Fertilizer Recommendations for 1936
Michigan State University Extension Service
C.E. Millar, G.M. Grantham, P.M. Harmer, and R.L. Cook
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Fertilizer Analyses Recommended For Use in Michigan

0 - 20 - 0	2 - 8 - 16
0 - 12 - 12	3 - 12 - 12
0 - 8 - 24	3 - 12 - 15
0 - 14 - 6	4 - 10 - 6
0 - 10 - 20	4 - 16 - 4
2 - 12 - 6	4 - 16 - 8
2 - 14 - 4	10 - 6 - 4
2 - 16 - 8	

Nitrogen Carriers
Potash Salts

MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

EXTENSION DIVISION
R. J. Baldwin, Director

East Lansing, Michigan

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PERTINENT POINTS

1. The increase in use of commercial fertilizers is evidence that Michigan farmers are finding their use profitable. The quantity used may be expected to continue to increase, especially by the more progressive farmers.
2. Fertilizers are used to supplement the plant food which becomes available in the soil and from manure, in order that greater yields may be possible.
3. The greatest returns from fertilizer on mineral soils cannot be expected on strongly acid soils or soils low in organic matter.
4. The method of application as well as the plant food content has much to do with the returns received from fertilizer applications.
5. Different soils have markedly different plant food deficiencies. Crops vary greatly in their nutrient requirements. Study Tables I, II, and III carefully to find what fertilizer analysis is best suited to your soil for the crop you wish to grow.
6. Fertilizers are not a cure-all. On mineral soils use them in conjunction with good tillage, lime, green crops plowed under, rotation, manure, and other good soil management practices.
7. The intensive production followed on muck soils requires special tillage and fertilizer practices. Refer to Table III and the Circular Bulletin 103, and Special Bulletins 168 and 136.

FERTILIZER RECOMMENDATIONS FOR 1936

C. E. Millar, G. M. Grantham, P. M. Harmer, and R. L. Cook

The increasing use of commercial fertilizers is sufficient evidence that Michigan farmers are finding their use profitable. The same situation pertains in the States adjoining Michigan, as well as in all of the older agricultural states. In fact, our sister States of Ohio and Indiana use very much larger quantities of fertilizer than do we. It is reasonable to suppose, as soils are cropped for a long period of years, and are thus removed further and further from the virgin state, that the supply of available plant food will become less and less and hence the necessity of supplementing the soil's supply grows more urgent. Unfortunately, the quantity of animal manures on Michigan farms is inadequate to make up the deficiency and hence we must resort to commercial sources.

Experimental farms where commercial fertilizer has been used regularly for from forty to eighty years have dispelled the old time fear that commercial plant foods will exhaust the humus supply or otherwise damage the soil.

In the last few years, fertilizers containing much higher percentages of plant food have been rapidly appearing on the market. These higher-analysis mixtures supply plant nutrients at a lower cost than the lower-analysis goods and hence are more economical, even though they cost more per ton. The price per ton should not be given too much consideration in purchasing fertilizers, since the higher priced (high analysis) goods may be applied in smaller quantities and hence fertilize more acres for the same total expenditure. The use of higher-analysis mixtures does require more information, however, as to proper rate and method of application in order to obtain best results and hence a more thorough knowledge of the soil conditions and crop requirements is being demanded of the farmer.

In the following pages, an endeavor has been made to give such information as will guide the farmer in selecting the fertilizer which most nearly meets the deficiencies of his soil and is best adapted to the crop he desires to grow. These recommendations are based on the results from a large number of experimental fields located on the principal soil types in all parts of the state. As the results from the experimental fields accumulate and advances are made in the manufacture of fertilizers, and with changing economic conditions, it is advisable to alter our recommendations from time to time and hence a revision of this bulletin will be made each year.

Selecting the Proper Fertilizer Analysis

The success obtained from fertilizers depends on their proper utilization. Some of the principal points to be considered are:

(1) Select a mixture containing the plant food elements which your soil will not supply in adequate quantities to the crop to be grown.

(2) Be sure the plant food elements are in the right proportion to fit the needs of your soil and crop.

(3) Use an adequate quantity of fertilizer.

(4) Apply the fertilizer at the right time and in the right way to give best results.

(5) Do not expect fertilizers to take the place of organic matter or of lime in soils deficient in these materials.

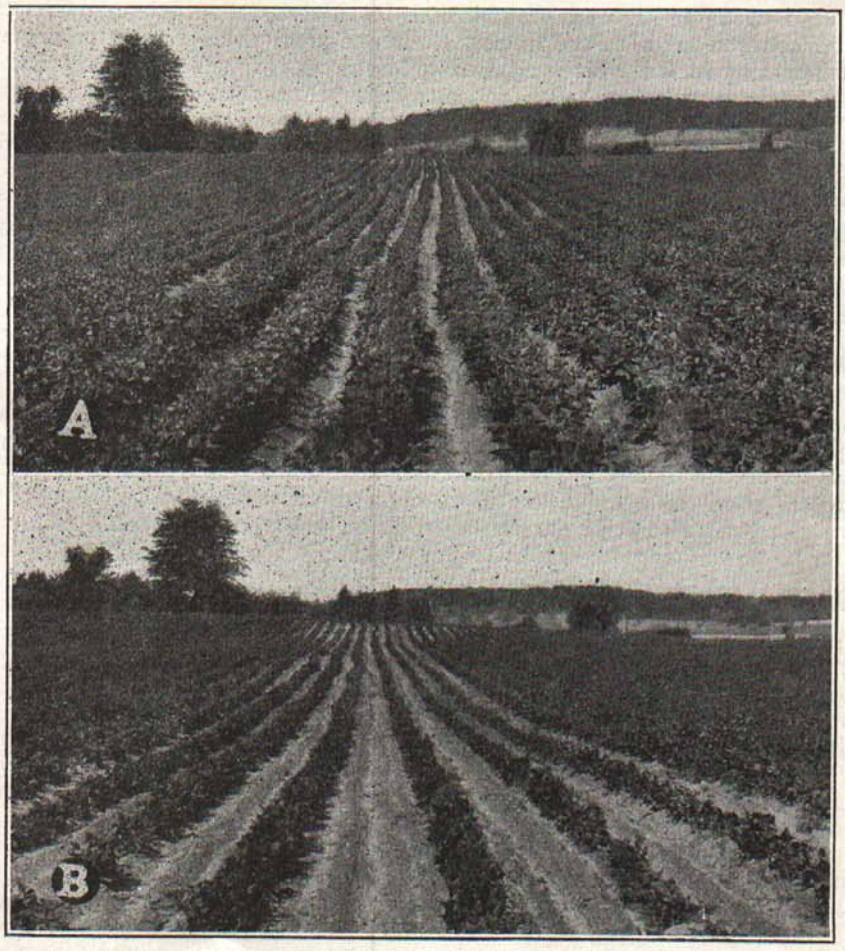

Fig. 1. Beans respond to fertilization. Upper—250 pounds per acre of complete fertilizer. Lower—No treatment.

Many years of experimentation have demonstrated that at least three fertilizer constituents may be needed by crops growing on Michigan soils. It is a well recognized fact that soils vary greatly in their ability to supply the different plant food elements to crops. Many mineral soils are quite deficient in nitrogen and phosphate but contain sufficient potash. Other soils have a satisfactory nitrogen content but require additional phosphate and potash. Very few Michigan soils supply sufficient phosphate for maximum crop yields.

It is not the total quantities of plant food elements in the soil, but rather the rate at which these nutrients become available for plant use that determines the need for fertilization. In this connection, the system of soil management practiced is of vital importance, since decaying organic matter is one of the most potent agents in making plant nutrients soluble. In determining what analysis of fertilizer fits your requirement, you must not only consider the natural deficiencies of your soil, but also the crop rotation you follow, how much manure has been applied in the last few years, and whether or not a green manuring crop or a heavy leguminous sod has been plowed under recently.

Fig. 2. The potatoes in the foreground received no fertilizer while those in the background received 1,000 pounds per acre of 4-16-8.

Different crops have quite different plant food needs. Some crops are grown primarily for their tops; in others, it is the grain or seed which is desired. In some cases, the plant is required to manufacture and store large quantities of starch or sugar and sometimes of oil. Frequently, early maturity of crops is of prime importance either for early market or to avoid frost and almost universally a product of high quality is desired. These points also must be considered in choosing your fertilizer.

Some of the most noticeable effects on crop growth of the three plant food elements, nitrogen, phosphate and potash, are as follows:

Nitrogen—

1. Increases top growth of crop.
2. Hastens growth of crop.

Phosphate—

1. Hastens maturity of crop.
2. Improves quality and stimulates root development.

Potash—

1. Improves vigor of crop and makes it more resistant to disease.
2. Increases growth of root crops and is essential for production of starch, sugar, and other carbohydrates.

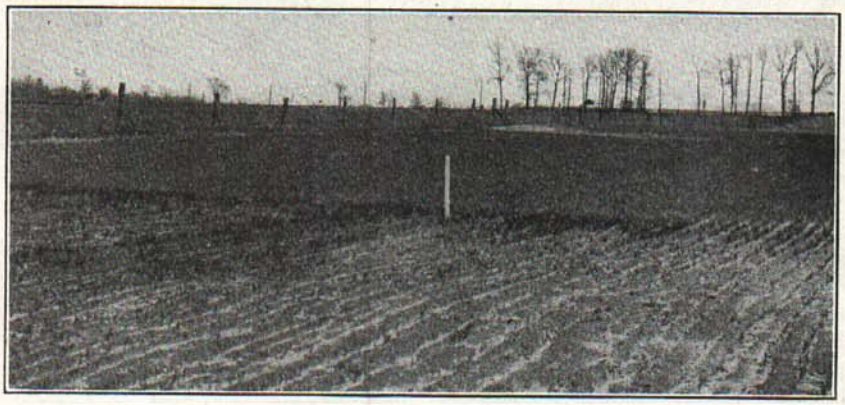

Fig. 3. The unfertilized wheat in the foreground was almost entirely winter-killed, while the fertilized wheat in the background produced a good yield of grain.

In making up a fertilizer mixture, it has been found convenient to express the content of these three constituents in the mixture by an analysis in which the per cent of each constituent is given, the constituents being arranged in alphabetical order in the analysis. Thus a 2-12-6 fertilizer contains 2 per cent of nitrogen, 12 per cent of phosphate (calculated as P_2O_5), and 6 per cent of potash (calculated as K_2O).

In the preparation of the Tables which appear in this report, it was impracticable to include all of the mixtures now on the market that would be adapted to a given crop. In fact an effort has been made to limit the recommendations to a comparatively few analyses which are commonly carried by most dealers, as this practice reduces manufacturing costs and hence leads to cheaper fertilizers. Special attention has been given the higher-grade mixtures. Although these are recommended, other mixtures having the same, or very similar ratios between

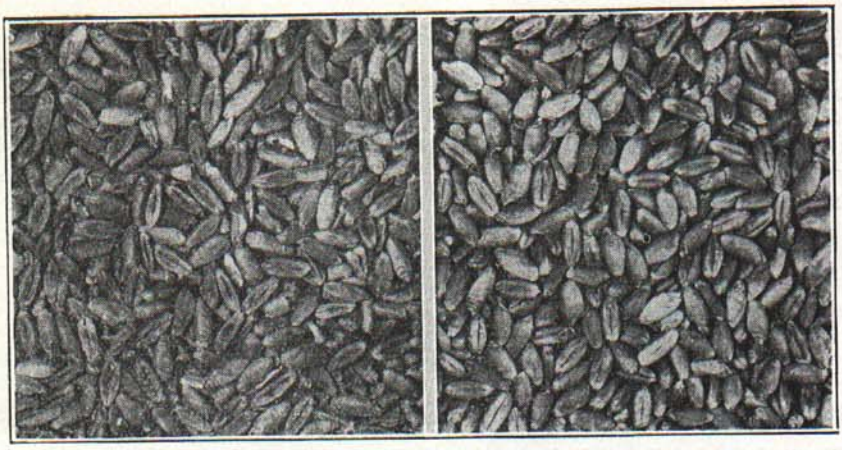

Fig. 4. Fertilizer improves the quality of grain. Left, wheat from unfertilized area. Right, wheat from area which received complete fertilizer.

the nitrogen, phosphate and potash, may sometimes be secured when the higher-analysis mixtures are unobtainable. Thus we find on the market the 4-16-4 and the 4-12-4 mixtures with similar, but not identical ratios. Likewise the 0-20-20, the 0-14-14, and 0-12-12, and the 0-10-10 mixtures have the same ratio between the phosphate and potash. While the highest-analysis mixture is cheapest per unit of plant food, all four would be equally desirable from the standpoint of increasing crop yields, providing correspondingly heavier applications of the lower analyses are used.

Fig. 5. Fertilizer stimplates early growth of corn. Rows 1 and 2 received no fertilizer while rows 3 and 4 received in the hills 75 pounds per acre of complete fertilizer.

Home Mixing of Fertilizer

The manufacturer should be able to mix fertilizer more cheaply and more efficiently than the farmer; however, conditions are sometimes such that one can economically mix them at home. The use of ready-mixed fertilizer is advisable if one can purchase a mixture which meets his needs, at a cost not appreciably above that of the home mixture when ready to apply to the soil.

FERTILIZER NEEDS OF MINERAL SOILS

Relation of Soil Type and Method of Farming to Fertilizer Needs

The mineral soils, soils other than muck, include two main divisions: first, the sands and sandy loams; and second, the loams, silt loams, and clay loams. If the soils belonging in the sands and sandy loams division have been poorly managed, receiving only little to no manure or green manures, they respond best to a complete fertilizer—that is, one containing nitrogen, phosphate, and potash, as is shown in Group 1 of Table 1.

Fig. 6. Potatoes respond to fertilization. Upper—Complete fertilizer. Lower—No fertilizer.

Clover and alfalfa on this group of soils should receive a fertilizer containing only phosphate and potash. Where good management has been practiced for a number of years, including growing legumes and application of manure systematically in the rotation, on soils containing from medium to high contents of organic matter and of medium productivity, the per cents of plant food elements in the fertilizer may be somewhat reduced, as shown in Table 1, Group 2.

The loams, silt loams, and clay loams, as a rule, require smaller proportions of nitrogen and potash in the fertilizer mixture for general crops than do the soils of the lighter-textured groups. On those soils where clover or alfalfa has not been grown and where manure has not been applied in the rotation, as in Group 1 of Table 2, a complete fer-

Fig. 7. Wheat grown on light soils respond to spring top dressings of nitrogen. Right—No treatment. Left—100 pounds per acre of nitrate of soda.

tilizer is usually the most economical. The nitrogen may be omitted from the mixture for the growing of alfalfa. Where a better system of management is practiced, including either the growing of clover or alfalfa or the application of manure in the rotation, as in Group 2 of Table 2, the proportions of nitrogen and potash in the fertilizer mixture may be reduced somewhat from those recommended in Group 1. Under a good system of soil management, where clover or alfalfa has been grown and where manure also has been applied in the rotation, phosphate should be given first consideration. For some crops on such soils, however, small amounts of nitrogen and potash should be included with the phosphate as is indicated in Group 3.

An efficient use of fertilizers can be obtained by fertilizing heavily the more valuable cash crops of a rotation and supplementing the fertilizer remaining in the soil with smaller applications for the less valuable and less responsive crops which follow.

TABLE 1. Fertilizers Recommended for Various Crops Grown on Sands and Sandy Loam Soils

Fertilizers are usually more effective on soils containing sufficient amounts of lime than on soils deficient in lime

Crop	Group 1 Soils suitable for agriculture; not needing lime; low in organic matter and low in productivity. Where recently few or no legumes have been grown and limited amounts of barn yard manure have been applied.		Group 2 Soils not needing lime; medium to high in organic matter and medium in productivity. Where legumes and barn yard manure have been used systematically in the rotation for a number of years.	
Without seeding of alfalfa or clover	**4-16-8**	***200-300 lbs.**	**2-12-6**	**200-300 lbs.**
Wheat or Rye	An early spring topdressing with **75** to **150** pounds of nitrogen fertilizer is recommended. Do not topdress with nitrogen fertilizer where alfalfa or clover seedings are made.			
Seeded to alfalfa or clover	**Seeding not recommended**		**0-12-12**	**250-350 lbs.**
Without seeding of alfalfa or clover	**4-16-8**	**150-250 lbs.**	**2-12-6**	**150-250 lbs.**
Oats or Barley	When late plantings are made, a spring topdressing of **60** to **120** pounds per acre of nitrogen fertilizer is recommended. Do not topdress with nitrogen fertilizer where alfalfa and clover seedings are made.			
Seeded to alfalfa or clover	**Seeding not recommended**		**0-12-12**	**250-350 lbs.**
Alfalfa or Clover, seeded alone or with a light nurse crop	**0-8-24** or **Muriate of Potash**	**250-350 lbs.** **120-160 lbs.**	**0-12-12**	**250-350 lbs.**
	Drill the fertilizer deeply into the soil at the time of seeding or before. On stands two or more years old, topdress every two years after the first cutting has been removed.			
Corn	**4-16-8**	**125-175 lbs.**	**2-12-6**	**125-200 lbs.**
	Apply the fertilizer in the row beside the seed. If other crops in the rotation have been judiciously fertilized, no fertilizer may be needed for corn.			

Sweet Corn	**4-16-8**	**150-175 lbs.**	**4-16-4**	**150-175 lbs.**
	Apply fertilizer in the row beside the seed.			
Early Potatoes	**4-10-6**	**400-500 lbs.**	**4-10-6**	**400-500 lbs.**
	Applications made in bands **2** inches to the side of the seed piece on the same level or slightly below are advisable.			
Late Potatoes	**4-16-8** or **3-12-12**	**400-500 lbs.**	**4-16-8** or **3-12-12**	**400-500 lbs.**
Beans	**4-16-4**	**Broadcast 200 lbs. Row 50 lbs.**	**2-12-6**	**Broadcast 200 lbs. Row 50 lbs.**
	Not more than **50** pounds per acre should be applied in the bean row. When broadcasting at the time of seeding, not more than **200** pounds per acre should be used.			
Tomatoes	**4-16-8**	**400-500 lbs.**	**4-16-8**	**400-500 lbs.**
	Fertilizer placed in bands **2** inches to the side and slightly below the root cluster at setting time is recommended.			
Cabbage	**4-16-8**	**400-500 lbs.**	**4-16-4**	**400-500 lbs.**
	Fertilizer placed in bands **2** inches to the side and slightly below the root cluster at setting time is recommended.			
Cantaloupes and Cucumbers	**4-16-8**	**300-500 lbs.**	**4-16-4**	**300-500 lbs.**
	For early market **200** to **300** pounds mixed with the soil in the hills and the remainder broadcast and worked into the soil before planting. Cucumbers for pickling, **300** to **500** pounds broadcast before planting.			
Beets, Carrots, Turnips, or Rutabagas	**4-16-8**	**300-500 lbs.**	**4-16-4**	**300-500 lbs.**
	Apply **300** to **500** pounds per acre broadcast and worked into the soil before planting.			

*All rates of application are on the acre basis.

TABLE 2. Fertilizer Recommendations for Various Crops Grown on Loam, Silt Loam, and Clay Loam Soils

Fertilizers are usually more effective on soils containing sufficient amounts of lime than on soils deficient in lime

Crop	Group 1 Where clover or alfalfa has **not** been grown and where manure has **not** been applied in the rotation	Group 2 Where clover or alfalfa **has** been grown **or** where manure **has** been applied in the rotation	Group 3 Where clover or alfalfa **has** been grown **and** where manure **has** been applied in the rotation
Without seedings of clover or alfalfa	**4-16-4**	**4-16-4** or **0-20-0**	**0-20-0**
Wheat or Rye Seeded to clover or alfalfa	Grain alone, apply **200-250*** pounds with the seed. If clover or alfalfa is to be seeded, increase the rate of application to **300** pounds.		
	2-12-6 or **4-16-4**	**2-14-4** or **0-20-0**	**0-20-0**
Without seedings of clover or alfalfa	**4-16-4**	**4-16-4** or **0-20-0**	**0-20-0**
Oats or Barley Seeded to clover or alfalfa	Grain alone, apply **150** to **250** pounds with the seed. With seedings of clover or alfalfa, increase the rate of application to **300** pounds.		
	2-12-6 or **4-16-4**	**2-14-4** or **0-20-0**	**0-20-0**
Alfalfa	**0-14-6**	**0-14-6** or **0-20-0**	**0-20-0**
	Seeded alone, **150** to **200** pounds drilled with the seed or **250** pounds broadcast and worked into the soil before seeding. On stands two or more years old, topdress with **150** to **200** pounds every two years.		
Corn	**2-14-4** or **0-20-0**	**0-20-0**	**0-20-0**
	Apply **100** to **150** pounds in the row beside the seed. Large applications in contact with the seed may prove injurious. Fertilizer may not be needed on soils of high fertility and where the other crops in the rotation are rather heavily fertilized.		
Sweet Corn	**2-12-6** or **2-14-4**	**2-14-4** or **0-20-0**	**0-20-0**
	Apply **100** to **150** pounds in the row beside the seed.		

Sugar Beets	**4-16-4** or **2-12-6** or **2-16-8**	**4-16-4** or **0-14-6** or **0-20-0**	**0-14-6** or **0-20-0**
	Apply **100** to **200** pounds in the row at planting time. Where larger applications are to be made plow under **200** to **400** pounds and apply **100** to **200** pounds in the row. Where fall plowing is practiced, plow under **0-14-6** or **0-20-0** and if needed apply a complete fertilizer in the spring. Larger applications in contact with the seed may prove injurious.		
Early **Potatoes**	**4-10-6**	**4-10-6**	**2-12-6**
	Apply **300** to **500** pounds in bands 2 inches to the side and slightly below the seed.		
Late	**4-16-4** or **2-16-8**	**4-16-4** or **2-16-8**	**2-16-8** or **0-20-0**
Beans	**4-16-4** or **2-14-4**	**2-14-4** or **0-20-0**	**0-14-6** or **0-20-0**
	On the poorer soils apply **200** pounds with a grain drill at seeding time, allowing the fertilizer to flow through all discs of the drill, or broadcast **150** pounds before planting and apply not more than **50** pounds with the seed. On the better soils and where other crops in the rotation have been well fertilized apply no fertilizer or not more than **50** pounds with the seed. Larger row applications may prove advisable, providing the fertilizer is placed close to the seed but not in contact with it.		
Tomatoes	**2-16-8** or **2-12-6**	**2-16-8** or **2-12-6**	**2-16-8** or **0-14-6** or **0-20-0**
	Apply **400** to **800** pounds in bands to the side and slightly below the root cluster at setting time.		
Cabbage	**4-16-4** or **2-16-8**	**4-16-4** or **2-16-8**	**4-16-4** or **2-16-8** or **0-20-0**
	Apply **400** to **800** pounds in bands to the side and slightly below the root cluster at setting time.		
Cantaloupes **Cucumbers**	**4-16-4** or **2-16-8**	**4-16-4** or **2-16-8**	**2-16-8** or **0-20-0**
	Apply **250** to **500** pounds in the bands beside the hills at planting time.		
Beets, Carrots, Turnips, or Rutabagas	**4-16-4** or **2-16-8**	**2-16-8** or **0-20-0**	**0-14-6** or **0-20-0**
	Broadcast **250** to **500** pounds and work into the soil before planting.		

*All rates of application are on the acre basis.

Method of Application of Fertilizer

On the mineral soils, the application of fertilizer in the row may be more effective than broadcasting and working it into the soil with the disc or spring-tooth harrow. Where row applications are made for corn, beans, and similar crops, it is better to keep the fertilizer away from the seed; preferably placing it at the side and deeper than the seed. The general tendency in fertilizer applications at the present time is to place the material deep in the soil. Good results have been secured with some crops by plowing the fertilizer under. Large fertilizer applications in the row, directly in contact with the seed should be avoided because of possible injury to germination.

Use of Lime on Mineral Soils

Fertilizers are usually more effective on soils containing sufficient amounts of lime than on soils which are very strongly acid. Lime is continually being removed from soils through leaching and crop removal, and as a result it is advisable to test the soil for acidity unless an adequate application of lime has been recently made. When lime is found to be lacking, its application should be one of the first steps in a good system of soil management.

Use of Manure and Green Manures

On the mineral soils, organic matter added in the form of manures or green manures greatly increases the efficiency of fertilizers. Where barn-yard manure is applied, it not only increases the soil's organic content, but also adds to the essential elements in the soil. If manure is not obtainable, green manures furnish an excellent source of organic matter. On those soils which have a low content of organic matter and are strongly acid, it is advisable to apply lime in order that the growing of sweet clover as a green manure crop may be included in the rotation. Such a procedure will also make it possible to grow alfalfa for hay, which will further increase the organic matter content of the soil. The application of phosphate and potash fertilizers for sweet clover, grown for green manure purposes, is a practice which is highly recommended.

FERTILIZER NEEDS OF MUCK SOILS

Relation of Type of Muck and Methods of Farming to Fertilizer Needs

The soil reaction and lime content of muck soil are of vital importance in their effect on the efficiency of fertilizers in improving crop growth. For that reason, it is advisable to roughly divide our muck soils into three main groups, insofar as their responses to fertilization are concerned: first, those which are low in lime content, as indicated by their very strongly acid reaction, and which must be limed before satisfactory crops can be grown; second, those which have sufficient lime for the production of crops (not acid to strongly acid in reaction); and third, those which contain an excess of water-soluble and alkaline salts and are alkaline in reaction. The last-named group is comparatively a small one and has resulted from the burning-off of a layer of the muck, possibly many years ago, from the presence of marl within a short distance of the surface, from the alkaline salts accumulating from the waters of spring-fed mucks, or from the continued use of alkaline irrigation water and of alkaline dusts and sprays on the crops being grown.

Fig. 8. Muck pasture, when properly drained and properly fertilized, produces a high yield of grass, which remains green and succulent when upland pasture may be dry and brown.

Use of Lime on Muck Land

Lime should never be applied on muck land unless the muck is low in lime content, as indicated by a very strongly acid reaction. Lime, applied to high-lime muck (not acid to strongly acid in reaction) may decrease the benefit to be secured from fertilization. Even on the low-lime muck, no lime should be applied if domesticated blueberries or cranberries are to be grown. For all other crops, however, the low-lime muck will require from two to twelve and occasionally more tons per acre of ground limestone or an equivalent quantity of marl, the amount needed depending on the intensity of the acidity and the depth to which it extends, as well as on the crops being grown.

Following liming, the fertilization of this low-lime muck should include, for a few years, more nitrogen than is needed on high-lime muck soils. After the soil has become more decomposed, the same fertilizer mixtures should be applied as are recommended for the high-lime mucks.

Use of Sulphur on "Alkali" Muck Soils

The "alkali" muck soils, mentioned in Group 3 above, contain an excess of lime and water-soluble salts and as a result have an effect on certain crops somewhat similar to that of the "alkali" soils of the semi-arid west. Of the crops most effected by this alkaline condition, onions, celery, potatoes, corn and spinach should be mentioned, but, if the alkali is quite marked, most crops will fail. When drainage conditions are satisfactory, cabbage, mangels, mint, parsnips, sugar beets, Swiss chard, table beets, and table carrots seem most tolerant to the "alkali" in the studies made thus far.

Experiments conducted for the past five years have proved that this alkaline condition, which results in complete failure of onions and poor crops of celery, can be entirely corrected by the application of powdered sulphur. If the alkaline condition has resulted from burning, the "alkali" is likely to be confined to the plowed layer. In cases where

Fig. 9. Celery on well fertilized "alkali" muck soil. The jar at the left received no sulphur, the center jar 1,000 pounds and the jar at the right 2,000 pounds per acre of sulphur flour, mixed thoroughly with the muck.

the underlying muck is quite acid, the condition may be overcome by very deep plowing and thorough disking; but, if the underlying muck is not acid, it is advisable to apply sulphur and to disk it in thoroughly, preferably before plowing. While 2,000 pounds per acre have been applied with beneficial results on our more "alkali" mucks, it is advisable not to apply more than 500 pounds per acre and to note the effects produced before using more. On some of our not-acid and very slightly acid mucks, the application of powdered sulphur at the rate of 100 to 200 pounds per acre, has proven of benefit with onions. Care should be taken not to use sulphur unless it is needed, since its application on the more acid mucks is likely to decrease yields.

Use of Copper Sulphate on Acid Muck Soils

The application of copper sulphate, first reported of value on the Florida Everglades muck, has been found beneficial on the acid muck soils of Michigan. The results thus far secured indicate that it will

give increased yields on most very strongly acid mucks for most crops and on many less acid mucks for many crops. Of these, onions, spinach, lettuce, carrots, potatoes, cauliflower, and tomatoes have been most responsive. Onion fields which will be found especially responsive to copper sulphate are those which have an acid reaction, on which the onion tops die back from the tip during hot weather, and on which the color of the mature bulb of the yellow varieties is yellowish-green rather than brownish-yellow.

The rate of application of copper sulphate which can be recommended for acid mucks, from studies thus far made, is 50 pounds per acre, preferably in the form of small crystals. Because of its greater cost, the dehydrated copper sulphate ordinarily used for dusting purposes cannot be recommended. On mucks which show a marked response to the copper sulphate applications, it is advisable to repeat the application the second year. On "alkali" mucks and on mucks which have received in recent years liberal applications of liquid or dry Bordeaux mixture in control of crop diseases, little or no benefit is likely to result from the copper sulphate application.

Because of the relatively small amounts of copper sulphate required, difficulty is likely to be encountered in making the application with the ordinary fertilizer distributor. The copper sulphate can be safely mixed with the fertilizer without injury to either. Several fertilizer companies have agreed to supply fertilizer containing copper sulphate on special order, a 2-8-16 and a 0-8-24 mixture each containing 100 or 200 pounds of copper sulphate per ton of fertilizer being offered by a majority of the organizations, at a cost practically equaling that of the two materials before mixing.

Use of Salt on Muck Soil

The use of salt, along with a fertilizer mixture high in potash, on muck land which has not been heavily fertilized for several years past, can be recommended for table beets, sugar beets, mangels, Swiss chard, celery, celeriac, and turnips. An application of from 500 to 1,000 pounds per acre, in addition to regular fertilization, is generally sufficient. The benefit resulting from the salt application is likely to be greater on acid muck than on muck having an alkaline reaction. Because of a slight toxicity of salt toward certain crops, it is advisable to make the application just preceding the crop which responds to it.

An application on celery land which has been heavily fertilized for a period of years sometimes is not warranted, owing to the fact that salt has been an impurity in considerable amount in the lower grade potash fertilizers which have been used in the past. Continued heavy applications of salt for celery, after two or three thousand pounds per acre have been applied, are not advisable.

The Fertilizer Requirement

While the low-lime mucks are likely to be in immediate need of a complete fertilizer after they have been properly limed, mucks which contain sufficient lime may not show any fertilizer requirements for one or more years after reclamation. All of the latter will develop a marked potash hunger within a very few years and, most of them, a

need of both potash and phosphate. Most mucks show this fertilizer need immediately after they are broken up, especially if several crops of wild hay have been removed before braking, or if the soil is cropped at once to certain special crops, such as celery or onions.

Whether or not a certain muck field is in need of a fertilizer containing potash alone, or both potash and phosphate, generally can be determined only by a field trial. If the field has been under cultivation

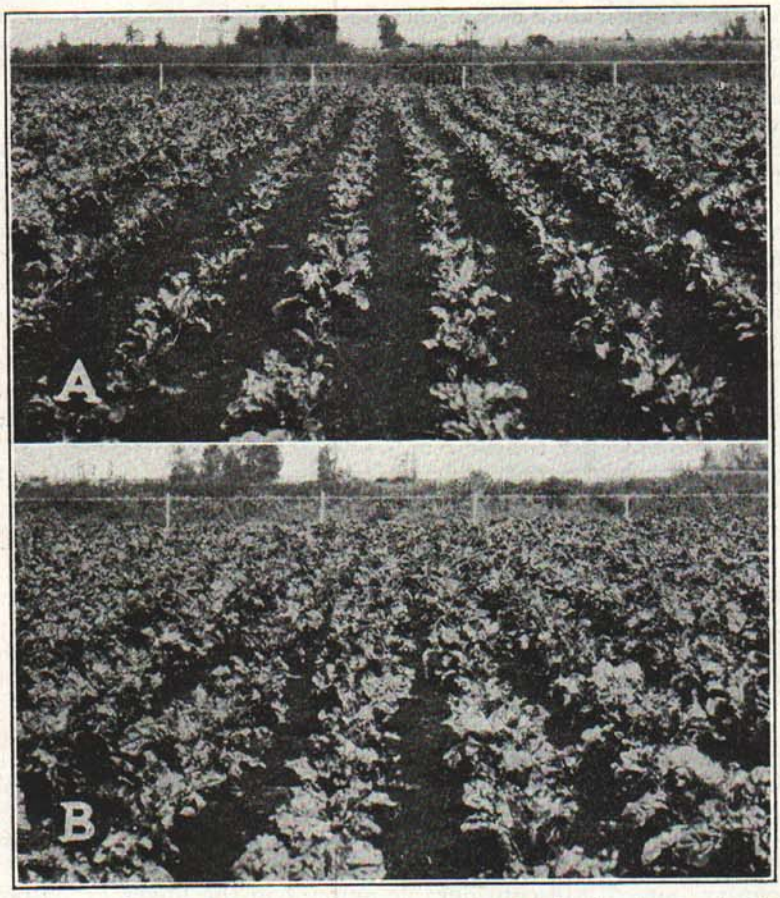

Fig. 10. Sugar beets on muck land. The beets in the upper picture received phosphate only while those in the lower picture received phosphate and potash. Yields: Phosphate only, 3.8 tons; phosphate and potash, 10.6 tons per acre.

for a long period of years without having been well fertilized, it is certain that both potash and phosphate will be needed for the production of any crop. If it has been reclaimed for only a few years, the field may require only potash for such crops as pasture, hay, and grain, but is more likely to need both fertilizing constituents for special crops such as onions and celery. Since a majority of our mucks give paying

returns when both potash and phosphate are applied in the fertilizer mixture, it is advisable to apply a mixture containing both for any crop on any muck, unless it is definitely known that only potash is needed.

In the maintenance of fertility of muck soils, the fertilizer should be applied each year, rather than once in a rotation, in order to prevent extensive loss by leaching. While the fertilizer to be applied should be high in potash content, the proportions of nitrogen, phosphate, and potash will depend both on the type of muck and on the crop which is to be grown. The proper rate of application of the fertilizer mixture is dependent upon several factors, of which the amount of fertilization in previous years, the closeness of planting of the crop, the method of fertilization, the analysis of the fertilizer, and the probable value of the crop, are especially important. While muck soil may contain sufficient natural fertility to produce a fair first crop without fertilization, it is frequently low in fertility and needs a fairly heavy initial application. After the first few years of fertilization, a reserve is built up in the soil and the rate of application may be slightly reduced. If a crop which

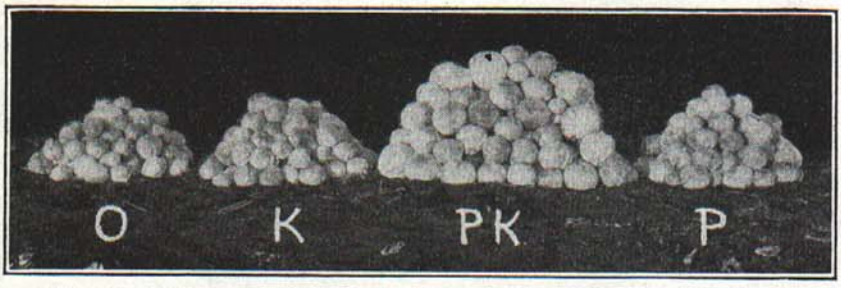

Fig. 11. Cabbage on muck land. From left to right, O—unfertilized, K—potash only, PK—phosphate and potash, and P—phosphate only.

received a heavy application of fertilizer is followed by one which requires a comparatively light application, a good yield of the latter can generally be secured the following year with a relatively light fertilization, especially if the growing season of the first year was droughty.

Method of Application of Fertilizer

Experiments on muck soils have shown that, with some cultivated crops, row applications of fertilizers may prove more economical than broadcast applications. Mucks which are well supplied with moisture generally give the best results with the row application. The row application is more likely to injure the seed on soils that have been heavily fertilized in preceding years than if little or no fertilizer has been applied in the past. Some seeds, of which beans and cabbage are examples, are much more susceptible to fertilizer injury than are others. Because of possible injury in droughty seasons, the fertilizer should be at least two inches from, and preferably below the seed. If a heavy application of fertilizer is being made, a considerable proportion of it should be applied broadcast and disked well into the soil previous to planting. If

(Continued page 22)

Table 3. Fertilizer Recommendations for Muck Soils.

Crop Where two fertilizer analyses are given, the first is generally preferred. See footnotes at bottom of table for response of crop to sulphur, copper sulphate and salt.	Annual broadcast application Pounds per acre In general the higher the analysis, the less the amount required per acre.	TYPE OF MUCK[4]		
		High-Lime Muck		Low-Lime Muck
		Deep and Medium Muck Properly drained, not acid to strongly acid	Shallow Muck, Alkaline Muck, or Poorly Drained Muck	Very strongly acid in reaction Limestone or marl should be applied preceding fertilization.
Lettuce [1] [2]	500-1000	2-8-16	3-12-15	3-12-15
Spinach [1] [2]	400-800	Broadcast and disc in fertilizer before seeding. Side-dressing of available nitrogen fertilizer, at rate of 75 to 100 pounds, sometimes advisable during growth.		
Swiss Chard [3]	500-1000			
Beets, Early [3]	600-1000	2-8-16	3-12-15	3-12-15
Celery, Early [1] [3]	1000-1800	Row application advisable for beets—300 to 500 pounds 2 inches below seed. Drill in remainder before seeding. Besides fertilizer, 500 to 1000 pounds salt beneficial.		
		If no manure has been applied for celery, side-dressing of available nitrogen fertilizer is often beneficial in cold or wet periods during growth. If manure has also been applied, no nitrogen is needed in the fertilizer mixture. Salt also beneficial (See page 17).		
Beets, Late [3]	600-1000			
Celery, Late [1] [3]	1200-2000	0-8-24	2-8-16	2-8-16
Radishes [1] [2] Early	400-800	2-8-16	2-8-16	2-8-16
		Apply with fertilizer drill or broadcast and disc in before seeding.		
Late		0-8-24	0-8-24	0-8-24
Cabbage [2]	500-1000	For cabbage and cauliflower, application of 400 to 500 pounds may be made in row 4 inches deep, if plants are transplanted to field. Broadcast remainder and disc in.		
Cauliflower [2]	800-1500	2-8-16 or 0-8-24	3-12-15	3-12-15
Onions [1] [2]	600-1200	Row application of 300 to 500 pounds 2 inches below seed advisable for onions. Drill or broadcast remainder before seeding and disc in. Seed early if possible. Protect from wind to save crop and fertilizer. For further information see Extension Bulletin 123.		
		2-8-16 or 0-10-20	2-8-16	3-12-15
Mint [2]	250-500	Fertilizer needed to maintain stand of mint, as well as to increase oil content. Apply broadcast fairly early in spring.		

Oats, Barley, Rye (With or without seeding)	250-400 250-400 200-350	To secure satisfactory results from fertilizers, grow grain varieties adapted to muck land, such as Gopher oats, Peatland barley, and Rosen rye.		
		0-8-24	0-8-24 or 0-10-20	0-8-24 or 2-8-16
Field Corn Sweet Corn Sunflowers	250-500 400-800 250-400	If row application is made for corn, do not use more than 200 pounds, preferably below and 2 inches from seed. Broadcast remainder and disc in.		
Potatoes (1) (2)	400-800	Row application sometimes advisable for potatoes but not more than 400 pounds, preferably in furrow 2 inches below seed. If mixed with muck with machine planter, 600 pounds can be safely applied. Plant close to avoid hollow heart and to minimize frost danger.		
Timothy and Alsike Sweet Clover Reed Canary Grass Hungarian Millet Sudan Grass	200-350 200-350 300-400 200-300 250-400	Seeding hay without nurse crop often advisable. Early seeding necessary to beat weed growth. Summer seeding of Sudan grass or millet for emergency hay crop. Reed canary grass for wet pastures or meadows can withstand severe flooding and produces heavy sod with high yields of grass or hay when properly fertilized.		
Permanent Pasture	100-200	Apply broadcast on pasture in spring. Growth increased and palatability and nutritive value of grass much improved by proper fertilization.		
		0-8-24	0-8-24	0-8-24 or 2-8-16
Sugar Beets (2) (3)	300-600	Row application advisable for sugar beets, not more than 150 pounds with seed, or not more than 300 pounds if 2 inches from seed. If more is applied, drill in before planting. In addition to fertilizer, 500 to 1000 pounds salt per acre advisable.		
Mangels (3) Parsnips Rutabagas Stock Carrots Table Carrots (2) Turnips (3)	300-500 600-1000 300-500 300-500 400-800 300-500	For root crops, apply with fertilizer drill, or broadcast and disc in before seeding. In addition to fertilizer, 500 to 1000 pounds salt per acre advisable for mangels and turnips.		
Beans	250-500	0-10-20 or 0-8-24	0-10-20	0-10-20
Cucumbers and Melons Pumpkins and Squash (1) Tomatoes (2)	400-800 300-600 500-1000	These crops easily killed by frost, therefore generally not safe on muck soil. Keep soil compact to help prevent frost injury.		

(1) These crops likely to show marked response to sulphur when grown on alkaline muck. (See top of page 16).
(2) These crops may respond to copper sulphate when grown on acid muck. (See bottom of page 16).
(3) If muck has not been heavily fertilized in past, these crops are likely to respond to salt in fertilizer mixture. (See page 17).
(4) Fertilizer mixtures having the same ratios as those recommended, but of higher or lower analysis, would be equally desirable, a proportionately smaller or larger amount per acre being needed by the crop.

the fertilizer is one of the higher-analysis mixtures, less should be applied in the row than if a lower-analysis fertilizer is used.

Use of Manure and Green Manure

Muck soils are relatively high in nitrogen content and consequently do not require a nitrogenous fertilizer, except for a very few special crops. The nitrogen content of manure, on the other hand, is its most valuable constituent. It is therefore, not a balanced fertilizer, when used alone on muck soil, and tends to produce excessive top growth, resulting in increased lodging of grain and in an increased proportion of scallions in onions. If there are mineral soils on the farm, it is desirable to use the manure on those fields and to maintain the fertility of the muck with commercial fertilizers and green manures.

Fig. 12. This muck had been well fertilized for onions each year for the six years preceding this crop, while the seventh application had been made and disked in just before the crop was sown. The six rows at the left of the center stake received no further treatment while the six at the right received a 500 pound application in the row two inches below the seed.

On some farms, however, the manure produced on the farm must be used on the muck. Here it should be applied in a well-rotted condition, as a supplement to the commercial fertilizer, from which the nitrogen may generally be omitted and the rate of application slightly reduced. Of the various crops, cabbage, cauliflower, celery, corn, lettuce, spinach, and Swiss chard respond to the use of manure with fertilizer.

The growing of green manure crops on muck land, which would otherwise lie fallow, is a highly desirable practice. The green manure tends to retain the residual potash, which would, to considerable extent, be leached away if the muck laid fallow. It also prevents the blowing away of the surface muck, while the fibrous organic matter of roots and tops incorporated in the soil, gives a more granular structure,

so that the soil does not blow as easily as does the finely divided muck. Still further, the green manure crop tends to keep down the weeds which otherwise are likely to flourish on well fertilized muck soil. A green manure crop in the rotation is especially desirable on shallow muck.

Sampling Muck Soils for Soil Reaction Test

Samples of muck soil will be tested by your county agricultural agent or by the Soils Department of Michigan State College. In securing samples for testing, care should be taken to avoid old "burn-outs," places where brush or refuse has been burned, old vegetable storage pits, trenches, tile lines or any other places where the soil has been abnormally disturbed or treated. Take the first sample in the surface layer at a depth of three to four inches, then with spade or post-hole auger take a second sample at a depth of two feet. Keep the samples separate and labeled properly. If the muck varies considerably in different parts of the field, more than one set of samples may be taken. Draw a map of the field and locate points of sampling by number. Half pint samples are sufficient. Samples should be sent in moist condition in *clean* cans. Complete information regarding the muck as to years under cultivation, drainage conditions, fertilization, crops grown and yields should be sent in a letter attached to the *outside* of the package.

AVAILABLE SOILS AND FERTILIZER BULLETINS

Further information regarding fertilizers and soils and any of the following bulletins on the subjects may be secured without charge by addressing the Soils Department, Michigan State College, East Lansing.

Special Bulletin No. 133 (Revised). Fertilizers, What They Are and How to Use Them.
Special Bulletin No. 91 (Revised). Lime for Sour Soils.
Special Bulletin No. 180. Grayling Sands.
Circular Bulletin No. 90. Cucumber Culture.
Special Bulletin No. 248. Sandy Soils—Methods of Management.
Special Bulletin No. 224. Marl—Its Formation, Excavation and Use.
Circular Bulletin No. 103 (Revised). The Prevention of Wind Injury to Crops on Muck Land.
Extension Bulletin No. 123. Muck Soil Management for Onion Production.