Fertilizer Recommendations for 1931
Michigan State University Agricultural Experiment Station
Circular Bulletin Series
C.E. Millar, G.M. Grantham, P.M. Harmer, Soils
Revised November 1930
22 pages

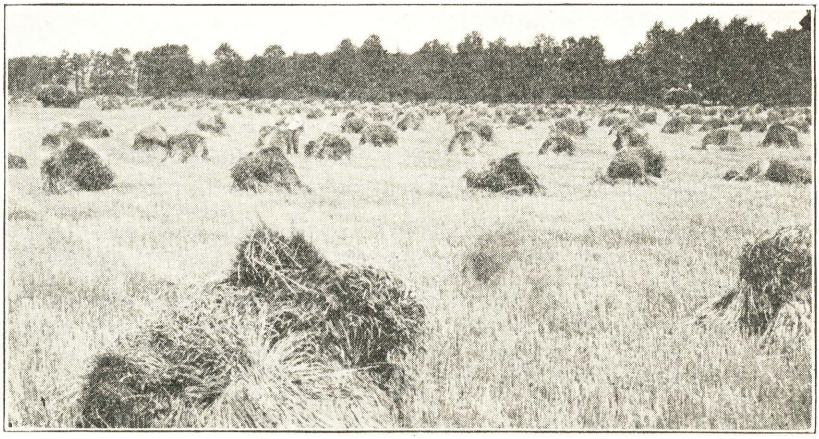
Oakley Lardie

Circular Bulletin No. 53, Revised

November, 1930

Fertilizer Recommendations for 1931

C. E. Millar, G. M. Grantham, and P. M. Harmer



AGRICULTURAL EXPERIMENT STATION

MICHIGAN STATE COLLEGE

Of Agriculture and Applied Science

SOILS SECTION

East Lansing, Mich.

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 to Circular Bulletin 103, and Special Bulletins 168 and 136.

FERTILIZER RECOMMENDATIONS FOR 1931

C. E. Millar, G. M. Grantham, and P. M. Harmer

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-analyses) 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 we have endeavored 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.

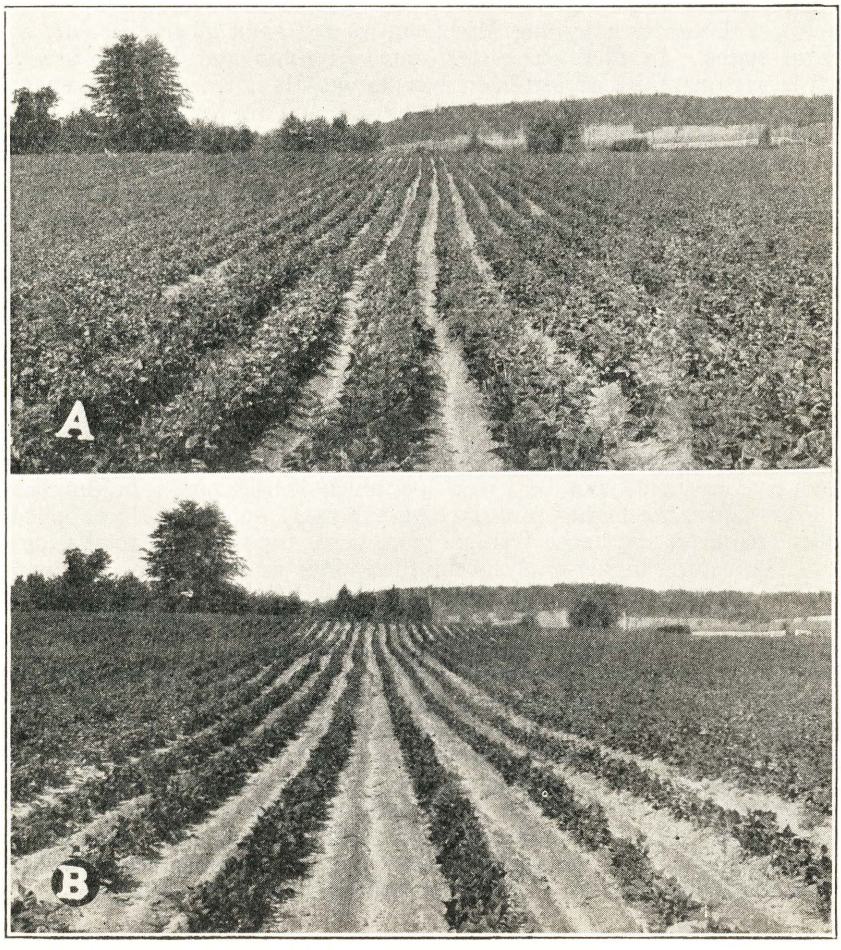


Fig. 1.—Beans respond to fertilization. Upper—250 pounds per acre of complete fertilizer. Lower—No treatment.

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.

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.

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.

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.

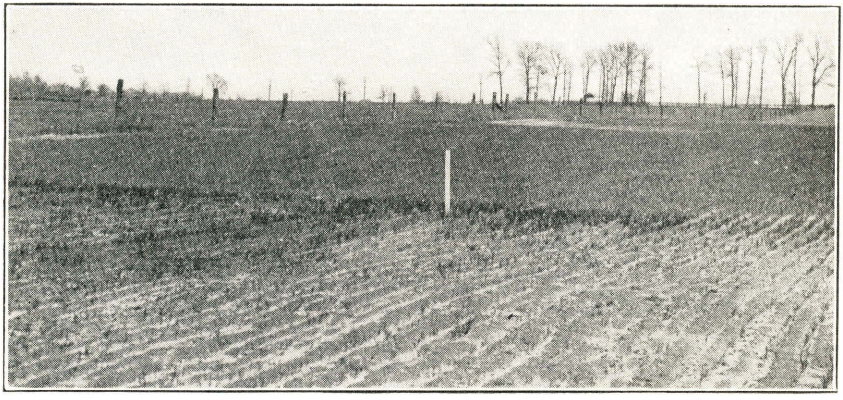


Fig. 3.—The unfertilized wheat in the foreground was almost entirely winter-killed, while the fertilized wheat in the background produced a good yield of grain.

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 the nitrogen, phosphate and potash, may sometimes be secured when the higher-analysis mixtures are

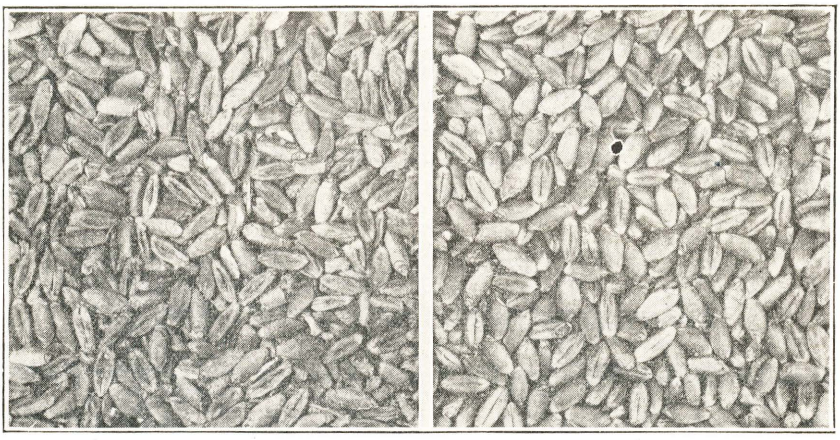


Fig. 4.—Fertilizer improves the quality of grain. Left, wheat from unfertilized area. Right, wheat from area which received complete fertilizer.

unobtainable. Thus we find on the market the 4-16-4 and the 3-12-4 mixtures with similar, but not identical ratios. Likewise the 0-20-20, the 0-14-14, the 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 stimulates early growth of corn. Rows 1 and 2 received no fertilizer while rows 3 and 4 received in the hill 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 light sandy loams, and second, the heavy sandy loams, silt loams, and clay loams. If the soils belonging in the sands and light sandy loams division have been poorly managed, receiving no manure or having no leguminous sod plowed under, they respond best, for most crops, to a complete fertilizer, that is one containing nitrogen, phosphate and

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

potash as is shown in Group 1 of Table 1. On the other hand clovers and alfalfa on this group of soils should receive a mixture containing only phosphate and potash. Where the soils have received better management, clovers or alfalfa having been grown, as in Group 2 of Table 1, the proportion of nitrogen used in the mixture can be reduced for many crops. Where good management has been practiced for a number of years and manure applied within the last two years as in Group 3 of Table 1, the amounts of both nitrogen and potash may be reduced.

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.

The heavy sandy 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. If these soils have been poorly managed and without the use of manure, clovers, or alfalfa, as in Group 5 of Table 2, a complete fertilizer is usually the most economical. The nitrogen may be omitted from the mixture for the growing of clovers or alfalfa. Where a better system of management is practiced, using clovers or alfalfa in the rotation, as in Group 6 of Table 2, the proportions of nitrogen and potash in the fertilizer mixture may be reduced somewhat from that recommended in Group 5. If barnyard manure has been used within the last two years, in a system where good management has been practiced, 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 6.

As 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 I—SANDS AND LIGHT SANDY LOAMS

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

Crop	Group 1 No manure or leguminous green manure used within the last two years.	Group 2 Clover or alfalfa grown within the last two years.	Group 3 Manured within the last two years.
Wheat or Rye			
With no seeding of clover or alfalfa	**2-12-6 or 4-16-8**	**2-16-2 or 2-12-6**	**2-16-2**
	Grain alone, 200 pounds or more. With alfalfa or clover seedings, 300 pounds or more at time of seeding the small grain. A spring top dressing of 12 to 25 pounds of nitrogen, supplied in 75 to 150 pounds nitrate of soda, 60 to 120 pounds sulphate of ammonia or equivalent quantity of other carrier is recommended.		
With seeding of clover or alfalfa	Legume seeding usually not recommended in this group.	**2-12-6 or 2-8-10**	**2-12-6**
Oats or Barley			
With no seeding of clover or alfalfa	**2-16-2 or 4-16-4**	**2-16-2 or 2-12-6**	**2-16-2**
	Grain alone, 200 pounds or more. With alfalfa or clover seedings. 300 pounds or more at time of seeding the small grain. A spring top dressing of 12 to 25 pounds of nitrogen, supplied in 75 to 150 pounds nitrate of soda, 60 to 120 pounds sulphate of ammonia or equivalent quantity of other carrier is recommended, when seasonal conditions necessitate a late planting.		
With seeding of clover or alfalfa	Legume seeding usually not recommended in this group.	**2-12-6 or 2-8-10**	**2-12-6**
Alfalfa, Sweet or other Clovers	**0-20-20 or 0-14-14 or 0-8-24**	**0-20-20 or 0-14-14**	**0-20-0**
	Broadcast, 300 pounds or more. Fertilizer should be drilled in or broadcast and worked into the soil before seeding.		
Corn or Sunflowers	**2-12-6 or 4-16-4**	**2-16-2 or 2-12-6**	**2-16-2**
	Broadcast, 250 pounds or more. In rows, 150 to 175 pounds. Broadcasting about 200 pounds of 0-20-0 previous to planting and, in addition, drilling 100 to 150 pounds of complete fertilizer in the row, is a good practice. If applied in the row large application may prove injurious.		

Sweet Corn	4-16-4 or 4-16-8	4-16-4 or 2-12-6	2-16-2 or 4-16-4
	For early market, broadcast 400 pounds or more, or apply 150 to 175 pounds in the row. For canning, 300 pounds or more broadcast and worked into the soil before planting.		
Early Potatoes	4-10-6	4-10-6	4-10-6
	400 pounds or more. The nitrogen in the fertilizer should be very readily available as early growth is important.		
Late Potatoes	4-16-8 or 4-16-4	2-12-6 or 4-16-8	4-16-4 or 2-12-6
	400 pounds or more. Applications beside the seed piece but not in contact with it are advisable.		
Beans	4-16-4	2-16-2 or 4-16-4	2-16-2 or 0-20-0
	200 pounds applied with grain drill (all holes running) at seeding time, or broadcast and dragged in before planting. When fertilizer is broadcast, an additional application of not to exceed 50 pounds may be drilled in bean row when seeding. Medium to large applications in the bean row should be avoided.		
Tomatoes	4-16-4 or 4-16-8	2-16-2 or 4-16-4	2-16-2 or 4-16-4
	For early market, 1,000 pounds or more. 300 to 400 pounds mixed with soil in hills and the remainder broadcast and worked into soil before setting. For canning, 400 pounds or more broadcast and worked into soil before setting.		
Cabbage	4-16-4 or 4-16-8	2-12-6 or 4-16-4	2-16-2 or 4-16-4
	For early market, 1,000 pounds or more. 300 to 400 pounds mixed with soil in hills and the remainder broadcast and worked into the soil before field setting. Late cabbage, 400 pounds or more broadcast and worked into the soil before setting.		
Cantaloupes and Cucumbers	4-10-6 or 4-16-4	2-16-2 or 4-16-4	2-16-2 or 4-16-4
	For early market, 400 pounds or more. 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 pounds or more broadcast before planting.		
Beets, Carrots, Turnips and Rutabagas	4-10-6 or 4-16-8	4-10-6 or 4-16-4	4-10-6 or 4-16-4
	400 pounds or more broadcast and worked into soil before planting.		

TABLE II—HEAVY SANDY LOAMS, SILT LOAMS AND CLAY LOAMS

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

Crop	Group 4 No manure or leguminous green manure used within the last two years.	Group 5 Clover or alfalfa grown within the last two years.	Group 6 Manured within the last two years.
With no seeding of clover or alfalfa	2-16-2 or 4-16-4	2-16-2	0-20-0 or 2-16-2
Wheat or Rye	Grain alone, 200 pounds or more. With alfalfa or clover seedings, 300 pounds or more at time of seeding the small grain. A spring top dressing of 12 to 25 pounds of nitrogen, supplied in 75 to 150 pounds nitrate of soda, 60 to 120 pounds sulphate of ammonia or equivalent quantity of other carrier is recommended.		
With seeding of clover or alfalfa	2-12-6 or 4-16-8	2-12-6 or 2-16-2	0-20-0
With no seeding of clover or alfalfa	2-16-2 or 4-16-4	2-16-2	0-20-0
Oats and Barley	Grain alone, 200 pounds or more. With alfalfa or clover seedings. 300 pounds or more at time of seeding the small grain. A spring top dressing of 12 to 25 pounds of nitrogen, supplied in 75 to 150 pounds nitrate of soda, 60 to 120 pounds sulphate of ammonia or equivalent quantity of other carrier is recommended, when seasonal conditions necessitate a late planting.		
With seeding of clover or alfalfa	2-12-6 or 4-16-8	2-12-6 or 2-16-2	0-20-0
Alfalfa, Sweet or other Clovers	0-14-6	0-14-6	0-20-0
	Broadcast, 300 pounds or more. Fertilizer should be drilled in or broadcast and worked into the soil before seeding.		
Corn or Sunflowers	2-16-2 or 2-12-6	0-20-0 or 2-16-2	0-20-0
	Broadcast, 250 pounds or more. In rows, 150 to 175 pounds. Broadcasting about 200 pounds of 0-20-0 previous to planting and in addition 100 to 150 pounds of complete fertilizer in the row is a good practice. If applied in the row large applications may prove injurious.		
Sweet Corn	4-16-4 or 4-16-8	2-16-2 or 4-16-4	2-16-2 or 4-16-4
	For early market, broadcast 400 pounds or more or apply 150 to 175 pounds in the row. For canning, 300 pounds or more broadcast and worked into the soil before planting.		

Sugar Beets	4-16-4 or 4-16-8	4-16-4 or 0-20-0	4-16-4 or 0-20-0
	In row, 200 to 250 pounds. A good practice is to broadcast 200 pounds or more before or after plowing and, in addition, apply 100 to 200 pounds in the row. If applied in the row large applications may prove injurious.		
Early Potatoes	4-10-6	4-10-6	4-10-6
	400 pounds or more. The nitrogen in the fertilizer should be very readily available as early growth is important.		
Late Potatoes	4-16-4 or 4-16-8	2-12-6 or 4-16-4	2-12-6 or 4-16-4
	400 pounds or more. Applications beside the seed piece but not in contact with it are advisable.		
Beans	2-16-2 or 4-16-4	2-16-2 or 0-20-0	0-20-0
	200 pounds applied with grain drill (all holes running) at seeding time, or broadcast and dragged in before planting. When fertilizer is broadcast an additional application of not to exceed 50 pounds may be drilled in the row when seeding. Medium to large applications in the bean row should be avoided.		
Tomatoes	4-16-8	2-12-6 or 4-16-8	0-14-6 or 2-12-6
	For early market, 1000 pounds or more. 300 to 400 pounds mixed with the soil in the hills and the remainder broadcast and worked into the soil before field setting. For canning, 500 pounds broadcast and worked into the soil before setting.		
Cabbage	4-16-4 or 4-16-8	4-16-4 or 2-12-6	4-16-4 or 2-12-6
	For early market, 1000 pounds or more. 300 to 400 pounds mixed with soil in hills and the remainder broadcast and worked into the soil before field setting. Late cabbage, 400 pounds or more broadcast and worked into the soil before setting.		
Cantaloupes and Cucumbers	4-16-4 or 4-16-8	4-16-4 or 2-12-6	2-16-2 or 0-20-0
	For early market, 400 pounds or more. 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 pounds or more broadcast before planting.		
Beets, Carrots, Turnips and Rutabagas	4-16-4 or 4-16-8	2-16-2 or 4-16-4	2-16-2 or 0-20-0
	400 pounds or more broadcast and worked into the soil before planting.		

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. Soils included in Groups 1 and 4, in practically all cases, are in need of lime, and it is advisable to consider the application of this material as the first step in a system of good 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 barnyard 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 sourse of organic matter. On those soils which have a low content of organic matter, as in Groups 1 and 4, it is frequently advisable to lime, if needed, and to grow a sweet clover crop to be plowed down before the general crops are grown. Probably no more economical use of fertilizer could be made than by applying the proper mixture for a sweet clover crop grown for green manuring purposes.

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;

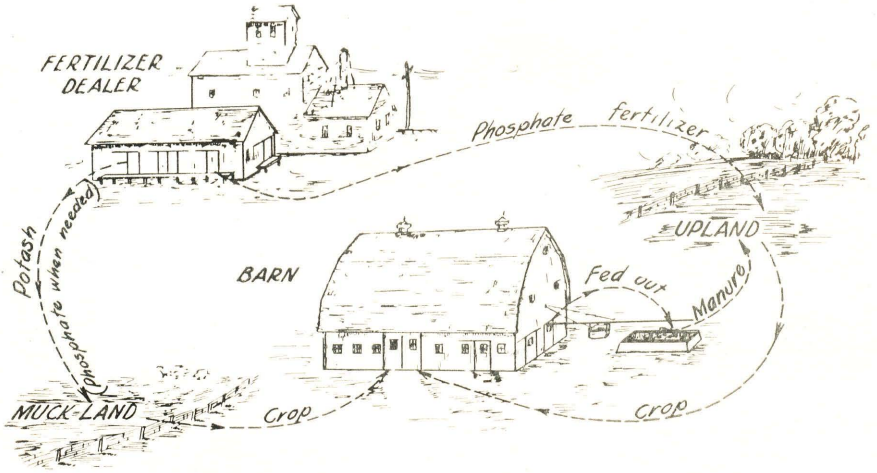


Fig. 8.—Showing proper maintenance of fertility of the soil on the farm which is composed of both mineral soil and muck. The nitrogen and organic matter content of the mineral soil is increased by applying all of the manure on it and the fertility of the muck is improved by the use of commercial fertilizer.

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, or from the continued use of alkaline irrigation water and of alkaline dusts and sprays on the crops being grown.

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, parsnips, sugar beets, Swiss chard, table beets and table carrots seem most tolerant of the "alkali" in the studies made thus far.

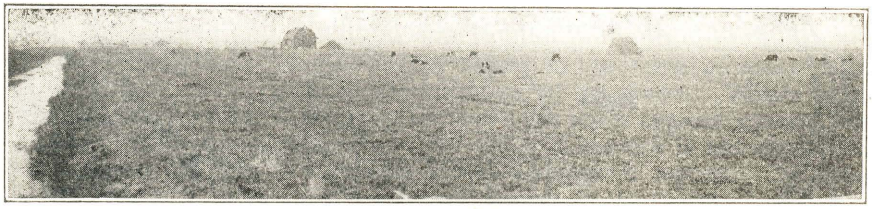


Fig. 9.—Muck pasture, when properly drained and properly fertilized, produces a high yield of grass, which remains green and succulent when upland pasture may be dry and brown.

Experiments conducted for the past four years have proven 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 the underlying muck is quite acid, the condition may be overcome by very deep plowing and thorough disking. On the other hand, 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.

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

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.

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 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.

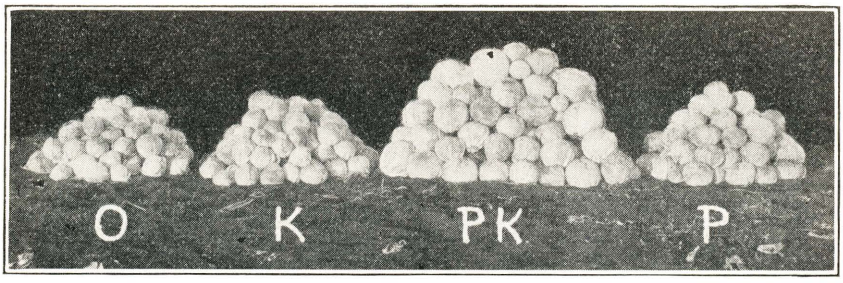


Fig. 11.—Cabbage on muck land. From left to right, O—unfertilized, K—potash only, PK—phosphate and potash, and P—phosphate only.

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 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 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.

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.

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.

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.

TABLE III—MUCK SOILS

Crop (In those columns in which two fertilizer recommendations are given, the first formula is generally preferred)	Annual broadcast application Pounds per acre (If only muriate of potash is needed, one-half to two-thirds these recommendations should be applied.)	TYPE OF MUCK			
		High-Lime Muck			Low-Lime Muck
		Deep and Medium Muck		Shallow Muck	Very strongly acid in reaction. Limestone or marl should be applied preceding fertilization.
		Mucks requiring both potash and phosphate.	Mucks showing little or no benefit from phosphate in mixture.	Manure or green manure recommended in rotation.	
Oats Barley Rye With or without seeding.	250-400 250-400 200-350	0-8-24 or 0-8-32	Muriate of Potash	0-20-20 or 0-8-24	3-9-18 or 2-8-16
		To secure satisfactory results from fertilizers, grow varieties adapted to muck land, such as Gopher oats, Peatland barley and Rosen rye.			
Timothy and alsike Sweet clover Hungarian millet	200-350 200-350 200-300	0-8-32 or 0-8-24	Muriate of Potash	0-8-24	0-8-24 or 3-9-18
		Seeding without nurse crop often advisable. Early seeding necessary to beat weed growth.			
Permanent pasture	100-200	0-8-32	Muriate of Potash	0-8-24	0-8-24 or 3-9-18
		Apply broadcast in spring. Growth increased and palatability and nutritive value of grass much improved by proper fertilization.			
Field corn* Sweet corn* Sunflowers	250-500 400-800 250-400	0-8-24 or 0-8-32	0-8-32 or Muriate of Potash	0-8-24	0-8-24
		If row application is made, do not use more than 200 pounds, preferably below and 2 inches from seed. Broadcast remainder and disc in.			
Sugar beets	400-600	0-8-32 or 0-8-24	Muriate of Potash	0-8-24	Crop not adapted
		Row application advisable; not more than 150 pounds with seed, or not more than 300 pounds if 2 inches from seed. If more is to be applied, broadcast it and disc in before planting.			
Potatoes*	400-800	0-8-24 or 0-8-32	0-8-32	0-8-24	0-8-24
		Row application advisable 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.			
Cabbage Cauliflower	500-1000 800-1500	3-9-18 or 2-8-16	4-8-28 or 0-8-24	2-8-10 or 3-9-18	3-9-18 or 2-8-16
		Application of 400-500 pounds advisable, in row 4 inches deep if plants are transplanted to field. Application of 200 pounds in row 2 inches below seed if sown in field. Broadcast remainder and disc in.			
Celery* Late	1200-2000	4-8-28 or 0-8-24	4-8-28 or 0-8-24	3-9-18 or 2-8-10	4-8-28 or 3-9-18
		If no manure has been applied, application 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.			
Early	1000-1800	3-9-18 or 2-8-10	3-9-18 or 2-8-16	3-9-18 or 2-8-10	3-9-18 or 2-8-16
Mint	250-500	3-9-18 or 2-8-16	4-8-28 or 0-8-24	3-9-18 or 2-8-10	Crop not adapted
		Fertilizer needed to maintain stand as well as to increase oil content. Apply broadcast fairly early in spring.			
Onions*	500-1200	3-9-18 or 2-8-16	4-8-28 or 3-9-18	2-8-10 or 3-9-18	2-8-10 or 3-9-18
		Row application of 400-500 pounds 2 inches below seed advisable. Broadcast remainder before seeding and disc in. Seed early if possible. Protect from wind to save crop and fertilizer. For further information see Special Bulletin 168.			
Lettuce Spinach*	500-1000 400-800	6-9-15 or 3-9-18	4-8-28 or 3-9-18	6-9-15 or 3-9-18	6-9-15 or 3-9-18

	Late	1200-2000	4-8-28 or 0-8-24	4-8-28 or 0-8-24	3-9-18 or 2-8-10	4-8-28 or 3-9-18
Celery*			If no manure has been applied, application 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.			
	Early	1000-1800	3-9-18 or 2-8-10	3-9-18 or 2-8-16	3-9-18 or 2-8-10	3-9-18 or 2-8-16
Mint		250-500	3-9-18 or 2-8-16	4-8-28 or 0-8-24	3-9-18 or 2-8-10	Crop not adapted
			Fertilizer needed to maintain stand as well as to increase oil content. Apply broadcast fairly early in spring.			
Onions*		500-1200	3-9-18 or 2-8-16	4-8-28 or 3-9-18	2-8-10 or 3-9-18	2-8-10 or 3-9-18
			Row application of 400-500 pounds 2 inches below seed advisable. Broadcast remainder before seeding and disc in. Seed early if possible. Protect from wind to save crop and fertilizer. For further information see Special Bulletin 168.			
Lettuce		500-1000	6-9-15 or 3-9-18	4-8-28 or 3-9-18	6-9-15 or 3-9-18	6-9-15 or 3-9-18
Spinach*		400-800				
Swiss chard		500-1000	Broadcast and disc in fertilizer before seeding. Sidedressing of available nitrogen fertilizer, at rate of 75-100 pounds, advisable during growth if 3-9-18 was used.			
Parsnips		700-1000	0-8-32 or 0-8-24	Muriate of Potash	0-8-24	0-8-24 or 3-9-18
Rutabagas		300-500				
Stock carrots		300-500				
Table carrots		400-800	Broadcast fertilizer and disc in before seeding.			
Turnips		300-500				
	Early		3-9-18 or 2-8-10	3-9-18 or 2-8-16	3-9-18 or 2-8-10	3-9-18 or 2-8-16
Radishes		400-800	Broadcast fertilizer and disc in before seeding.			
	Late		0-8-24	0-8-32	0-8-24	0-8-24
	Early		3-9-18 or 2-8-16	3-9-18 or 2-8-16	3-9-18 or 2-8-10	Crop not adapted
Table beets		600-1000	Row application advisable—not more than 500 pounds 2 inches below seed. Broadcast remainder and disc in before seeding.			
	Late		4-8-28 or 0-8-24	4-8-28 or 0-8-32	3-9-18 or 2-8-16	Crop not adapted
Beans		300-500	0-20-20 or 0-8-24	0-8-24	0-20-20	0-20-20
Cucumbers		500-1000				
Melons		500-1000				
Pumpkins		400-600	These crops easily killed by frost, therefore generally not safe on muck soil. The smallest application recommended for each crop may safely be made in the row 2 inches below seed. Keep soil compact to help prevent frost injury.			
Squash		400-600				
Tomatoes		600-1000				

*These crops show marked response to sulphur when grown on "alkali" muck. See page 16.

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). Some General Information on Lime and Its Uses and Functions in Soils.

Special Bulletin No. 180. Grayling Sands.

Circular Bulletin No. 90. Cucumber Culture.

Special Bulletin No. 136. The Muck Soils of Michigan, Their Management for the Production of General Crops.

Special Bulletin No. 168. The Management of Michigan Muck Soils for the Production of Onions.

Circular Bulletin No. 103 (Revised). The Prevention of Wind Injury to Crops on Muck Land.