Fertilizer Recommendations
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*Extension Bulletin 159*

# FERTILIZER RECOMMENDATIONS *for* MICHIGAN CROPS

*PREPARED BY THE*

**DEPARTMENTS OF SOIL SCIENCE and HORTICULTURE**

MICHIGAN STATE COLLEGE
COOPERATIVE EXTENSION SERVICE
EAST LANSING

## CONTENTS

## HOW TO USE THIS BULLETIN

To make the best use of the information presented in this bulletin, follow the instructions presented below:

1. Growers of tree fruits, grapes, bush fruits, brambles, strawberries, and blueberries—Turn to page 19 if the soil is mineral; turn to pages 20-21 if it is an organic soil.

2. Growers of other crops—Determine the soil-type name wherever possible. (Obtain this information from a soil survey map—or at the office of the county agricultural agent; from the vocational agricultural teacher; from the Soil Science Department, Michigan State College; or, through your local Soil Conservation District.) Locate the soil-type name in the alphabetical list of soil types recorded in Table 8, pages 34-39; then refer to the particular fertilizer recommendation table indicated there.

3. If the soil is MUCK, turn to pages 20-21.

4. If the soil is MINERAL and the type-name is not known, use the following key to determine the correct fertilizer recommendation table to use:

   **a.** If the soil is rolling, naturally well-drained, and heavy enough to class as a loam, silt loam, or clay loam, refer to Table 1.

   **b.** If the soil is level, naturally poorly drained and heavy enough to class as a loam, silt loam, or clay loam, refer to Table 2.

   **c.** If the soil is a fairly productive, well-to-imperfectly drained sandy loam or an imperfectly drained loamy sand—refer to Table 3.

   **d.** If the soil is a sand or well-drained loamy sand, refer to Table 4.

   **e.** Refer to soil test results obtained from the nearest county soil testing laboratory; the soil testing laboratory at East Lansing; or from any reputable laboratory where it is known that the Spurway method of testing was followed. If the phosphorus (P) and potassium (K) tests were low (below 50 and 150 pounds per acre, respectively, reserve tests), follow the recommendations in *column 1* of Tables 1, 2, 3, or 4.

   If the phosphorus (P) test was low (below 50) but potassium

(K) was high (above 150), follow the recommendations in *column* 2 of Tables 1, 2, 3, or 4. If the quantities of both elements were high, according to the tests above 50 and 150 pounds, respectively, follow the recommendations in *column 4* of Tables 1, 2, 3, or 4.

The information in the third column of those tables pertains to soils which tested high in phosphorus (above 50), but low in potassium (below 150). If the soil pH is above 7.5, the dividing line between "low" and "high" phosphorus should be placed at 100 pounds per acre.

**f.** Turn to page 12 for advice as to method of fertilizer application. This is especially important for row crops.

**g.** If the pH of the soil being considered is above 6.5, read the section on "Minor Elements" (page 16). Pay special attention to the footnotes under Tables 1, 2, 3, or 4.

**5.** Study the remainder of the bulletin, as time permits.

# Fertilizer Recommendations for Michigan Crops

*Prepared by the DEPARTMENTS OF SOIL SCIENCE and HORTICULTURE*

## RATIOS AND MINIMUM FERTILIZER GRADES RECOMMENDED[1]

| *Ratio* | *Minimum Grades* |
|---|---|
| 0-1-3 | 0-9-27 |
| 0-1-2 | 0-10-20 |
| 0-1-1 | 0-12-12 |
| 0-2-1 | 0-20-10 |
| 1-6-3 | 3-18-9 |
| 1-4-4 | 3-12-12 |
| 1-4-2 | 4-16-8 |
| 1-3-6 | 3-9-18 |
| 1-4-1 | 4-16-4 |
| 1-1-1 | 8-8-8 |
| 1-3-9 | 3-9-27 |
| 2-1-1 | 12-6-6 |
| 1-2-2 | 6-12-12 |

(Carriers of nitrogen, phosphorus, and potassium)

The use of higher grades of the recommended ratios is encouraged. Such substitutions result in a saving of money and labor. For instance, 400 pounds of 3-18-9 fertilizer is required to furnish the plant food contained in 300 pounds of 4-24-12. Besides a cash saving in cost, the farmer gains through lower trucking charges and lessened labor in the field at planting time.

The first figure in the grade is the percentage of total nitrogen (N); the second, the percentage of available phosphoric acid ($P_2O_5$); and the third is the percentage of water-soluble potash ($K_2O$). Actually, it is impossible to place these three plant nutrients together just as

[1]Ratio simply refers to the proportion of nitrogen, phosphoric acid and potash in the mixture. The grade indicates the percentage of each nutrient contained in the finished fertilizer.

they are expressed in the grade percentage figures. For instance, nitrogen in the pure state is a *gas* not used directly by plants. It must be placed in the fertilizer as a *salt* containing perhaps only 20 percent nitrogen, or as ammonia containing 82 percent nitrogen. Phosphoric acid is usually supplied as *superphosphate* (monocalcium phosphate and calcium sulfate), while potash may be supplied as a *salt* such as muriate of potash or sulfate of potash.

Thus the "percents" not accounted for in the sum of the grade percentages are not made up entirely with filler, but largely with the other elements contained in the salts or compounds used as carriers for the plant nutrients purchased. A considerable portion is made up of calcium, sulfur, hydrogen, and oxygen. The grades of fertilizer recommended in this bulletin are not likely to contain "make weight" materials.

## *I. Recommendations for Mineral Soils*

### NO "CURE-ALL" MAGIC COMPOUNDS

Fertilizers may produce their greatest returns on what are generally considered the better soils. The soils must be well drained. If an excess of water results in a puddled soil condition, with poor aeration, plants cannot thrive—even though nutrient levels are ideal for growth. Likewise improper tillage (too little or too much) may influence the size of the harvest.

Plant nutrients, particularly phosphorus, are most available in soils of pH 6.5 to 7.0. This means that soils more acid than indicated by a pH of 6.5 should be limed, preferably with a dolomitic limestone, in order to obtain greatest efficiency from added fertilizers. However, where the pH is 6.3 to 6.5, the increased availability of phosphorus may not be sufficient reason for liming if good alfalfa can be produced without lime. Care should be exercised to avoid raising the pH above 7.0. For vegetables on very sandy soils, lime to pH 6.5.

High productivity is correlated with high organic-matter levels. Fertilizers are not a substitute for organic matter, but they can be applied to help increase organic matter levels. The system of man-

agement must be such, however, as to favor the production of organic matter. Animal manures should be carefully saved and spread on the fields. Crop residues should be plowed under—not burned—and green manure crops should be seeded regularly and often. Rotations must be planned to provide for soil-building green manure crops.

Legumes make the best green manures because they work with the soil organisms to use atmospheric nitrogen, if properly inoculated. The production of an alfalfa crop through one harvest year may add to the soil as much as 100 pounds of elemental nitrogen. That is, as much nitrogen as is contained in 2,500 pounds of 4-16-8 fertilizer, or in 500 pounds of ammonium sulfate.

## BASIS FOR RECOMMENDATIONS

Fertilizer recommendations are based primarily upon the results from field experiments. There are some 300 recognized types of soil in Michigan. The great variation in climate from north to south has been partly responsible for so much variation in soil. The action of the glaciers, and movement of soil by wind and water since that time, has resulted in much more variability. The shape of the land surface and the height of the water table cause additional soil differences.

Taking into consideration this variability, experiments have been conducted over the state on as many soil types as possible. However, it has been impossible to work on all the types now recognized. In addition, of course, there are areas not characteristic of any recognized type. Thus it is often necessary for the person who makes a specific recommendation to resort to experience and judgment in classifying the soil, before he can come to a conclusion as to the best fertilizer for the crop in mind.

It is recognized that those who use this bulletin may have but a slight knowledge of soil types. For that reason, only four general groupings of mineral soils, and two of muck, are considered. The farmer may know the name of his soil and thus place it in the right group, or he may make use of the section entitled "How to Use This Bulletin" and locate his soil in the correct group. Then he will know from which of the tables, Tables 1 through 6, to obtain the specific recommendation for his field.

**Soil Tests Now a Valuable Aid**

During recent years, much work has been done to make possible the use of soil tests as a means of diagnosing the needs of a crop on any particular soil. Thus it is now possible to make better recommendations than when soil type alone was used as a basis.

Furthermore, the use of soil-testing results makes less essential a knowledge of how the soil has previously been managed. This does not hold true so much with respect to nitrogen as it does for phosphoric acid and potash.

Only soil-test results obtained by the Spurway method of testing should be used in locating fertilizer recommendations in this bulletin. (In the Spurway "reserve" method recommended for general crops on mineral soil, the extracting reagent is the No. 8 reagent, 0.13 normal hydrochloric acid.) In making up the recommendation tables for mineral soils, it is assumed that all phosphorus tests below 50 pounds per acre are low, and those above 50 are high. This division between "low" and "high" should be placed at 100 pounds per acre, if the soil pH is above 7.5.

Potassium tests are assumed to be high if they are above 150 pounds per acre, and low if they are below 150. As test results fall very close to these values, one way or the other, a certain amount of judgment should be used in determining the amount of fertilizer to use.

In this publication, test results are not used to determine whether or not fertilizer should be applied—but rather as to *how much* should be applied, and what the grade should be. In general, the recommendations as to rate of application on mineral soil are doubled as the test results change from "high" to "low" in both phosphorus and potassium (P and K). In other words it is assumed that fertilizer should be applied for *all* crops.

The logic for this lies in the fact that in but few instances have well-balanced fertilizers failed to cause economical increases in yield in field experiments. As more field experimental results are supported by soil tests, it may become advisable to modify this viewpoint. If the soil has not been tested use the tables in this manner: Use column 1 in each table if you believe the soil is in a low state of fertility; use column 4 if you believe the fertility level is high.

If it is known that rock phosphate was applied on the area represented by the soil sample, the "active" Spurway test should be employed. One should then use different levels of phosphorus and

*TABLE 1—Fertilizer recommendations for general crops and vegetables on upland loams, silt loams, and clay loams of the Miami, Conover, St. Clair, Nappanee, Isabella, Kent, Nester, Selkirk, and similar series*

| CROP | Ratio, Recommended Grade and Rate per Acre | | | |
|---|---|---|---|---|
| | [1] Phosphorus *low* Potassium *low* | [2] Phosphorus *low* Potassium *high* | [3] Phosphorus *high* Potassium *low* | [4] Phosphorus *high* Potassium *high* |
| Alfalfa, alfalfa-brome, clover, sweet clover | (0-2-1) 0-20-10 *400 lb.* | (0-1-0) 0-20-0 *400 lb.* | (0-1-1) 0-20-20 *200 lb.* | (0-2-1) 0-20-10 *200 lb.* |
| Alfalfa, after 2nd harvest year | (0-2-1) 0-20-10 *300 lb.* | (0-1-0) 0-20-0 *300 lb.* | (0-1-1) 0-20-20 *150 lb.* | (0-2-1) 0-20-10 *150 lb.* |
| Grass, no legume | (2-1-1) 12-6-6 *400 lb.*; or 50 lb. nitrogen | | | |
| Barley*, oats* with legume seeding | (1-6-3) 4-24-12 *250 lb.* 3-18-9 *333 lb.* | (1-4-1) 4-16-4 *360 lb.* | (1-4-4) 3-12-12 *250 lb.* | (1-6-3) 4-24-12 *125 lb.* 3-18-9 *166 lb.* |
| Barley*, oats*, sudan grass*, without legume seeding | (1-6-3) 4-24-12 *200 lb.* 3-18-9 *267 lb.* | (1-4-1) 4-16-4 *300 lb.* | (1-4-4) 3-12-12 *200 lb.* | (1-6-3) 4-24-12 *100 lb.* 3-18-9 *133 lb.* |
| Field beans, soybeans, peas | (1-4-2) 4-16-8 *300 lb.* | (1-4-1) 4-16-4 *300 lb.* | (1-4-4) 3-12-12 *200 lb.* | (1-4-2) 4-16-8 *150 lb.* |
| Sugar beets†‡, chicory†, red beets†, tomatoes‡ | (1-4-2) 4-16-8 *600 lb.* | (1-4-1) 4-16-4 *600 lb.* | (1-4-4) 3-12-12 *400 lb.* | (1-4-2) 4-16-8 *300 lb.* |
| Potatoes‡§ | (1-4-4) 3-12-12 *600 lb.* | (1-4-2) 4-16-8 *450 lb.* | (1-3-6) 3-9-18 *400 lb.* | (1-4-4) 3-12-12 *300 lb.* |
| Wheat*, rye*, legume seeding | (1-6-3) 4-24-12 *300 lb.* 3-18-9 *400 lb.* | (1-4-1) 4-16-4 *450 lb.* | (1-4-4) 3-12-12 *300 lb.* | (1-6-3) 4-24-12 *150 lb.* 3-18-9 *200 lb.* |
| Wheat*, rye*, without legume seeding | (1-6-3) 4-24-12 *250 lb.* 3-18-9 *333 lb.* | (1-4-1) 4-16-4 *375 lb.* | (1-4-4) 3-12-12 *250 lb.* | (1-6-3) 4-24-12 *125 lb.* 3-18-9 *166 lb.* |
| Corn‡ | (1-4-2) 4-16-8 *200 lb.* | (0-1-0) 0-20-0 *160 lb.* | (1-4-4) 3-12-12 *133 lb.* | *(none)* |
| Sweet corn‡ | (1-4-2) 4-16-8 *400 lb.* | (0-1-0) 0-20-0 *320 lb.* | (1-4-4) 3-12-12 *267 lb.* | (1-4-2) 4-16-8 *200 lb.* |
| Market gardens¶, home gardens¶ | (1-4-2) 4-16-8 *1000 lb.* | (1-4-1) 4-16-4 *1000 lb.* | (1-4-4) 3-12-12 *667 lb.* | (1-4-2) 4-16-8 *500 lb.* |

*Topdress with 20 pounds nitrogen where leaf color, tissue test, or rotation history indicates a need. (20 pounds nitrogen contained in 100 pounds ammonium sulfate, 60 pounds ammonium nitrate, 25 pounds anhydrous ammonia, or 43 pounds urea).

†Apply fertilizer containing 50 pounds borax per ton.

‡Sidedress with 40 pounds of nitrogen where plant color, tissue tests, or rotation history indicates a need. Potatoes need more nitrogen than tomatoes. For transplants use a soluble fertilizer at the rate of 3 pounds per 50 gallons of transplanting water. (2 tablespoons per gallon).

§Avoid white-skinned varieties where soil pH is above 5.5.

¶Apply supplemental nitrogen where plant color or tissue test indicates a need. Leafy green vegetables and cucumbers will respond to 40 pounds of nitrogen per application. Others require less or none. Apply manganese sulfate at the rate of 100 pounds per acre if the soil pH is above 6.5. Where the soil pH is above 6.9, apply borax at the rate of 4 ounces per 1000 square feet for those crops which are sensitive to boron starvation. See page 16 for a list of such crops. (Ten cups per 100 feet of 24-inch row is approximately equal to 1000 pounds per acre.)

potassium as dividing lines between "low" and "high" tests. That line for phosphorus (P) should be at 25 pounds per acre for acid soils, and at 50 for those with pH above 7.5. The dividing line for potassium (K) should be at 80 pounds per acre.

Greenhouse and garden soils should also be tested by the "active" method (extraction with No. 1 reagent, 0.018 normal acetic acid). For these soils, however, it is desirable to maintain much higher nutrient levels—so the same dividing lines may be used as where extraction was with the stronger acid. (50 pounds phosphorus per acre in soils with pH below 7.5; 100 pounds where pH is above that figure. Below 150 is low for potassium).

**How to Take Soil Samples**

The results from a soil test may be worthless, or actually misleading, unless the sample tested truly represents the area of soil under consideration. A word of advice in regard to taking the sample may be worthwhile.

One should first survey the area to determine soil-type boundaries. Types should never be mixed to obtain a composite sample to send in for analysis. Thus the number of samples finally analyzed should be equal to or greater than the number of soil types in the field to be fertilized.

The final sample for analysis should be a composite from at least 5 samples scattered over the area to be sampled *(one soil type)*. The samples should be taken with some tool which removes a core or slice to the depth of plowing. Several good soil sampling tubes are now on the market. A sharp, clean spade is satisfactory. The five cores or slices should be thoroughly mixed. A one-half pint portion of the mixture is sufficient for the tests. All tools and containers should be clean.

If the person taking the soil samples is uncertain of the types of soil being sampled, it is well to take one subsoil sample in each soil type area. The pH test is usually the only one needed on subsoil samples.

**Nitrogen**

The immediate nitrogen needs of a crop growing on a mineral soil depends more on the system of management than on the soil type or test at the time of planting. Bacteria in the nodules on the roots of alfalfa and the clovers take nitrogen from the air to build their own

*TABLE 2—Fertilizer recommendations for general crops and vegetables on the low land loams, silt loams, and clay loams of the Brookston, Bergland, Wisner, and similar series*

| CROP | Ratio, Recommended Grade and Rate per Acre | | | |
|---|---|---|---|---|
| | [1] Phosphorus *low* Potassium *low* | [2] Phosphorus *low* Potassium *high* | [3] Phosphorus *high* Potassium *low* | [4] Phosphorus *high* Potassium *high* |
| Alfalfa, alfalfa-brome, clover, sweet clover | (0-2-1) 0-20-10 *300 lb.* | (0-1-0) 0-20-0 *300 lb.* | (0-1-1) 0-20-20 *150 lb.* 0-12-12 *250 lb.* | (0-2-1) 0-20-10 *150 lb.* |
| Alfalfa, after 2nd harvest year | (0-2-1) 0-20-10 *200 lb.* | (0-1-0) 0-20-0 *200 lb.* | (0-1-1) 0-20-20 *100 lb.* | (0-2-1) 0-20-10 *100 lb.* |
| Grass, no legume | (2-1-1) 12-6-6 *400 lb.*; or 50 lb. nitrogen | | | |
| Barley*, oats*†, with legume seeding | (1-6-3) 4-24-12 *250 lb.* 3-18-9 *333 lb.* | (1-4-1) 4-16-4 *360 lb.* | (1-4-4) 3-12-12 *250 lb.* | (1-6-3) 4-24-12 *125 lb.* 3-18-9 *166 lb.* |
| Barley*, oats*†, sudan grass* without legume seeding | (1-6-3) 4-24-12 *200 lb.* 3-18-9 *267 lb.* | (1-4-1) 4-16-4 *300 lb.* | (1-4-4) 3-12-12 *200 lb.* | (1-6-3) 4-24-12 *100 lb.* 3-18-9 *133 lb.* |
| Field beans†, soybeans, peas | (1-4-2) 4-16-8 *300 lb.* | (1-4-1) 4-16-4 *300 lb.* | (1-4-4) 3-12-12 *200 lb.* | (1-4-2) 4-16-8 *150 lb.* |
| Sugar beets†‡§, chicory‡, red beets‡ | (1-4-2) 4-16-8 *500 lb.* | (1-4-1) 4-16-4 *500 lb.* | (1-4-4) 3-12-12 *333 lb.* | (1-4-2) 4-16-8 *250 lb.* |
| Wheat*, rye*, legume seeding | (1-6-3) 4-24-12 *300 lb.* 3-18-9 *400 lb.* | (1-4-1) 4-16-4 *450 lb.* | (1-4-4) 3-12-12 *300 lb.* | (1-6-3) 4-24-12 *150 lb.* 3-18-9 *200 lb.* |
| Wheat*, rye*, without legume seeding | (1-6-3) 4-24-12 *250 lb.* 3-18-9 *333 lb.* | (1-4-1) 4-16-4 *375 lb.* | (1-4-4) 3-12-12 *250 lb.* | (1-6-3) 4-24-12 *125 lb.* 3-18-9 *166 lb.* |
| Corn§ | (1-4-2) 4-16-8 *200 lb.* | (0-1-0) 0-20-0 *160 lb.* | (1-4-4) 3-12-12 *133 lb.* | (*none*) |
| Sweet corn§ | (1-4-2) 4-16-8 *400 lb.* | (0-1-0) 0-20-0 *320 lb.* | (1-4-4) 3-12-12 *267 lb.* | (1-4-2) 4-16-8 *200 lb.* |
| Potatoes§¶, tomatoes§ | (1-4-2) 4-16-8 *600 lb.* | (1-4-1) 4-16-4 *600 lb.* | (1-4-4) 3-12-12 *400 lb.* | (1-4-2) 4-16-8 *300 lb.* |
| Market gardens**, home gardens** | (1-4-2) 4-16-8 *1000 lb.* | (1-4-1) 4-16-4 *1000 lb.* | (1-4-4) 3-12-12 *667 lb.* | (1-4-2) 4-16-8 *500 lb.* |

*Topdress with 20 pounds nitrogen where leaf color, tissue test, or rotation history indicates a need. (20 pounds nitrogen is contained in 100 pounds ammonium sulfate, 60 pounds ammonium nitrate, 25 pounds anhydrous ammonia, or 43 pounds urea.)

†Where pH is above 6.5, apply fertilizer containing 100 or 200 pounds manganese sulfate per ton.

‡Apply fertilizer containing 50 pounds borax per ton.

§Sidedress with 40 pounds nitrogen where plant color, tissue test, or rotation history indicates a need. Potatoes need more nitrogen than tomatoes. For transplants, use a soluble fertilizer at the rate of 3 pounds per 50 gallons of transplanting water (2 tablespoons per gallon).

¶Avoid white-skinned varieties where soil pH is above 5.5.

**Apply supplemental nitrogen where plant color or tissue test indicates a need. Leafy green vegetables and cucumbers will respond to 40 pounds of nitrogen per application. Others require less or none. Apply manganese sulfate at the rate of 100 pounds per acre if the soil pH is above 6.5. Where the soil pH is above 6.9, apply borax at the rate of 4 ounces per 1000 square feet for those crops which are sensitive to boron starvation. See page 16 for a list of such crops. (Ten cups per 100 feet of 24-inch row is approximately equal to 1000 pounds per acre.)

bodies. They soon die, and the plant is able to make use of the nitrogen thus turned loose in the soil. Companion crops, such as grass, may also use the nitrogen. Because of this "nitrogen fixation" by the legume bacteria, it is not usually necessary to apply nitrogen fertilizer for these crops. In fact, the crops which *immediately follow* alfalfa or clover may obtain sufficient nitrogen from the decomposing plant residues.

Unweathered animal manures are relatively high in available nitrogen—unless the product is unusually high in straw, or in other highly carbonaceous bedding such as shavings or sawdust. It may be advisable to omit nitrogen from the fertilizer where manure has recently been applied. In most cases, however, a small quantity of nitrogen at planting time is desirable. In many instances, additional nitrogen should be applied as a topdressing in the case of small grains and as sidedressings for row crops.

Deficiency symptoms and green-tissue-tests make it possible to predict, with a considerable degree of accuracy, where supplemental nitrogen applications are likely to be profitable. (The symptoms of nitrogen starvation are illustrated in color in Michigan Experiment Station Special Bulletin 353. Also described in that publication are the methods used in making tests for nitrate in the growing plant.) After growth has started in the spring, a nitrate test will tell whether or not it will pay to topdress wheat. The same may be said about oats after they have made 6 inches of growth.

Tests should be made on corn, sugar beets, tomatoes, and potatoes just before each cultivation. Apply nitrogen fertilizer as soon as a deficiency is noticed. Deficiencies may be spotted sooner through use of chemical tests than by observing deficiency symptoms.

Profitable response to supplemental nitrogen applications is not likely to result where there is starvation for other nutrients. The farmer should make soil tests for phosphorus and potassium unless adequate fertilizers were applied at planting.

## METHODS OF APPLYING FERTILIZER

This subject has received much attention at the Michigan Experiment Station during the past two decades. With most crops, some rather definite recommendations may be made as a result of the experiments performed.

*TABLE 3—Fertilizer recommendations for general crops and vegetables on light loams and sandy loams of the Hillsdale, Fox, Bellefontaine, Wauseon, Berrien, Ogemaw, Emmet, and similar series*

| CROP | Ratio, Recommended Grade and Rate per Acre | | | |
|---|---|---|---|---|
| | [1] Phosphorus *low* Potassium *low* | [2] Phosphorus *low* Potassium *high* | [3] Phosphorus *high* Potassium *low* | [4] Phosphorus *high* Potassium *high* |
| Alfalfa, alfalfa-brome, clover, sweet clover | (0-1-1) 0-20-20 *300 lb.* 0-12-12 *500 lb.* | (0-2-1) 0-20-10 *300 lb.* | (0-1-2) 0-10-20 *300 lb.* | (0-1-1) 0-20-20 *150 lb.* 0-12-12 *250 lb.* |
| Alfalfa, after first hay crop | (0-1-1) 0-20-20 *200 lb.* 0-12-12 *333 lb.* | (0-2-1) 0-20-10 *200 lb.* | (0-1-2) 0-10-20 *200 lb.* | (0-1-1) 0-20-20 *100 lb.* 0-12-12 *167 lb.* |
| Grass, no legume | (2-1-1) 12-6-6 *400 lb.*; or 50 lb. nitrogen | | | |
| Barley*, oats*, with legume seeding | (1-4-4) 3-12-12 *500 lb.* | (1-4-2) 4-16-8 *375 lb.* | (1-3-6) 3-9-18 *333 lb.* | (1-4-4) 3-12-12 *250 lb.* |
| Barley*, oats*, sudan grass* without legume seeding | (1-4-4) 3-12-12 *300 lb.* | (1-4-2) 4-16-8 *225 lb.* | (1-3-6) 3-9-18 *200 lb.* | (1-4-4) 3-12-12 *150 lb.* |
| Field beans, soybeans, peas | (1-4-4) 3-12-12 *300 lb.* | (1-4-2) 4-16-8 *225 lb.* | (1-3-6) 3-9-18 *200 lb.* | (1-4-4) 3-12-12 *150 lb.* |
| Sugar beets†‡, chicory†‡, red beets†‡ | (1-4-4) 3-12-12 *650 lb.* | (1-4-2) 4-16-8 *488 lb.* | (1-3-6) 3-9-18 *433 lb.* | (1-4-4) 3-12-12 *325 lb.* |
| Wheat*, rye*, legume seeding | (1-4-4) 3-12-12 *600 lb.* | (1-4-2) 4-16-8 *450 lb.* | (1-3-6) 3-9-18 *400 lb.* | (1-4-4) 3-12-12 *300 lb.* |
| Wheat*, rye* without legume seeding | (1-4-4) 3-12-12 *500 lb.* | (1-4-2) 4-16-8 *375 lb.* | (1-3-6) 3-9-18 *333 lb.* | (1-4-4) 3-12-12 *250 lb.* |
| Corn‡ | (1-4-4) 3-12-12 *200 lb.* | (1-4-2) 4-16-8 *150 lb.* | (1-3-6) 3-9-18 *133 lb.* | (*none*) |
| Sweet corn‡ | (1-4-4) 3-12-12 *400 lb.* | (1-4-2) 4-16-8 *300 lb.* | (1-3-6) 3-9-18 *267 lb.* | (1-4-4) 3-12-12 *200 lb.* |
| Potatoes‡§, tomatoes‡ | (1-4-4) 3-12-12 *800 lb.* | (1-4-2) 4-16-8 *600 lb.* | (1-3-6) 3-9-18 *533 lb.* | (1-4-4) 3-12-12 *400 lb.* |
| Market gardens¶, home gardens¶ | (1-4-4) 3-12-12 *1200 lb.* | (1-4-2) 4-16-8 *900 lb.* | (1-3-6) 3-9-18 *800 lb.* | (1-4-4) 3-12-12 *600 lb.* |

*Topdress with 20 pounds nitrogen where leaf color, tissue test, or rotation history indicates a need. (20 pounds nitrogen contained in 100 pounds sulfate of ammonia, 60 pounds ammonium nitrate, 25 pounds anhydrous ammonia, or 48 pounds of urea.)

†Apply fertilizer containing 50 pounds borax per ton.

‡Sidedress with 40 pounds of nitrogen where plant color, tissue test, or rotation history indicates a need. Potatoes need more nitrogen than tomatoes. For transplants use a soluble fertilizer at the rate of 3 pounds per 50 gallons of transplanting water (2 tablespoons per gallon).

§Avoid white-skinned varieties where soil pH is above 5.5.

¶Apply supplemental nitrogen where plant color or tissue test indicates a need. Leafy green vegetables and cucumbers will respond to 40 pounds of nitrogen per application. Others require less or none. Apply manganese sulfate at the rate of 100 pounds per acre if the soil pH is above 6.5. Where the soil pH is above 6.9, apply borax at the rate of 4 ounces per 1000 square feet for those crops which are sensitive to boron starvation. See page 16 for a list of such crops. (Ten cups per 100 feet of 24-inch row is approximately equal to 1000 pounds per acre.)

ALFALFA, ALFALFA-BROME, CLOVER—(with or without a companion crop)—Drill through the fertilizer attachment on a grain drill. Allow legume seeds to fall on top of the soil above the fertilizer bands.

SMALL GRAINS—Drill directly in contact with the seed. Do not broadcast.

FIELD BEANS, SOYBEANS, PEAS—Apply one inch to the side and one and a half inches below the seed. Do not apply directly in contact with the seed.

SUGAR BEETS, CHICORY, RED BEETS—Apply one inch to the side and one and a half inches below the seed. Apply no more than 150 pounds in direct contact with the seed. If a side-band placement drill is not available, drill all but 150 pounds of the fertilizer deeply before planting, then apply 150 pounds with the seed at planting time. Apply extra nitrogen fertilizer as soon as a need is noticed.

CORN AND SWEET CORN—Apply in a single band 2 inches to the side and 2 inches below the seed level. The split-boot applicator largely used on conventional corn planters, is not satisfactory. Apply nitrogen fertilizer as soon after the corn emerges as a need is observed.

POTATOES—Apply in bands two inches to the side on the level or slightly below the seed piece.

TOMATOES—Plow one-half of the fertilizer under. Apply the remainder in bands 3 to 4 inches to the side of the row at planting time. For potatoes and tomatoes, apply additional nitrogen fertilizer at the time of the last cultivation or earlier if the need is noticed.

MARKET GARDEN—Plow under one-half the fertilizer. Drill the remainder in bands 1 inch to the side and 1½ inches below the seed. If experience has shown that extra nitrogen is beneficial, apply between the rows at the time of cultivating. Apply no more than 40 pounds nitrogen at one time.

HOME GARDEN—Apply a portion of the fertilizer, one to two pounds per 100 square feet before plowing or spading. Place two to three pounds (4 to 6 cups) per 100 feet of row in shallow trenches 2 inches to the side and 2 inches below the seed. For tomatoes, place one-third pound (⅔ cup) in a circular trench around the plant, approximately 5 inches out from and 5 inches below the root cluster. Such a method may also be used for other transplants—but the rate of application should be relative to the square feet of space taken by each plant. It is assumed that each tomato plant would occupy 10 to 16 square feet.

*TABLE 4—Fertilizer recommendations for general crops and vegetables on loamy sands and sandy soils of the Plainfield, Coloma, Kalkaska and similar series*

| CROP | Ratio, Recommended Grade and Rate per Acre | | | |
|---|---|---|---|---|
| | [1] Phosphorus *low* Potassium *low* | [2] Phosphorus *low* Potassium *high* | [3] Phosphorus *high* Potassium *low* | [4] Phosphorus *high* Potassium *high* |
| Alfalfa, alfalfa-brome, clover, sweet clover | (0-1-2) 0-10-20 *400 lb.* | (0-1-1) 0-20-20 *200 lb.* | (0-1-3) 0-9-27 *300 lb.* | (0-1-2) 0-10-20 *200 lb.* |
| Alfalfa, after first hay crop | (0-1-2) 0-10-20 *100 lb.* | (0-1-1) 0-20-20 *150 lb.* | (0-1-3) 0-9-27 *200 lb.* | (0-1-2) 0-10-20 *150 lb.* |
| Grass, no legume | (2-1-1) 12-6-6 *400 lb.*; or 50 lb. nitrogen | | | |
| Oats*, without legume seeding | (1-4-4) 3-12-12 *400 lb.* | (1-4-2) 4-16-8 *300 lb.* | (1-3-6) 3-9-18 *265 lb.* | (1-4-4) 3-12-12 *200 lb.* |
| Oats—with legume seeding. Oats at one-half usual rate of seeding | (1-4-4) 3-12-12 *600 lb.* | (1-4-2) 4-16-8 *450 lb.* | (1-3-6) 3-9-18 *400 lb.* | (1-4-4) 3-12-12 *300 lb.* |
| Wheat, rye* | (1-4-4) 3-12-12 *600 lb.* | (1-4-2) 4-16-8 *450 lb.* | (1-3-6) 3-9-18 *400 lb.* | (1-4-4) 3-12-12 *300 lb.* |
| Corn† | (1-4-4) 3-12-12 *300 lb.* | (1-4-2) 4-16-8 *233 lb.* | (1-3-6) 3-9-18 *200 lb.* | (1-4-4) 3-12-12 *150 lb.* |
| Sweet corn† | (1-4-4) 3-12-12 *600 lb.* | (1-4-2) 4-16-8 *450 lb.* | (1-3-6) 3-9-18 *400 lb.* | (1-4-4) 3-12-12 *300 lb.* |
| Potatoes†‡, tomatoes† | (1-4-4) 3-12-12 *1000 lb.* | (1-4-2) 4-16-8 *750 lb.* | (1-3-6) 3-9-18 *667 lb.* | (1-4-4) 3-12-12 *500 lb.* |
| Market gardens§, home gardens§ | (1-4-4) 3-12-12 *1500 lb.* | (1-4-2) 4-16-8 *1125 lb.* | (1-3-6) 3-9-18 *1000 lb.* | (1-4-4) 3-12-12 *750 lb.* |

*Topdress with 20 pounds nitrogen where leaf color, tissue test, or rotation history indicates a need. (20 pounds nitrogen contained in 100 pounds sulfate of ammonia, 60 pounds ammonium nitrate, 25 pounds anhydrous ammonia, or 43 pounds of urea.)

†Sidedress with 40 pounds nitrogen where plant color, tissue test, or rotation history indicates a need. Usually needed on these soils unless manure has recently been applied. Potatoes need more nitrogen than tomatoes. For transplants use a soluble fertilizer at the rate of 3 pounds per 50 gallons of transplanting water (2 tablespoons per gallon).

‡Avoid white-skinned varieties where soil pH is above 5.5.

§Apply supplemental nitrogen where plant color or tissue test indicates a need. Usually needed on these soils. Leafy green vegetables and cucumbers will respond to 40 pounds of nitrogen per application. Others require less or none. Apply manganese sulfate at the rate of 100 pounds per acre if the soil pH is above 6.5. Where the soil pH is above 6.9, apply borax at the rate of 4 ounces per 1000 square feet for those crops which are sensitive to boron starvation. See page 16 for a list of such crops. (Ten cups per 100 feet of 24-inch row is approximately equal to 1000 pounds per acre.)

**Starter Solutions**

Starter solutions may be used for home gardens. Stir 1 cup dry fertilizer into 12 quarts of water. Apply 1 cup of the solution to 10 feet of row or around transplants. This solution should be in addition to the recommended rates of dry fertilizer.

*2 cups = 1 pint*
*1 pint = 1 pound dry fertilizer*
*1 cup = 16 tablespoons*
*1 cup = 48 teaspoons*

## MINOR ELEMENTS IN MINERAL SOILS

The mineral soils of Michigan may be deficient in manganese and/or boron for certain crops. Such deficiencies are not likely to occur where the soil pH is below 6.5. Where it is above that figure, manganese sulfate may be needed for oats, beans, snap beans, soybeans, spinach and sugar beets. In extreme cases, barley and wheat may respond to manganese. Manganese deficiency is most likely to be encountered on the soils to which Table 2 applies.

Where the pH is above 6.9, borax is likely to be needed for sugar beets, spinach, table beets, cabbage, cauliflower, lettuce, turnips, rutabagas, celery, broccoli, and brussel sprouts. *It should never be applied for beans, snap beans, peas or small grains.* Rates of application should range, for most crops, from 5 to 25 pounds per acre depending upon how the material is applied.

Manganese sulfate and borax can be mixed with the regular fertilizers by the fertilizer manufacturer. Borax may be supplied at the rate of 50 pounds per ton, and manganese sulfate at 100 or 200 pounds per ton. Orders for such mixtures should be placed early as they are not held in stock by most companies.

## PURCHASE FERTILIZERS WISELY

Efficiency in the use of fertilizer is urged during the next few years. This may be accomplished by resorting to approved methods of application (see page 12), and by applying the bulk of the fertilizers for the most responsive crops.

A few of the more common crops, listed approximately in order of greatest response are (1) vegetable crops, (2) wheat, (3) sugar beets, (4) alfalfa, (5) potatoes, (6) beans, (7) barley, (8) oats, (9) corn. This order would, of course, vary with soil type. One thing is sure,

vegetable crops, including tomatoes, stand at the top of the list and corn is at the bottom.

The fertilizer business is seasonal. Production is held up, many times, by the lack of storage space. If farmers would purchase their fertilizers during the winter and summer months, storage space would be relieved—and the farmer would be surer of getting the particular grade most suited to his needs. Furthermore, the condition of the final product, when it reached the farm, would in many instances be improved. Fertilizers compounded during the planting season may not reach the farm in good condition. They must have time to cure.

Properly cured fertilizer, stored in a dry place on the farm, will remain in good condition for several months. Storage should be in a well-ventilated place, on boards to aid air circulation beneath the pile. Fertilizer should not be stacked over four bags high, as weight causes hardening. Re-piling is advisable if long storage is necessary.

A gravel screen having ⅜ to ½ inch mesh should be built into the top of fertilizer hoppers. Fertilizer poured through such a screen cannot plug the drill. Lumps are easily crushed through the screen. Where such a precaution is taken one need have no fear of trouble from lumpy fertilizer.

## PLANTS SHOW STARVATION SYMPTOMS

Efficiency in fertilizer usage may be improved by making use of starvation symptoms. Plants are normally green. When another color develops, it is very likely caused by a deficiency of some plant nutrient. Most deficiencies result in yellowing of leaves. The pattern of yellowing varies with different nutrients and with different species of plants.

For many years, these deficiency symptoms have been studied under controlled conditions. The time has arrived when, in many cases, one can tell from the appearance of a starved plant just what nutrient shortage was responsible for its unhealthy condition. Growers can very easily become familiar with these symptoms, and decide for themselves when their plants are suffering for lack of plant food. There may still be time to profitably fertilize that particular crop, or the information may be useful in selecting the fertilizer for the next crop. Green plant tissue tests may be used to verify the symptoms of starvation.

A bulletin on these subjects, Michigan Agricultural Experiment Station Special Bulletin 353, may be obtained from the Bulletin Office, Michigan State College, East Lansing, Michigan.

*TABLE 5—Nitrogen application recommended for fruit production in Michigan*

| Fruit Crop | Form of Nitrogen | Remarks |
|---|---|---|
| Apples | Ammonium nitrate, nitrate of soda, sulfate of ammonia, or nitrogen solutions | Use no fertilizer when trees are planted except on light soils and no fertilizer during first year. Use to ½ pound of ammonium nitrate, or its equivalent, per tree for each year of orchard age until 5-7 pounds are being applied per tree. |
| Peaches | (Same as above) | Use 1 to 2 ounces the first year that trees are planted. Use ⅓ to ½ pound of ammonium nitrate, or its equivalent, per tree for each year of orchard age until 2-3½ pounds are being used per tree. |
| Cherries<br>Pears<br>Plums | (Same as above) | Use 1 to 2 ounces the first year that trees are planted. Use to ⅓ pound of ammonium nitrate, or its equivalent, per tree per year of orchard age until ½-3 pounds are being applied per tree. |
| Grapes | (Same as above) | Use 1 to 2 ounces the first year planted. Use to ½ pound of ammonium nitrate per vine according to cane vigor. |
| Currants<br>Gooseberries | (Same as above) | Use 2 to 4 ounces per bush or 150-250 pounds per acre of ammonium nitrate or its equivalent. |
| Raspberries | (Same as above) | Use 5-10 pounds per 100 feet of row or 150-300 pounds per acre of ammonium nitrate or its equivalent. |
| Strawberries | Superphosphate or 4-16-4 | 500-1000 pounds per acre applied in spring, when preparing soil for planting. |
| | Sulfate of ammonia | Sidedress with 200 pounds per acre two weeks after planting. Repeat first of August. Sidedress weak beds in spring of fruiting year with 100 pounds per acre.<br>*CAUTION—Spring applications on vigorous beds have caused serious loss of fruit.* |
| | 12-6-6 or 4-16-4 | 500-1000 pounds per acre soon after harvest for second and third crop. |

1. Care should be used when making summer applications to prevent burning of leaves.
2. Soils well supplied with organic matter and high in fertility may not need any commercial fertilizers.
3. Soils vary considerably. Consult local county agricultural agent or district horticultural agent about the use of lime, phosphate, potash and minor elements.

| | *(Soils should be strongly acid, pH 5.2 or lower)* | |
|---|---|---|
| Blueberries | 8-8-8 | On sandy soil, 2 ounces in the spring the second year in the field, and increased 1 ounce each year until a total of 7 ounces per plant is being used. |

## TREE FRUITS, GRAPES, BUSH FRUITS AND BRAMBLES

Nitrogen is the fertilizer most commonly needed, and the one for which definite recommendations can be given—as shown in the accompanying table. (Table 5.) There may be locations where potassium, phosphorus, and certain minor elements are needed. It is impossible to make blanket recommendations concerning these fertilizers. Where needed, applications of 0-9-27 or 0-20-20 at a rate of 300 - 500 pounds per acre are suggested. A complete fertilizer such as 8-8-8 or 10-10-10, applied at a rate that would provide nitrogen equivalent to that shown in the table, may be used.

A grower should consult the county agent or district horticultural agent concerning the use of fertilizers containing potassium, phosphorus and minor elements.

Deficiencies of magnesium, manganese, and boron have been found. Magnesium deficiency may be corrected by use of Epsom Salts (magnesium sulfate), sulfate of potash magnesia, or high magnesium lime (dolomitic lime). Sprays of 5 pounds of Epsom Salts per 100 gallons applied twice after petal fall may be used on older trees. Manganese deficiency may be corrected by use of sprays containing 5 pounds of manganese sulfate per 100 gallons. Boron deficiency may be corrected by applying from 1 ounce to 1 pound of borax per tree, the amount varying with age of the tree. *CAUTION: Borax may be very toxic to plant growth and should be applied sparingly.*

Complete fertilizers may be needed to improve growth of cover crops, or sods. These may be fertilized according to recommendations for the specific crop, as given in the preceding tables (Tables 1-4), during the first few years. Later rates of application may be reduced.

The application of nitrogen should be regulated according to tree growth and fruit production. Reduce the amount applied on overly vigorous plants. Increase the amount applied on plants of poor vigor. More severe pruning and mulching will also stimulate plant growth.

No dry fertilizer should be placed in the tree holes at planting time. There is some evidence to indicate that starter solutions may be of some benefit.

Table 5 summarizes recommendation on nitrogen applications for tree fruits and small fruits.

*TABLE 6—Fertilizer Recommendations for MUCK SOILS. (These symbols indicate fertilizer placement: Br—"broadcast," D—"drilled in, R—"under row," S—"beside row." Where two fertilizer grades are given, the upper analysis is for soils with good drainage; the lower for soils with fair drainage. Figures in parentheses, under the percentages given for the minor element salts, indicate the* actual percent *of boron, copper or manganese present.)*

| CROP* (fertilizer placement indicated by symbol) | FERTILIZER ANALYSIS† ACCORDING TO SOIL TEST (Grade and rate of application per acre) | | | | MINOR ELEMENT REQUIREMENTS‡ (Percent of element salts in fertilizer for initial application) | | | | | SALT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Acid Mucks (pH 6.5 or less) | | Alkaline—Faintly Acid Mucks (above pH 6.5) | | | For All Mucks |
| | Phosphorus *low* Potassium *low* | Phosphorus *low* Potassium *high* | Phosphorus *high* Potassium *low* | Phosphorus *high* Potassium *high* | Borax (*Boron*) | Copper Sulfate (*Copper*) | Borax (*Boron*) | Copper Sulfate (*Copper*) | Manganese Sulfate (*Manganese*) | (pounds per acre) |
| Asparagus (S) | 0-9-27 *1100 lb.* | 0-10-20 *1000 lb.* | 0-9-27 *1100 lb.* | 0-9-27 *700 lb.* | 0 | 0 | 0 | 0 | 5%-10% (1.25-2.5) | 0 |
| Beans (D) | 0-20-20 *600 lb.* | 0-20-10 *600 lb.* | 0-10-20 *600 lb.* | 0-20-20 *400 lb.* | 0 | 0 | 0 | 0 | 10%-20% (2.5-5.0) | 0 |
| Broccoli-kale, cabbage (D) | 0-9-27 *1000 lb.* 3-9-27 | 0-10-20 *1000 lb.* 3- 9-18 | 0-9-27 *1000 lb.* 3-9-27 | 0-9-27 *600 lb.* 3-9-27 | 0%-2.5% (0-0.3) | 2.5%-5% (0.63-1.25) | 2.5%-5% (0.3-0.6) | 0 | 5%-10% (1.25-2.5) | 100-200 lb. |
| Carrots (R and D) | 0-9-27 *1000 lb.* | 0-10-20 *900 lb.* | 0-9-27 *1000 lb.* | 0-9-27 *600 lb.* | 0 | 5% (1.25) | 0 | 0 | 5%-10% (1.25-2.5) | 0 |
| Celery (D and S) Early Late | 3-9-18 *2500 lb.* 0-9-27 *2000 lb.* | 3-12-12 *2000 lb.* 0-10 20 *1800 lb.* | 3-9-27 *2000 lb.* 0-9-27 *2000 lb.* | 3-9-18 *1800 lb.* 0-9-27 *1500 lb.* | 2.5% (0-0.3) | 2.5% (0.63) | 2.5%-5% (0.3-0.6) | 0 | 5%-10% (1.25-2.5) | 250-500 lb. |
| Cucumbers (S) | 0-10-20 *1000 lb.* 3-9-18 | 0-12-12 *800 lb.* 3-12-12 | 0-9-27 *800 lb.* 3-9-27 | 0-10-20 *500 lb.* 3-9-18 | 0 | 2.5% (0.63) | 0 | 0 | 5%-10% (1.25-2.5) | 0 |
| Head lettuce (Br) | 3-12-12 *1500 lb.* | 3-18-9 *1000 lb.* | 3-9-18 *1000 lb.* | 6-12-12 *600 lb.* | 2.5% (0.3) | 5% (1.25) | 2.5-5% (0.3-0.6) | 2.5-5% (0.63-1.25) | 10% (2.5) | 0 |
| Leaf lettuce, spinach, endive (D and R) | 3-9-18 *1200 lb.* | 3-12-12 *900 lb.* 6-12-12 | 3-9-27 *900 lb.* | 6-12-12 *500 lb.* | 2.5% (0.3) | 5% (1.25) | 2.5%-5% (0.3-0.6) | 2.5%-5% (0.63-1.25) | 10% (2.5) | 0 |
| Mint (D or S) | 0-12-12 *700 lb.* 3-12-12 | 0-20-10 *500 lb.* 4-16-8 | 0-10-20 *500 lb.* 3-9-18 | 0-12-12 *400 lb.* 3-12-12 | 0 | 2.5% (0.63) | 0 | 0 | *10%-20% for spearmint* (2.5-5) | 0 |
| Onions¶ (R and D) | 3-12-12 *1800 lb.* | 3-18-9 *1200 lb.* | 3-9-18 *1200 lb.* | 3-9-18 *1000 lb.* 6-12-12 | 0 | 5% (1.25) | 0 | 2.5% (0.63) | 5%-10% (1.25-2.5) | 0 |
| Parsnips (R and D) | 0-9-27 *1200 lb.* | 0-10-20 *1100 lb.* | 0-9-27 *1200 lb.* | 0-9-27 *800 lb.* | 2.5% (0.3) | 2.5%-5% (0.63-1.25) | 5% (0.6) | 0 | 5%-10% (1.25-2.5) | 0 |
| Peas (D) | 0-9-27 *1000 lb.* | 0-10-20 *900 lb.* | 0-9-27 *1000 lb.* | 0-9-27 *6000 lb.* | 0 | 2.5% (0.63) | 0 | 0 | 10% (2.5) | 100-200 lb. |
| Potatoes** (D and S) | 0-9-27 *1200 lb.* 3-9-27 | 0-10-20 *1200 lb.* 3-9-18 | 0-9-27 *1200 lb.* 3-9-27 | 0-9-27 *800 lb.* 3-9-27 | 0%-2.5% (0-0.3) | 2.5% (0.63) | 2.5% (0.3) | 0 | 5%-10% (1.25-2.5) | 0 |
| Pumpkins, Squash (D or S) | 0-9-27 *600 lb.* | 0-10-20 *500 lb.* | 0-9-27 *600 lb.* | 0-9-27 *400 lb.* | 0 | 2.5% (0.63) | 0 | 0 | 10% (2.5) | 0 |
| Radishes (Br) | 0-9-27 *800 lb.* 3-9-27 | 0-10-20 *800 lb.* 3-9-18 | 0-9-27 *800 lb.* 3-9-27 | 0-9-27 *500 lb.* 3-9-27 | 2.5% (0.3) | 2.5% (0.63) | 5% (0.6) | 0 | 10% (2.5) | 100-200 lb. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rutabagas, Turnips (D) | 0-9-27 | *600 lb.* | 0-10-20 | *500 lb.* | 0-9-27 | *600 lb.* | 0-9-27 | *400 lb.* | 2.5% (0.3) | 5% (1.25) | 2.5%-5% (0.3-0.6) | 0 | 5%-10% (1.25-2.5) | 0 |
| Sweet Corn (D and S) | 0-10-20<br>3-9-18 | *1000 lb.* | 0-12-12<br>3-12-12 | *800 lb.* | 0-9-27<br>3-9-27 | *800 lb.* | 0-10-20<br>3-9-18 | *500 lb.* | 2.5% (0.3) | 2.5% (0.63) | 2.5% (0.3) | 0 | 10% (2.5) | 0 |
| Table beets, Swiss chard (R) | 0-9-27<br>3-9-27 | *1000 lb.* | 0-10-20<br>3-9-18 | *1000 lb.* | 0-9-27<br>3-9-27 | *1000 lb.* | 0-9-27<br>3-9-27 | *600 lb.* | 2.5% (0.3) | 2.5%-5% (0.63-1.25) | 2.5%-5% (0.3-0.6) | 0 | 5%-10% (1.25-2.5) | 500-1000 lb. |
| Tomatoes (D) | 0-10-20<br>3-9-18 | *1000 lb.* | 0-12-12<br>3-12-12 | *800 lb.* | 0-9-27<br>3-9-27 | *800 lb.* | 0-10-20<br>3-9-18 | *600 lb.* | 0 | 5% (1.25) | 0 | 0 | 5%-10% (1.25-2.5) | 0 |
| Alfalfa (D) | 0-9-27 | *600 lb.* | 0-10-20 | *500 lb.* | 0-9-27 | *600 lb.* | 0-9-27 | *300 lb.* | (0.3-0.6) | 5%-10% (1.25-2.5) | (0.6) | 5% | 5%-20% (1.25-2.5) | 0 |
| Corn (field) (S and D) | 0-9-27<br>3-9-27 | *600 lb.* | 0-10-20<br>3-9-18 | *600 lb.* | 0-9-27<br>3-9-27 | *600 lb.* | 0-9-27<br>3-9-27 | *300 lb.* | 0%-2.5% (0-0.3) | 0%-2.5% (0-0.63) | 2.5% (0.3) | 0 | 5%-20% (1.25-2.5) | 0 |
| Barley, Oats, Rye (D) | 0-10-20<br>3-9-18 | *500 lb.* | 0-12-12<br>3-12-12 | *400 lb.* | 0-9-27<br>3-9-27 | *400 lb.* | 0-9-27<br>3-9-18 | *250 lb.* | 0 | 5% (1.25) | 0 | 0 | 10%-20% (2.5-5.0) | 0 |
| Wheat (D) | 0-9-27 | *500 lb.* | 0-10-20 | *450 lb.* | 0-9-27 | *500 lb.* | 0-9-27 | *300 lb.* | 0 | 10%-20% (2.5-5.0) | 0 | 5%-10% (1.25-2.5) | 10%-20% (2.5-5.0) | 100-200 lb. |
| Sugar Beets, Mangels (D and R) | 0-9-27<br>3-9-27 | *700 lb.* | 0-10-20<br>3-9-18 | *700 lb.* | 0-9-27<br>3-9-27 | *700 lb.* | 0-9-27<br>3-9-27 | *400 lb.* | 2.5% (0.3) | 2.5%-5% (0.63-1.25) | 5% (0.6) | 0 | 5%-10% (1.25-2.5) | 500-1000 lb. |
| Permanent Pasture (Br) | 0-9-27 | *300 lb.* | 0-10-20 | *300 lb.* | 0-9-27 | *300 lb.* | *(none)* | | 0 | 5% (1.25) | 2.5%-5% (0.3-0.6) | 2.5% (0.63) | 10%-20% (2.5-5.0) | 0 |
| Brome grass and Ladino clover (D or Br) | 0-9-27 | *500 lb.* | 0-10-20 | *500 lb.* | 0-9-27 | *500 lb.* | 0-9-27 | *250 lb.* | 0 | 5% (1.25) | 0%-2.5% (0-0.3) | 2.5% (0.63) | 10%-20% (2.5-5) | 0 |
| Soybeans, Sweet Clover (D or Br) | 0-9-27 | *400 lb.* | 0-10-20 | *400 lb.* | 0-9-27 | *400 lb.* | 0-9-27 | *200 lb.* | 0 | 2.5-5% (0.63-1.25) | 0 | 0 | 10%-20% (2.5-5) | 0 |
| Sudan Grass, Millet (D) | 0-9-27 | *400 lb.* | 0-10-20 | *400 lb.* | 0-9-27 | *400 lb.* | 0-9-27 | *200 lb.* | 0 | 10% (2.5) | 0 | 5%-10% (12.5-2.5) | 10%-20% (2.5-5) | 0 |
| Reed Canary Grass (D or Br) | 3-9-18 | (not recommended for well-drained soils)<br>*500 lb.* | 3-12-12 | *400 lb.* | 3-9-27 | *400 lb.* | 3-9-18 | *200 lb.* | 0 | 5% (1.25) | 0 | 0 | 10%-20% (2.5-5) | 0 |
| Raspberries (S) | 0-9-27 | *800 lb.* | 0-10-20 | *700 lb.* | 0-9-27 | *800 lb.* | 0-9-27 | *500 lb.* | 0 | 2.5%-5% (0.63-1.25) | 0 | 0 | 10%-20% (2.5-5) | 0 |
| Strawberries (D or Br) | 0-12-12<br>3-12-12 | *500 lb.* | 0-20-10<br>3-18-9 | *300 lb.* | 0-10-20<br>3-9-18 | *300 lb.* | 0-12-12<br>3-12-12 | *200 lb.* | 0 | 5% (1.25) | 0 | 0 | 5%-10% (1.25-2.5) | 0 |

*Where two crops are produced on the same field in one growing season, the maximum fertilization for the year need not be more than the maximum recommended for the first crop *plus* two-thirds of the maximum recommended for the second crop. Where a crop requiring light fertilization (such as mint, soybeans, or head lettuce) follows one which received heavy fertilization (such as celery or onions) the preceding year, the rate of fertilization can be considerably reduced below that recommended.

†Sidedressings of nitrogen may be required during growth for broccoli, cabbage and cauliflower at the rate of 35 to 40 pounds per acre (approximately equivalent to 100 to 125 pounds of *ammonium nitrate*, or 170 to 200 pounds of *sulfate of ammonia*), and for celery at 50 to 75 pounds per acre. In exceptionally wet or cool periods, topdressings or sidedressings of nitrogen at 35 to 70 pounds per acre may be required for lettuce, mint, onions, radishes, spinach, table beets, Swiss chard, and corn. (See page 32.)

‡The percentage of minor elements which should be included in the fertilizer depends on three factors: (1) Past application of that minor element; (2) amount of fertilizer applied; and (3) the degree of acidity or alkalinity of the muck. Zinc sulfate or boron are not generally advisable in row fertilization. *Copper oxide* may be substituted for copper sulfate, using the same quantity of the element copper. Read the section on minor elements carefully (see pages 28-32).

§Where an 0-9-27 analysis is recommended for a "low-phosphoric acid, low potash" soil test, an 0-9-36 grade would be logical for soils having a "high phosphoric acid, low potash" test. Since such a grade is not on the recommended list, growers may use either the amount of 0-9-27 as suggested by the table, or a mixture of 0-9-27 and a straight potash. The total pounds of $K_2O$ (potassium oxide) applied per acre would remain the same.

¶A 2½-percent zinc sulfate is advisable for onions for the first 2 to 3 years after breaking, in the fertilizer mixture broadcast. The need is likely to be greater if the drainage is rather poor.

**If available, use fertilizer made from *potassium sulfate* for potatoes.

## *II. Recommendations for Muck Soils*

Muck soils—as distinguished from mineral soils in Michigan—include all soils very high in organic matter, even though they are somewhat peaty in nature. In the several county soil surveys, these organic soils are classified either as mucks or peats. CARLYLE, HOUGHTON, KERSTON, LUPTON and CARBONDALE mucks and RIFLE and GREENWOOD peats represent the more important types.

Within each of these types, the acidity or alkalinity varies considerably—except that Greenwood peat is always very acid. Greenwood peat must be limed for the production of all crops except blueberries. Even blueberries may derive benefit from limestone, if the soil pH is below 4.0.

In southern Michigan, probably 90 percent or more of the mucks are well supplied with lime; while in central and northern Michigan, this percentage probably will range from 75 to 90 percent. Muck soil ordinarily does not benefit from liming unless the soil pH is below 5.0. Application of lime on muck, when it is not needed, is likely to depress crop yields.

Sometimes the pH of the surface foot of soil is around 5.0, but the second foot of soil may have a pH around 4.0—in which case deep plowing to bring the very acid layer to the surface, then liming, is the answer. When muck soil requires lime, the magnesium content of the soil is generally fairly low, so the use of dolomitic limestone is advisable. The fact that part of a muck area requires lime is not proof that the whole area does. Occasionally one part may be too acid and another part too alkaline for optimum crop yields.

The amount of ground limestone required for muck soils with pH below 5.0 will depend on the pH, and the depth to which the extreme acidity extends. With the pH between 4.6 and 5.0, an application of 2 to 3 tons per acre of agricultural dolomitic limestone is likely to be needed for most crops; with a pH ranging from 4.3 to 4.5, from 3 to 5 tons of limestone; and with pH 3.8 to 4.2, from 7 to 10 tons. If the pH is higher in the second foot of soil, less limestone may be required, or if lower, more will be needed. With lower pH readings, more limestone is likely to be needed after a few years of farming. If a well-pulverized, high-test marl or other liming material is used, from 1½ to 2 cubic yards should be used for each ton of limestone recommended. Care should be taken to avoid excessive applications of marl.

## THE SOIL TEST

Since muck soils which are too alkaline and those which are too acid are unproductive for a large number of crops, it is evident that a soil-reaction test is very important. Most newly reclaimed mucks are low in available phosphorus and available potassium. After the muck has been farmed for several years, either phosphorus or potassium, or both, may be increased by repeated fertilization—thus, the tests may become considerably higher. At that time it becomes desirable to modify the fertilizer grade and the rate of fertilizer application.

Fertilizer recommendations for muck soils are based on the available soil tests, using Spurway active extracting agent (0.018 N. acetic acid). *In making up these recommendations it is considered that available phosphorus tests below 12 pounds per acre are "low"; those above 24, "high". Potassium tests are considered "low" when they are below 150 pounds per acre, and "high" when they are above 300 pounds per acre.*

Soils testing between 12 and 24 pounds of phosphorus, and 150 and 300 pounds of potassium are considered "medium" in fertility level. Fertilizer rates for medium-testing soils should be intermediate between rates recommended for high and low testing soils.

### Directions for Sampling Muck Soils

Since muck soils which have never been fertilized are almost always low in phosphorus and potassium, only the reaction test, made on the plowed layer and on the underlying soil at a depth of 18 to 24 inches, is necessary. After the muck has been well fertilized for two or three years, determinations of the available phosphorus and potassium—along with the pH—is advisable in a sample taken at a depth of 3 to 6 inches. Since the applied fertilizer remains largely in the plowed layer, only the pH test is necessary at the 18 to 24 inch depth. Rechecking of the soil tests every two to four years is advisable.

In securing samples for testing, care should be taken to avoid old burnouts, places where brush or refuse has been burned, old vegetable storage pits, trenches, tile lines, ditch banks, or any other place at which some disturbing factor may have affected the soil reaction. Composite samples made up of individual samples taken from areas where the soils are widely different are never advisable. Care should be taken that none of the surface layer falls into the lower sample.

Keep the samples separate and properly labeled. If part of the field has been burned at sometime—or if the muck or the native vegetation varies considerably in different parts of the field—more than one set of samples may be required.

Draw a map of the field and keep it for your own information. Locate the points of sampling on the map by number (1, 2, 3, etc.) and number the samples (1A *above*, 1B *below*, 2A, 2B, etc.) accordingly. Approximately half-pint samples should be sent in, in a moist condition, in clean cans or ice cream cartons. Avoid handling the soil with your hands.

Fill in complete information regarding the muck—as to depths, years under cultivation, drainage condition, fertilization, use of minor elements, yields and conditions of crops grown in the past years, and crops to be grown on each field next year. This should be sent in a letter attached to the package, addressed to the Soil Science Department, Michigan State College, or to one of the county soil testing laboratories.

A sample of the type of form used for muck soil samples is shown in the accompanying illustration (Fig. 1).

### Effect of Time of Sampling

In the case of newly reclaimed mucks, or mucks which have not been heavily fertilized, there is little variation in the soil test from one part of the year to another. With mucks that have been heavily fertilized, however, consideration should be given to the time of obtaining the samples. Considerable potassium may be leached out of the soil between early fall sampling and time for cropping in the spring if there is heavy rainfall in the interim. Thus a muck with a high potassium test in October may show a medium test around May 1 or a medium test may be reduced to a medium low. Determination of the muck's available nitrogen generally is not worth while except during the growing season. Even then the test should be made within a very few hours after sampling.

## EFFECTS OF DRAINAGE

In the table giving fertilizer recommendations for muck soil (Table 6, pp. 20-21), no recommendations are given for mucks which have poor drainage. With the exception of Reed canary grass, so great are the chances of the loss of a crop with poor drainage that the grower

## MUCK SOIL INFORMATION SHEET

(GROWER: Fill in complete information regarding muck samples)

Name.....

Address.....

.....

| Field number | Depth of muck (feet) | Drainage ("fair," "good," "too dry") | Number of years in crops | Manured last year (loads) | Results in cropping last year | |
|---|---|---|---|---|---|---|
| | | | | | Crop grown | Condition of the crop |
| 1. | | | | | | |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. | | | | | | |

| Field number | Sample number (A+B) | Crop to be grown | Treatment last year | | | | | Total applied in past years (pounds per acre) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Fertilizer | | Pounds per acre | | | | |
| | | | Analysis | Pounds per acre | Manganese sulfate | Borax | Salt | Copper | Zinc sulfate |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**Fig. 1. Type of information sheet used with muck samples taken for soil testing.**

is advised to improve his drainage system so that it will be fairly good, before he attempts fertilization and cropping.

Under wet conditions more phosphorus and manganese fertilizers are advisable. Excess moisture also retards decomposition of the muck, and delays formation of nitrates.

Control of the water level, so that drainage will not be excessive during dry periods will produce the highest yields with a given amount of fertilizer. It also aids in preventing loss of the topsoil and fertilizer by the wind, and in reducing loss of the fertilized crop by summer frosts.

## FERTILIZER GRADES

Table 6 (see pages 20-21) offers recommendations on fertilizer grades and rates of application, based on soil tests—together with the percentages of the minor element salts—for various crops on properly drained muck. Only one grade is presented in the table for each soil and crop condition. However, attention should be called to the fact that higher fertilizer grades having the same ratios as those recommended are equally satisfactory—when the rate of application is amended so that the same amounts of plant food elements are applied.

The depth of muck and the level of the water table determine nitrogen requirements. A comparatively high water level limits decomposition. It should be fertilized as recommended in Table 6, for soils fertilizer mixture. In the same way a shallow muck (less than 18 inches deep) or a very acid one (pH below 5.0) has a limited layer of decomposition. It should be fertilized as recommended in Table 6, for soils with "fair" drainage. A properly drained muck which is thoroughly decomposed as a result of many years of intensive farming likewise will respond to more nitrogen.

Most crops will produce greater yields with an increase in the percentage of potash in the fertilizer, up to a certain point. Beyond that point, additional amounts of potash will not appreciably change the yields.

Both mint and onions are likely to give the largest yields when the ratio of phosphate to potash is 1 to 1, in the case of new or rather poorly drained mucks; and a ratio of 1 to 2 for older, better drained mucks. Beyond that, an increase in potash is likely to result in decreased yields of marketable onions and of mint oil. Because of this effect of excess potash in delaying maturity—and thus decreasing yields of onions and of mint oil—it is highly advisable to build up the phosphate content of a new muck with a 1 to 1 phosphate-potash ratio, when the soil tests show low phosphorus, before switching to a 1 to 2 ratio for those two crops.

*TABLE 7—Notes regarding muck soil fertilization and cropping*

| CROP | Remarks |
|---|---|
| Broccoli<br>Cabbage<br>Cauliflower<br>Spinach<br>Swiss chard<br>Leaf lettuce | Apply fertilizer in 7″ drills 3″ deep before seeding or transplanting. For cabbage or cauliflower on muck well supplied with moisture, 400 to 500 lb. per acre can be applied in row 4″ deep before or at transplanting. Spinach responsive to row fertilization. All crops responsive to manure or to nitrogen sidedressing. |
| Head lettuce | Heavy fertilization increases tipburn. Use little fertilizer if well fertilized previous years. See Extension Bull. 403, "Muck Soil Management for Head Lettuce Production." |
| Celery<br>Radishes<br>Table beets | Nitrogen advisable in fertilizer mixture for early crops. Celery responsive to manure supplemented with 0-9-27 fertilizer. In absence of manure sidedress celery with nitrogen fertilizer. |
| Onions | Row application 600 to 800 lb. 2″ below seed advisable on moist muck, with 600 to 800 lb. per acre previously drilled over field if soil is low in fertility. Try 6-12-12 or 4-16-8 if crop has been slow in maturing. |
| Mint | Fertilizer needed to maintain stand, as well as to increase oil content. Try 0-12-12 on properly drained or 3-18-9 on poorly drained muck if mint is late in blossoming. Heavy fertilization and deeper plowing down of peppermint advisable where wilt is prevalent. |
| Potatoes | Fertilize in 7″ drills 4″ deep or, on moist muck put 800 lb. per acre beside row at planting. Plant close to avoid hollow heart and reduce frost injury, and fairly early for good yields. Plant 3-4″ deep and keep soil firm to reduce scab. |
| Carrots<br>Parsnips | Row application 2″ below seed, 600 to 800 lb. for carrots and parsnips. Sow parsnips early for good yields. |
| Field corn<br>Sweet corn | Not more than 300 pounds 3-9-18 in row. Include borax in broadcast fertilizer, drilled over field 4″ deep. |
| Grain<br>Soybeans | Apply fertilizer in 7″ drills 4″ deep. Grow adapted varieties as Mars barley, Rosen or Balboa rye, Yorkwin (Fall) or Henry (Spring) wheat, Flambeau soybeans. Seed grain around May 1 and soybeans around May 20 in vicinity of Michigan State College with weather favorable. |
| Meadows,<br>Permanent pasture | Seeding without nurse crop often advisable. Seeding around August 1 necessary on weedy fields. Fertilize broadcast before seeding and annually in spring. See Ext. Bull. 304, "Muck Soil Management for Hay and Pasture Production." |
| Reed canary | Adapted only for fair drained or wet soils. If drainage is poor, use 600 lb. per acre of 10-10-10 fertilizer. |
| Sugar beets | Apply around 200 lb. per acre fertilizer (without borax) in row, preferably 2″ below seed. Drill remainder and salt over field 4″ deep before planting. |
| Beans<br>Cucumbers<br>Squash<br>Tomatoes | These crops easily killed by frosts; therefore generally not safe on muck. Keep soil compact and well supplied with moisture to help prevent frost injury. Early tomato varieties preferable. |

## FERTILIZER PLACEMENT

The best methods of applying the fertilizer for optimum returns are indicated in Table 6 by the symbols accompanying the different crops. Several crops—notably onions, table beets, spinach, head lettuce, and parsnips—generally give higher yields with an under-the-row application. With application 2 inches below the seed, the amount of fertilizer to be applied in the row should not be more than one-half to three-fourths the amounts recommended in Table 6. Further, due to the earlier maturing effect of the row application on the onion crop, a higher potash mixture should be used for that crop. Thus the 3-12-12 would be substituted for the 3-18-9, and a 3-9-18 for the 3-12-12 mixture, when applied in the row instead of broadcast.

Sidedressing of widely spaced crops—such as cucumbers, pumpkins and squash, or transplanted tomatoes—generally can be done with a saving of one-third to one-half the amount of fertilizer which would be required if applied broadcast. The fertilizer should be applied in bands 3 to 4 inches to the side of the row, at seeding time or immediately after transplanting.

### Combining Grades in Partial Row Fertilization

Several crops may require a small amount of nitrogen for early growth on well-drained muck, but do not need nitrogen in the broadcast portion of the fertilizer. Thus sugar beets, table beets, potatoes, and corn are likely to respond to a 3-9-18 mixture (without borax) as a row application, and to a 0-9-27 (containing borax) drilled over the field at a depth of 3 to 4 inches, previous to planting.

## MINOR ELEMENTS IN MUCK SOILS

Crops growing on muck soils may benefit from any of six different elements other than the N-P-K (nitrogen, phosphorus, potassium) which are commonly used. These elements are copper, manganese, zinc, magnesium, boron, and sodium. The first four are generally applied in the form of sulfates; boron in the form of borax; and sodium in the form of ordinary salt. Recommended percentages of the salts of these elements which should be included in the fertilizer as an initial application, are given in Table 6 (see pages 20-21). The heavier the fertilizer application, the lower the percentage of the minor element salt which should be included in the fertilizer.

**Copper**

Application of copper results in a healthier, increased growth of most crops on muck with a pH of 6.5 or less. A few crops will show a benefit from copper even when the muck is alkaline. Following the initial application (Table 6), from ¼ to ½ as much copper sulfate should be included each year in the fertilizer—until a total of 100 to 150 pounds per acre has been applied for general crops, and 250 to 300 pounds for special crops such as onions, lettuce, spinach, and carrots.

When half of these amounts has been applied, copper sulfate can be left out of the mixture for a year or two, when convenient, without any appreciable decrease in yield of any crop. In case considerable copper in the form of dusts and sprays has been used on the muck in past years, that quantity should be taken into consideration in calculating the total amount applied. In some instances, the copper requirements of soils have been completely satisfied by repeated applications of copper dusts or sprays. Copper oxide may be used to replace copper sulfate so long as the same quantity of actual copper is applied.

**Manganese**

Manganese deficiency is likely to occur on alkaline and near-alkaline (6.6 or above) mucks. The deficiency may occur on soils of pH as low as 6.0, if the drainage conditions are not satisfactory. The deficiency can be corrected by the application of sulfur to acidify the muck and thus make the manganese available; or by the application of manganese salts—usually in the form of manganese sulfate. Onions, potatoes, beans, lettuce, wheat and spinach are among the most responsive crops. Although manganese sulfate is more effective and cheapest when immediate results are desired, sulfur is the more economical when the effects are considered over a period of years.

When the soil is decidedly alkaline (7.4 or above), it is advisable to apply some sulfur along with a light application (around 100 pounds per acre) of manganese sulfate. Unless sulfur is applied, the manganese requirement is likely to continue the same each year for a considerable period of years. If sulfur is used without manganese, the application required will range from 300 pounds to 1 ton per acre, the amount depending on several factors as listed below.

The amount of manganese sulfate which should be applied on a muck depends on (1) the crop being grown, (2) the degree of alka-

linity of the muck, (3) the depth to which the alkalinity extends, (4) the method of application of the manganese sulfate, and (5) whether sulfur is also being applied.

If manganese sulfate is applied broadcast, the rate should be from 100 pounds per acre when the pH is above 7.0, to around 300 pounds when the pH is around 8.0. If the alkalinity extends into the soil below the plowed layer, more manganese may be needed.

If the application can be made as a band in fertilizer—either below or beside the row—those amounts can be cut one-half. If part of the fertilizer is drilled over the field and part under or beside the row, it is desirable to omit the manganese from the broadcast portion and to increase the percentage in the row fertilizer.

It is also possible to include in the spray from 1 to 5 pounds of *water-soluble manganese sulfate,* per 100 gallons, for any crop which is to be sprayed. Best results appear to be obtained when it is added to a copper or carbamate spray. Where dust is used on a crop, it is possible to include a finely powdered manganese dust, which can be incorporated in the regular dust and is effective in correcting manganese deficiency. Generally it is advisable to use the manganese spray or dust along with the under-the-row or sidedressed application, if the soil is quite alkaline.

**Boron**

Boron is beneficial to a number of crops, not only on mucks which are alkaline or near alkaline, but sometimes also on strongly acid mucks. Application of a sufficient quantity of sulfur to alkaline muck will make the boron, as well the manganese, available to the crop—but of course it should not be used on the very acid soils. Celery, table and sugar beets, alfalfa, cauliflower, lettuce, turnips and spinach are among the most responsive crops.

Initial amounts of borax required for the responsive crops range from 10 to 25 pounds per acre on new acid muck, to 25 to 75 pounds on alkaline and near-alkaline mucks. The more alkaline the muck, the heavier the application should be. On the acid mucks, the boron deficiency may disappear permanently after 2 or 3 years of heavy fertilization. On the alkaline mucks in succeeding years, about half the initial application should be made whenever a boron responsive crop is grown. Boron can be applied as a spray. Apply only about ½ pound per acre as borax.

Recommendations for borax are given in Table 6 (see pages 20-21). In general, the use of borax in a sidedressed or under-the-row application should be avoided. Because of its great toxicity, it is far safer to increase the percentage in the broadcast portion of the fertilizer.

**Magnesium**

Although the magnesium content of very acid mucks can be increased by the application of dolomitic limestone, there are mucks which because of extremely heavy potash fertilization are low in available magnesium but do not require lime. It is believed that 100 to 300 pounds per acre of magnesium sulfate (epsom salt) will meet most plant requirements. Present research, however, has shown that some celery varieties (e.g. Utah 10-B) are not able to adequately feed on soil magnesium. For such varieties, a weekly application of from 5 to 10 pounds per acre of magnesium sulfate, as a spray or dust on the plant, is necessary to correct the deficiency.

**Zinc**

Zinc deficiency occurs on newly broken muck soil. It has been observed to affect only onions under Michigan conditions. Most of the zinc is in the sod, which ordinarily is turned down to a depth of 14 to 18 inches in the original breaking. The deficiency is likely to continue until the land is plowed again, unless zinc sulfate is used. Since new breaking is ordinarily not plowed again until three crops have been removed, an application of approximately 50 pounds per acre of zinc sulfate should be made annually for 2 or 3 years after the original breaking.

Zinc deficiency is likely to be more severe with poorer than with good drainage. It is much safer to include all the zinc sulfate in the broadcast portion of the fertilizer when a considerable portion of the fertilizer is applied in the row.

**Salt**

Sodium, applied in the form of ordinary salt, is beneficial on muck soil to a number of crops, including celery and the members of the beet family. It is beneficial only in the presence of potash fertilizer. Initial rate of application for the responsive crops varies from 100 to 200 pounds per acre for the less responsive crops, to as much as 1000 pounds for the most responsive crops, such as table beets and sugar beets. Where a crop such as celery is grown continuously, an initial

application of 500 pounds per acre should be followed by a 250 pound annual application. More can be used by a crop on a muck with fair drainage than on a well-drained muck. When desired, the broadcast salt can be mixed with the fertilizer.

## SUPPLEMENTAL FERTILIZATION

The need of supplemental fertilization on muck soil is generally the result of unfavorable climatic conditions, such as continued wet and cold conditions. Supplemental nitrogen, applied as a sidedressing, may also be needed on areas having a high water level, and with some crops even under normal drainage conditions. Thus a sidedressing of 30 to 60 pounds per acre of nitrogen (approximately equivalent to 100 to 200 pounds ammonium nitrate, or 150 to 300 pounds of ammonium sulfate) for spinach two to three weeks before harvest, and for cauliflower about the time when heads first start to form, is likely to produce considerable increase in yields.

A sidedressing of 25 to 35 pounds of nitrogen is recommended at the last cultivation of corn; at the state of heading of cabbage, and sometimes head lettuce; and as a sidedressing or topdressing on mint in late June, if the mint has a reddish cast or small leaves. Care must be exercised not to use too much nitrogen on head lettuce and celery—because of the danger of increasing tipburn of lettuce and black heart of celery in hot weather.

In continued wet weather, the above amounts should be increased 50 percent. They should be used also as a sidedressing on all leafy crops and onions, and sometimes on potatoes and other crops, if the leaves are rather yellow. If a soil test following rains causing continued leaching indicates low phosphorus and potassium in the soil, a 10-10-10 at around 300 to 500 pounds per acre may give better results as a sidedressing than straight nitrogen.

Celery requires heavier fertilization than does any other crop. On some mucks, best results are obtained with a single application of 3-9-18 or 0-9-27, supplemented with a sidedressing of 100 pounds per acre of nitrogen (approximately 225 to 450 pounds ammonium nitrate) divided into 2 or 3 installment applications. Sometimes the grower finds he obtains better yields when he applies a 3-12-12 at transplanting, and supplements it with nitrogen and potash as a sidedressing.

Thus an initial application of 1500 pounds per acre of 3-12-12, for celery—supplemented with a total sidedressed mixture of 225 pounds

ammonium nitrate, and 300 pounds of 60 percent muriate of potash—would be approximately equal to a 2000 pound application of 6-9-18. If the 60-percent potash, sidedressed application was increased to 720 pounds per acre, the total application would approximate 2000 pounds of 6-9-27.

## *III. Recommendations According to Soil Type*

Whenever the name of the Michigan soil type is known, or can be determined from a soil survey map or other sources, the proper recommendation table to follow can be checked by means of Table 8, on pages 34-39.

Some 326 different soil types are listed alphabetically in Table 8. Locate the soil-type name wanted, then refer to the particular fertilizer recommendation table indicated there for specific crop recommendations.

*TABLE 8—Fertilizer recommendation tables to use for Michigan soil types*

| SOIL TYPE | Fertilizer Table |
|---|---|
| Adolph loam | 2 |
| Adolph silt loam | 2 |
| Ahmeek loam | 1 |
| Ahmeek silt loam | 1 |
| Alcona silt loam | 3 |
| Alger loam | 3 |
| Allendale sandy loam | 3 |
| Allendale fine sandy loam | 3 |
| Allouez loamy sand | 4* |
| Allouez sandy loam | 4 |
| Allouez loam | 3 |
| Alpena loamy sand | 4 |
| Alpena sandy loam | 3 |
| Amasa fine sandy loam | 3 |
| Angelica loam | 2 |
| Angelica cobbly loam | 2 |
| Antrim loamy sand | 3 |
| Antrim sandy loam | 3 |
| Antrim sandy loam (mottled) | 3 |
| Arenac loamy sand | 3 |
| Arenac fine sandy loam | 3 |
| Au Train sand | 4* |
| Baraga loam | 1 |
| Baraga silt loam | 1 |
| Barker loam | 1 |
| Barker silt loam | 1 |
| Bark River fine sandy loam | 1 |
| Bellefontaine sandy loam | 3 |
| Bellefontaine loam | 1 |
| Bergland loam | 2 |
| Bergland silt loam | 2 |
| Bergland clay loam | 2 |
| Bergland silty clay loam | 2 |
| Berrien loamy sand | 3 |
| Berrien sandy loam | 3 |
| Berrien fine sandy loam | 3 |
| Blue Lake loamy sand | 4 |
| Blue Lake loam sand (maximal B) | 4 |
| Bohemian loamy fine sand | 4 |
| Bohemian fine sandy loam | 3 |
| Bohemian silt loam | 1 |
| Bono silty clay loam | 2 |
| Bono clay | 2 |
| Bowers sandy loam | 3 |
| Boyer loamy sand | 4 |
| Brady sandy loam | 3 |
| Brady loam | 3 |
| Brady silt loam | 1 |
| Brevort loam | 2 |
| Bridgman fine sand | 4* |
| Brimley loamy fine sand | 3 |
| Brimley fine sandy loam | 3 |
| Brimley silt loam | 1 |
| Bronson sandy loam | 3 |
| Bronson loam | 1 |
| Brookston loam | 2 |
| Brookston silt loam | 2 |
| Brookston clay loam | 2 |
| Brookston sandy clay loam | 2 |
| Bruce loamy fine sand | 3 |
| Bruce fine sandy loam | 3 |
| Bruce silt loam | 2 |
| Brule (*undifferentiated*) | 1 |
| Butternut loam | 2 |
| Burt loam | 2 |
| Cadmus sandy loam | 3 |

*Practicability of fertilization doubtful because of droughtiness of these soils.

*TABLE 8—Continued*

| SOIL TYPE | Fertilizer Table |
|---|---|
| Carbondale muck or peat | 6 |
| Carlisle muck | 6 |
| Colina loam | 1 |
| Champion loam | 3 |
| Champion silt loam | 3 |
| Channing fine sandy loam | 3 |
| Channing loam | 1 |
| Chatham loam | 1 |
| Cheneaux sandy loam | 3 |
| Coldwater loam | 1 |
| Coldwater silt loam | 1 |
| Coldwater silty clay loam | 2 |
| Coloma sand | 4* |
| Coloma loamy sand | 4 |
| Colwood loamy fine sand | 3 |
| Colwood fine sandy loam | 3 |
| Colwood silt loam | 2 |
| Conover loam | 1 |
| Conover silt loam | 1 |
| Coral fine sandy loam | 3 |
| Coventry loam | 3 |
| Coventry silt loam | 3 |
| Crosby loam | 1 |
| Crystal Falls complex | 1 |
| Dawson peat | 6 |
| Deer Park fine sand | 4* |
| Detour loam | 1 |
| Diana stony loam | 2 |
| Duel | 4 |
| East Lake loamy sand | 4 |
| East Lake sandy loam | 4 |
| Eastport sand | 4* |
| Echo (*undifferentiated*) | 4* |
| Edmore (*Granby*) sandy loam (*lenses*) | 3 |
| Edmore (*Granby*) fine sandy loam | 3 |
| Edwards muck | 6 |
| Eel (*undifferentiated*) | 3 |
| Emmert sandy loam | 3 |
| Emmet sandy loam | 3 |
| Emmet sandy loam (*high lime phase*) | 3 |
| Emmet sandy loam (*imperfectly drained*) | 3 |
| Emmet sandy loam (*poorly drained*) | 3 |
| Ensley loam | 2 |
| Epoufette loamy sand | 4 |
| Essexville loamy fine sand | 3 |
| Essexville loamy fine sand (*clay 20" to 40"*) | 3 |
| Ewen (*undifferentiated*) | 1 |
| Fox sandy loam | 3 |
| Fox sandy loam (*shallow water table*) | 3 |
| Fox loam | 1 |
| Fox cobbly loam | 1 |
| Fox silt loam | 1 |
| Freesoil sandy loam | 1 |
| Freesoil loam | 1 |
| Freer silt loam | 2 |
| Froberg loam | 1 |
| Froberg silt loam | 1 |

*Practicability of fertilization doubtful because of droughtiness of these soils.

*TABLE 8—Continued*

| SOIL TYPE | Fertilizer Table |
|---|---|
| Froberg clay loam | 1 |
| Fulton silt loam | 1 |
| Gaastra silt loam | 1 |
| Genesee coarse textured | 4 |
| Genesee medium textured | 3 |
| Genesee fine textured | 1 |
| Gilchrist loamy sand | 4 |
| Gilchrist sandy loam | 4 |
| Gilford sandy loam | 3 |
| Gilford loam | 2 |
| Gilford silt loam | 2 |
| Gogebic fine sandy loam | 3 |
| Granby loamy sand | 3 |
| Grayling sand | 4* |
| Greenwood peat | 6 |
| Griffin coarse-textured | 4 |
| Griffin medium textured | 3 |
| Griffin fine textured | 2 |
| Hartwick sand | 4* |
| Hessel loam | 2 |
| Hiawatha sand | 4* |
| Hiawatha loamy sand | 4 |
| Hibbing loam | 1 |
| Hibbing silt loam | 1 |
| Hillsdale sandy loam | 3 |
| Hillsdale fine sandy loam | 3 |
| Hillsdale loam | 1 |
| Houghton muck or peat | 6 |
| Ingalls loamy sand | 3 |
| Ingalls fine sandy loam | 3 |
| Iosco loamy sand | 3 |
| Iosco sandy loam | 3 |
| Iron River loam | 1 |
| Isabella loam | 1 |
| Jeddo silty clay loam | 2 |
| Johnswood loam | 1 |
| Kalkaska sand | 4* |
| Kalkaska loamy sand | 4* |
| Kalkaska sandy loam | 4 |
| Karlin loamy fine sand | 4 |
| Karlin fine sandy loam | 3 |
| Kawkawlin fine sandy loam | 1 |
| Kawkawlin loam | 1 |
| Kawkawlin silt loam | 1 |
| Kendalville sandy loam | 3 |
| Kennan silt loam | 1 |
| Kent silt loam | 1 |
| Kent imperfectly drained loam | 1 |
| Kent imperfectly drained silt loam | 1 |
| Kent imperfectly drained silty clay loam | 1 |
| Kerston muck | 6 |
| Kibbie loamy fine sand | 3 |
| Kibbie fine sandy loam | 3 |
| Kibbie silt loam | 1 |
| Kiva sandy loam | 3 |
| Kokomo loam | 2 |
| Kokomo clay loam | 2 |
| Lacota loam | 2 |
| Lacota silt loam | 2 |
| Lake Linden silt loam | 1 |
| Locke sandy loam | 3 |
| Longrie series | 3 |

*Practicability of fertilization doubtful because of droughtiness of these soils.

*TABLE 8—Continued*

| SOIL TYPE | Fertilizer Table |
|---|---|
| Macomb fine sandy loam | 1 |
| Macomb loam | 1 |
| Macomb stony loam | 1 |
| Mackinac loam | 1 |
| Mancelona loamy sand | 4 |
| Mancelona sandy loam | 4 |
| Mancelona loam | 3 |
| Mancelona sandy loam (*poorly drained*) | 3 |
| Manistee loamy sand | 4 |
| Manistee sandy loam | 3 |
| Maumee sandy loam | 3 |
| Maumee loam | 2 |
| McBride sandy loam | 3 |
| Menominee loamy sand | 4 |
| Menominee sandy loam | 3 |
| Meta sandy loam | 3 |
| Miami loam | 1 |
| Miami silt loam | 1 |
| Montcalm loamy sand | 4 |
| Montcalm sandy loam | 4 |
| Montcalm sandy loam (*imperfectly drained*) | 3 |
| Moran silt loam | 1 |
| Moye fine sandy loam | 3 |
| Munising sandy loam | 3 |
| Munising fine sandy loam | 3 |
| Munising loam | 1 |
| Munuscong loamy fine sand | 3 |
| Munuscong fine sandy loam | 3 |
| Nappanee (*shallow sand-silty clay cover*) | 1 |
| Nappanee loam | 1 |
| Nappanee silt loam | 1 |
| Nappanee silty clay loam | 1 |
| Negaunee loam | 1 |
| Negaunee silt loam | 1 |
| Nester loam | 1 |
| Nester silt loam | 1 |
| Newton loamy sand | 3 |
| Nunica silt loam | 1 |
| Ogemaw loamy sand | 3 |
| Ogemaw fine sandy loam | 3 |
| Omega sand | 4* |
| Onamia loamy fine sand | 4 |
| Onamia fine sandy loam | 4 |
| Onaway fine sandy loam | 1 |
| Onaway loam | 1 |
| Onota series | 3 |
| Ontonagon loam | 1 |
| Ontonagon silt loam | 1 |
| Ontonagon silty clay loam | 1 |
| Ontonagon clay | 1 |
| Oscoda loamy sand | 4* |
| Oshtemo loamy sand | 4 |
| Oshtemo sandy loam | 4 |
| Ottawa loamy sand | 4 |
| Ottawa loamy fine sand | 4 |
| Ottawa sandy loam | 4 |
| Parma series | 3 |
| Pelkie (*undifferentiated*) | 2 |
| Peshekee complex | 1 |
| Pickford loam | 2 |
| Pickford silt loam | 2 |
| Pickford silty clay loam | 2 |
| Pickford clay | 2 |
| Plainfield sand | 4* |

*Practicability of fertilization doubtful because of droughtiness of these soils.

*TABLE 8—Continued*

| SOIL TYPE | Fertilizer Table |
|---|---|
| Plainfield loamy sand | 4* |
| Plainfield loamy fine sand | 4 |
| Posen stony sandy loam | 3 |
| Poygan silty clay loam | 2 |
| Randville loamy fine sand | 4 |
| Randville fine sandy loam | 4 |
| Rifle peat | 6 |
| Rimer sandy loam | 3 |
| Rodman gravelly loamy sand | 4 |
| Rodman gravelly sandy loam | 3 |
| Roscommon sand | 4 |
| Roselawn sand | 4* |
| Rubicon sand | 4* |
| Ruse series | 2 |
| St. Clair silt loam | 1 |
| St. Ignace stony silt loam | 1 |
| Satago silt loam | 2 |
| Sauble fine sand | 4* |
| Saugatuck sand | 3 |
| Saugatuck loamy sand | 3 |
| Selkirk loam | 1 |
| Selkirk silt loam | 1 |
| Selkirk silty clay loam | 1 |
| Selkirk silt loam (*imperfectly drained*) | 1 |
| Shelldrake sand | 4* |
| Shoals (*undifferentiated*) | 3 |
| Skanee fine sandy loam | 3 |
| Skanee loam | 3 |
| Skanee silt loam | 1 |
| Spalding peat | 6 |
| Sparta loamy sand | 4* |
| Spinks (*Metea*) loamy sand | 4 |
| Spinks (*Metea*) loamy fine sand | 4 |
| Stambaugh very fine sandy loam | 3 |
| Stambaugh silt loam | 3 |
| Strongs sand | 4* |
| Strongs sandy loam | 4 |
| Summerville series | 1 |
| Tahquamenon peat | 6 |
| Thomas loam (*mucky phase*) | 2 |
| Thomas loam | 2 |
| Thomas clay loam | 2 |
| Thomastown loamy fine sand | 4 |
| Toledo silty clay loam | 2 |
| Toledo silty clay | 2 |
| Traunik loamy fine sand | 3 |
| Traverse sandy loam | 3 |
| Traverse loam | 1 |
| Trenary fine sandy loam | 3 |
| Trenary loam | 1 |
| Trout Lake loamy fine sand | 3 |
| Trout Lake fine sandy loam | 3 |
| Tuscola loamy fine sand | 4 |
| Tuscola fine sandy loam | 3 |
| Tuscola silt loam | 1 |
| Vilas sand | 4* |
| Vilas loamy sand | 4* |
| Waiska loamy sand | 4* |
| Waiska sandy loam | 4 |
| Wallace sand | 4* |

*Practicability of fertilization doubtful because of droughtiness of these soils.

*TABLE 8—Concluded*

| SOIL TYPE | Fertilizer Table | SOIL TYPE | Fertilizer Table |
|---|---|---|---|
| Wallkill (*undifferentiated*) | 2 | Watton silt loam | 1 |
| | | Watton clay loam | 1 |
| Warners | 2 | | |
| | | Wauseon loamy fine sand | 3 |
| Warsaw sandy loam | 3 | Wauseon fine sandy loam | 3 |
| Warsaw cobbly sandy loam | 3 | | |
| Warsaw loam | 1 | Weare sand | 4* |
| Warsaw silt loam | 1 | | |
| | | Wexford sand | 4* |
| Washtenaw loamy sands-sandy loams | 3 | Wisner loam | 2 |
| Washtenaw loams-silt loams | 2 | | |
| | | Wisner clay loam | 2 |
| Watton loam | 1 | | |

*Praticability of fertilization doubtful because of droughtiness of these soils.

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