of seeds of not only the blue (narrow leaf) lupine, but also of yellow lupine; from here seed could be supplied to the northern areas where the seeds do not mature and also the extreme south where seed is needed for winter sowing of lupine to be used as fertilizer, but where it is not worthwhile to tie up valuable land for seed production. Then it is possible that large amounts of lupine seed would become readily available where their production on a large scale is found advantageous by farming communities. An example of such advantageous production may be found in farming areas in sandy soil regions, provided it is based on the three pillars of lupine, potatoes and hogs.

I had occasion to observe abroad in 1927 farming practices in sandy soil areas, where hogs were fed on a large scale exclusively on potatoes and lupine; but in those days lupine seed had to be steamed and soaked to remove its bitter taste, while now with "sweet" lupine available and serving as a valuable source of proteins in feeding young pigs this tedious operation has been eliminated. At the same time these two plants (lupine and potato) form a very good combination in rotation, since lupine harvested for seed leaves in the soil no less nitrogen than lupine turned under in bloom (this was ascertained by prior experiments of Kudrin), and, if farming practices also utilize lupine straw, the total amount of nitrogen put to use, excluding the seed, is greater than that obtained on plowing under the lupine while in blossom. Incidentally, tests at the Sudogorsk Experimental Field have shown that the straw of sweet lupine, when cut-up and treated with boiling water, is readily eaten by livestock. Since in the vicinity of Tambov and Yoronezh, rye can follow early potatoes, it is conceivable that on humous, riverside sands the following intensive four-course system is possible: lupine to yield a seed crop, potatoes, rye and serradilla (to be mowed after the rye harvest), and spring grain. But individual cases may vary. What is important is that lupine seed must cease being considered as some sort of oddity, which has to be disposed of elsewhere; it must acquire a local importance as a product; then it will be always possible to increase its production for sowing purposes, accepting it within certain limits in lieu of rye. Unfortunately outside of Belorussia this has not taken place up to now. For example, the Sudogodsk Station could not promote ordinary lupine grown for seed in local farming communities of Ivanov Oblast'; only the sweet lupine attracted the interest of collective farm members.

Let us consider other entirely novel possibilities of green manure utilization in Central Asia, where conditions have undergone drastic changes during the war. On the one hand cotton growing has been deprived of nitrogen fertilizers which played the principal part in the cotton yield increases, so that yields dropped sharply reverting to 1930 levels; on the other hand, in 1943 there became apparent unprecedented possibilities for a wide utilization of green manures, due to substantial alterations of the rotation system. Up to then, farming was surfeited with cotton; growing of grains on irrigated areas was not permitted at all. Hence farms were deprived of straw, and without straw no means were available for absorbing liquid excretions of cattle, which contain all the nitrogen of the digested portion of alfalfa hay. Therefore there was little manure and it was poor in nitrogen. Hence the huge demand for mineral nitrogen and its shortage in cotton growing during the war.

In addition, under the then-prevailing rotation system in irrigated areas, no use could be made of autumn sown nitrogen collecting crops. The system of sowing cotton in succession to cotton for six consecutive years precluded utilization of this procedure, since cotton occupied the land until December, when it is too late to sow winter peas, while attempts to sow peas between rows before cotton harvest time were not successful. But since 1943, of the 900,000 hectares of irrigated land in Uzbekistan previously cropped exclusively to cotton, 300,000 hectares were allocated to grain crops and sugar beets, thus making possible the modest utilization of autumn-sown nitrogen collecting crops. Since not only grains but sugar beets as well are harvested much earlier than cotton.

(Partial harvesting of the beet crop must begin on August 15, since at that time the sugar content of beets planted in March reaches 17 percent, and it is much more advantageous to put the mills in operation earlier than to process later on in March beets of 10 - 12 percent sugar content because beets in the south stand storage less well than in the Ukraine.)

But the most extensive field for utilization of autumn-sown nitrogen collecting crops develops on the area vacated by grain crops. In the case of winter grains it is possible to visualize the attainment of a three-stage sowing and to effect autumn planting of legumes as the third sowing of the season. Since harvesting of winter barley begins around Samarkand about June 1st and in Tadzhikistan and Turkmeniya in the middle of May, it is possible to have another harvest of a food crop (potatoes, early varieties of dzhugora, etc.) and still make possible a sowing of winter peas in September or October depending on the latitude. The winter-grain crop can also be sowed together with Persian clover and use its summer mowing either as hay or green fodder, (which would yield additional amounts of milk, which is so badly needed in Central Asian towns) and carry the second stand through the winter to be plowed under in the spring as a green manure for cotton. Finally, there are data (Gel'tser) showing that certain varieties of peas, if irrigated after grain harvest, continue to grow and yield again a stand of green plants; this it is possible to sow in early June peas as a seed crop, leaving the harvest residues to serve as a fertilizer for cotton through subsequent plowing under in October - November or in the spring.

Concerning the effectiveness of green manures under Central Asian conditions, we can cite the results obtained by Academician Ye. K. Alekseyev near Samarkand in 1942. He attained a doubled yield of beets (384 centners as compared with 182 centners of control) through having peas plowed under as a fertilizer. In Kazakhstan there were obtained increases in the yield of beets amounting to 140 - 160 centners due to after-harvest green manures (Zubrilin), (We do not make reference here to previous experiments in which the green manure crop was sown in the spring in lieu of cotton; at present only after-harvest growing and concurrent growing of nitrogen fixing crops are of interest.) Analogous effect must be produced on cotton by green manure. The question of the special importance of wide utilization of autumn-sown nitrogen fixing crops in Central Asia during the war was raised by me in the spring of 1943 so as to allow time for obtaining seeds from the United States. We were unable to secure these seeds by the autumn of 1943, but in 1944 a shipment of 4 thousand tons of winter peas and other nitrogen fixing plants was received, which were used for propagation. If by so doing, the supply of these seeds is raised to 30 - 45 thousand tons, this amount would be sufficient to cover an area of 200 - 300 thousand hectares, which would constitute an important factor in raising cotton yields in Uzbekistan.

While my suggestion, made in 1943, relative to the sowing of nitrogen gathering crops following the harvesting of grains and beets was limited, in spite of the importance of this measure, to only one out of six fields of cotton, encountered in the usual rotation systems, as early as 1944 I raised another question, namely: would it be possible not to limit this procedure to a single application, but to find means for utilizing it repeatedly? In this connection there appeared the possibility of attaining even a 100 percent saturation of the cotton-growing area with nitrogen fixing crops without decreasing the planting of cotton.

The reason for bringing up this question is to be found in certain data relative to cotton growing in Egypt. Experience gained in Egypt cannot, of course, be applied directly to the entire cotton belt, but on due consideration there might be derived therefrom certain problems which should be studied by our own researchers.

The basic problem which interested me is the following: In some portions of Egypt, especially in the delta of the Nile, there is practiced the repeated sowing of cotton on the same areas, and yet this cannot be designated as a single crop method because in between the consecutive cotton crops the land is cropped to Alexandria clover which produces several mowings during the "winter period," the last of which is not utilized as hay, but is plowed under as green manure. The acreage under this clover in Egypt is about 520 thousand hectares, while cotton occupies 770 thousand hectares, i.e. practically all the cotton is planted in succession to clover. In part there is also cultivated there, on the same dual rotation system, another pair of crops, namely corn and wheat, but from our standpoint what is important is the fact that as a rule cotton is sown over plowed-under clover, which is its main source of nitrogen.

Could we not adopt some similar method in our country? Would it not be possible to obtain at least one legume crop between two sowings of cotton? Hitherto it appeared that this could not be done, since experiments in which winter peas were grown with cotton did not yield satisfactory results. However, we should not give up and consider the problem as being settled; we must test different nitrogen fixing plants, different methods, and times of sowing. That a transition is attainable by such means is apparent from the publications of V. G. Petrov (see Sovkhoznoye proizvodstvo, 1944, No 7) concerning the planting of winter wheat with cotton, which previously also did not produce good results, but now, according to data presented in the above-referred-to publication, the problem could be solved satisfactorily, if the proper variety (one of the Graecum species) were to be used, and the time of sowing changed. The wheat is sown between cotton rows fairly early – in August.

This leads us to believe that among the numerous varieties constituting the genus of legumes, there can be found annual species adapted for sowing in conjunction with cotton. Whereas Alexandrian clover may be suitable only in Tadzhikistan and Turkmeniya, in Uzbekistan we must consider, for instance, fenugreek (Trigonella foenum graecum) which is grown successfully as a feed crop in Azerbajdzhan, where it is called "shambola". The growing of this crop is centered in the Nakhichevan' Kray, where it occupies a fairly prominent position among field crops. The literature contains but little information on the technical aspects of growing this plant, but we do find the following characteristic statement in the article by Surpukhova (V. N. Serpukhova. "Fenugreek (Shambola)", Rasteniyevodstrov SSSR, 1933, Vir Press. Volume II, Pages 457 -476): " . . . due to its very short vegetative period it can be utilized in intensified rotation systems as a forage and green-manure after-harvest crop, and is a good crop for planting immediately before valuable industrial crops (cotton, tobacco). In France shambola is occasionally grown as an after-harvest, autumn-sown crop."

Obviously, it is of interest to test this plant in Central Asia by growing it together with cotton as well as an after-harvest crop.

Then there is of possible interest the crimson clover sown in South Europe in admixture with winter rye to yield the very earliest feed crop in the spring. Persian clover must be tested not just as "a clover" but in all its different varieties found in Iran and Afghanistan; there should also be tested other annual varieties of legumes available at botanical gardens (here and abroad) or growing wild.

Introduction of nitrogen fixing plants of this type is a very important measure of substituting for shortages in nitrogen fertilizers and manure, and this means is free of certain shortcomings inherent in manure, which are especially prominent in Central Asia. It provides for imparting to the soil all of the fertilizer nitrogen without any losses, and in addition obviates transportation. It is manure growing on the very field which requires fertilizer; and it does not need bedding to produce the fertilizer.

If a legume could be found which could be grown with cotton by V. G. Petrov's method, then this procedure could be carried out systematically, ensuring good yields of cotton even when mineral nitrogen fertilizers are temporarily not available. Let us assume (to simplify the presentation) that fenugreek is such a nitrogen fixing plant; then the hypothetic rotation system assumes the following form: (1) barley and alfalfa; (2) alfalfa (3) alfalfa; (4) and (5) cotton plus fenugreek; (6) cotton + winter grain; (7) winter grain + summer after-harvest crops + fenugreek; (8) and (9) cotton + fenugreek.

It may be assumed that five sowings of funugreek and three years of alfalfa, even on taking into account only its root residues, should supply a sufficient amount of nitrogen to five cotton crops. One may go even further in this assumption and suppose that the comination of cotton + fenugreek can be repeated without harm not only for two consecutive years, but even longer. This would make it possible to increase the percentage of acreage under cotton without decreasing its yields; but to do so, one must have at hand such a nitrogen gathering legume (whether it be fenugreek, crimson clover, or Alexandrian clover) which could be successfully sown in the autumn on the cotton fields and which would accumulate by spring up to 100 kilograms of nitrogen in the green plant material.

The more successfully this problem is solved the better will we be insured against decreases of cotton crop yields at times when there is a shortage of mineral fertilizers. But not only when there is a shortage of mineral fertilizers but later on as well, when there would be plenty of mineral fertilizers we must still retain the growing of nitrogen fixing winter crops, the more so, since they can be used not only as green manures but also as cattle fodder during the winter, especially for dairy cattle, the number of which in Central Asia must be increased, and which are in such a need of protein feed. In general, by means of winter crops (grain, feed and nitrogen fixing) we can utilize additional sunlight energy, which in Central Asia is fairly well supplied, not only during autumn, but also in the spring (prior to sowing of cotton), but which can be utilized only by those plants which have developed during the autumn season their assimilative parts. Hence, we should not in general allow our fields to remain unsown during the winter. (Naturally in order to obtain a definite response to the propounded question, additional experimental study is necessary. But a satisfactory solution would be most desirable; at the same time, work in this direction is so remunerative that it should attract attention of Central Asian researchers.)

In the Transcancasus conditions for winter legume crops grown as fertilizers are even more propitious. Within the humid subtropics no frosts occur during winter, whereas they are common inUzbekistan. For example, even though at Sukhumi it snows occasionally in January the snow melts so rapidly that it does no harm to the roses in bloom. Also within these areas precipitation is sufficiently high to make irrigation unnecessary. Up to now the use of green manures in the south was confined primarily to tea and citrous fruit plantations but at present attention has been called to it in connection with extensive corn fields which remain bare from September or October until early in May (Kulzhinskiy), although they could produce during this period from 50 to 100 tons of green plant material per hectare, especially if they are treated with ground phosphate rock and potassium salts. With good yields, it is entirely possible to use a portion of the plant material as cattle feed and obtain a good yield of corn by plowing under the remainder. It is also possible to produce in the spring a valuable food crop by harvesting the green pods of early peas and plowing under the remaining vines or using them as a feed. In addition to winter peas consideration should be given to small seed legumes requiring less seed in sowing such as the annual clovers: crimson, Persian and Alexandrian. (Under these conditions it is entirely possible to utilize the above-referred to Egyptian rotation system employing nitrogen gathering crops during the winter and corn in the summer.) The acid soil of the Transcancasus, unlike the carbonate soils of Central Asia, make possible cultivation of serradilla and lupine while the perennial lupine has here also its uses as an erosion preventive cover crop on steep slopes between the terraces of tea and citrous fruit plantations.

In addition to the production of green plant material as feed and fertilizer, winter crops of nitrogen gathering plants are a very important means of preventing soil erosion in areas (in the Transcancasus) where the annual precipitation reaches 2000 millimeters.

Corn-growing areas can supply their own needs for seed, but the requirements for lupine, serradilla and pea seed for sowing on tea and citrous fruit plantations must be met by importation from the north so as to avoid tying up valuable land which can be used for the production of southern crops.

Even though legume seed reserves can be increased to start with by obtaining them from abroad to meet future years requirements we must forthwith resort to a number of coordinated measures for the development of new areas for the production of seed of valuable nitrogen fixing plants which will assist us in expanding agriculture in the north, in sustaining grain and potato production in the Central areas, and, within the subtropics, ensuring good yields of such important industrial and food crops as cotton, tea and citrous fruits.

In the subtropics the mild climate is favorable to the growing of nitrogen fixing legumes in conjunction with other crops; in Siberia, on the other hand, there exist conditions favoring wide utilization of green manures, namely; availability of fallow preceding spring wheat. There are also encountered difficulties in transportation of manure frequently caused by the remote location of fields from the homestead and by the hilly nature of the terrain, especially in Eastern Siberia. Insofar as selection of green manure crops is concerned the conditions which hinder wider utilization of annual lupine in the northern portion of European USSR and induce its replacement by the perennial lupine are the very conditions which prevail on a wider scale in Siberia. They include, among others, the possibility of growing the seed locally and greater ease of seed transportation. Of course, in Altay and Minusinsk krays the annual lupine can also be grown for seed production but there is also the fact that 30 kilograms of seed are sufficient in lieu of 180 - 200 kilograms to effect the sowing may be the determining factor. In many instances sweet clover will be found to be useful, since, while unsuited on acid soils, it is better adapted than lupine for solonetz soils and weakly alkaline soils and may be thus used with spring-sown grains and plowed under the next year as a fallow crop (the fear that sweet clover will become a weed is unfounded; all that is necessary is to prevent seed formation).

Thus, under most diverse climatic and soil conditions there is a possibility of utilizing green manures as a means

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of making it possible to introduce rapidly into the agricultural cycle a huge amount of nitrogen, thereby enhancing yield increases of grain and a number of industrial crops while awaiting restoration and expansion of clover growing areas and rehabilitation of animal husbandry. But it must be borne in mind that even when acreage under clover reaches 25 percent of the total cultivated area within the podsolic belt there still would be no sense in giving up using green manures for autumn-sown grains, for they make it possible to use manure obtained from clover feed as a fertilizer for potatoes, sugar beets, hemp, tobacco and other valuable crops.

Among sources of nitrogen we must also mention the necessity of making wider use of city refuse nitrogen and of peat nitrogen.

The total nitrogen content of human excreta for an anticipated 230 million population of our union may be assumed to equal 1100 thousand tons. This would constitute a very sizeable item exceeding several times the output of our pre-war nitrogen industry, if these residues were not so difficult to collect. In cities they flow into sewers, in rural areas they are scattered to a considerable extent haphazardly. It is very difficult to say what portion of them could be utilized in the future. It is clear, however, that with a general shortage of fertilizers, one may not ignore the vast possibilities afforded by this source of nitrogen, especially utilized in conjunction with peat. Expansion of the method for producing peat-fecal composts in inhabited locations deprived of sewers is important not only from the standpoint of nitrogen conservation but

~~but~~ from a sanitary one as well. Where peat is not available, excrements should be combined with earth to make composts. (As a good example of fecal matter utilization for agricultural needs, while at the same time solving the problem of removing them from populated areas we can cite the following instance, taking place in one small town of Central Asia. The local collective farmers have undertaken the maintenance of city toilets; - when the pit is filled with refuse, they dig a new one nearby and transfer to it the superstructure. The old pit is filled with earth. This compost is left undisturbed for several months after which the contents, now completely odorless, are carted to the fields.)

A method to be preferred over that of making a compost producing a bulky material is a procedure which results not only in sterilization of the excreta but also in the production of a valuable concentrate rich in nitrogen and containing an appreciable amount of phosphorus; it consists in chlorination of fecal material followed by drying on a plate drier (S. P. Gusev, (Dissertation). However, this method is applicable only in those instances where fuel costs are not included entirely in the price of the poudrette but are in part defrayed by the city (as an item relating to refuse sterilization and disposal). There exists however conditions under which poudrette production can be effected by means of solar heat. This can be done for example in Central Asia, where, as a rule, towns do not have sewers, while climatic conditions render certain the lack of rains and strong thermal emanation from the sun throughout the six-month summer period. Production of ammonium sulfate may be considered possible if fluid material from public toilets were to be collected as a shallow layer in flat reservoirs, provided with a black colored bottom, into which there also would be discharged acid wastes (for instance, sulfuric acid from scouring shops of cotton processing plants or bisulfate), and the concentrated solution then passed into tanks shielded from the sun to permit ammonium sulfate to crystallize. In the same manner solar heat could be used in the production of poudrettes from ordinary mixtures of excreta when these are first subjected to a chlorination process. Thus several results would be attained simultaneously: - conservation of ammonia, sterilization, and elimination of objectionable odors. But where chemical means are not available the Central Asian sun makes it possible to use a number of procedures for partial or complete utilization of fecal mass with better results than those attainable anywhere else. (These include in the first place separate collection of liquid and solid excrements so that only the forum are discharged into a pit while the latter are permitted to dry unadmixed with any other material. A more complete utilization of both is possible by substituting for pits aboveground devices providing for continuous addition to the excreta of loose soil which is very well adapted for fine comminution, thus making possible a considerable decrease in the amount of inert material to be added. (P. Ya. Gurov).

Insofar as peat is concerned, in addition to its use as bedding to increase the quality of manure, while also increasing its bulk, it is also of importance in the preparation of peat composts containing various substances other than feces, like manure liquor, bird-droppings, weeds, slops (if not completely utilized in feed) with addition of ashes, especially if acidic peat, pond silt, and so forth are being used.

In preparing peat-feces fertilizers, the nitrogen contained in the peat is included. At times peat as such is used as fertilizer. But it should be mentioned that peat nitrogen cannot be simply mechanically added to the nitrogen of fecal masses, since peat nitrogen is much less readily mineralized. Hence, it is hardly worthwhile to compute the amount of peat nitrogen that can be assimilated, although it can be assumed, approximately, that by the combined use of peat and fecal materials we can provide easily an additional amount of about 500 thousand tons of readily utilizable nitrogen.

To sum up, the conclusion may be made that we have available tremendous potentialities for undertaking a radical change of the nitrogen balance of our agriculture as well as for an immediate decrease in the nitrogen deficit which has become exceedingly great under wartime conditions.

CONCLUSIONS

As is apparent from all of what has been stated above, solution of the nitrogen problem comprises a combined use of two means: (1) increasing the amount of mineral fertilizers made available primarily to industrial crops, and (2) utilizing to the greatest extent biological nitrogen by expanding cultivation of nitrogen fixing plants, by better management of manure accumulation and utilization, and by drawing upon other local resources of fertilizer material (peat, feces, etc.). In this connection difference in the method of fertilizer application for cultivating industrial crops and for growing grain must by no means be considered as merely a temporary condition depending solely on the fact that our newly created chemical industry is not in a position to provide as much fertilizer for grain as it supplies for cotton or beets. It is clear that for economic reasons there will also prevail in the future a fundamental difference in this respect between crops whose acreage is limited (cotton, tea) and in whose cultivation we can alter substantially only one factor (the yield), and those crops, such as grains and clover, in whose cultivation we can alter both factors (acreage and yield) which determine the total harvest.

Of course when we speak of two contrasting methods of establishing a fertilizer utilization system, we are only making a first approximation; actually we have here a series of transitory steps. Thus, at one end of this multicolored spectrum we find the manureless cropping system of tea and citrus fruit plantations, where to combat erosion and to accumulate organic matter it is necessary, of course, to resort to the growing of nitrogen fixing crops, but where the essential supply of mineral food for the plants must be founded on use of synthetic fertilizers. In cotton farming, alongside of highly important mineral fertilizers, an important role has come to be performed by alfalfa which in turn makes possible cattle and manure. A further shift toward manure utilization is found in beet growing. This shift is even more pronounced in Northern agriculture where grains alternate with clover and potatoes; here a strong trend exists toward a "super-manure" economy (flax, however, should still be supplied with mineral fertilizers). But if tea plantations in the South and dairy farming in the North are contrasting, they are both different from the steppe agriculture of the East including the irrigated parts of Kazakhstan, Kirgiziya, and Eastern Siberia, where even manure is as yet inadequately utilized as fertilizer. Within the treeless steppe areas, one of the obstacles for such utilization is the consumption of manure as a fuel ("kizyak"), while in the wooded, hilly regions of Eastern Siberia another obstacle is the difficulty of conveying manure to the tilled plots scattered in the taiga which suggests utilization of green manure. Thus sometimes such extremes as continental Siberia and the humid subtropics can sometimes display in certain respects a definite similarity.

Between the above-referred to. contrasting types, there is present, of course, a whole gamut of transitions in the establishment of a fertilizing system, which is due to the wide variety of conditions that exist within our vast fatherland. When we are speaking of a contemplated average yield of a crop, or of average balance of removal and return of soil nutrients, we must remember that these averages are obtained on the basis of most widely ranging components.