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Fertilizer Recommendations for Michigan Crops
Michigan State University Extension Service
Soil Science and Horticulture
Revised April 1963
52 pages

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EXTENSION BULLETIN E-159
12th Revision—April 1963

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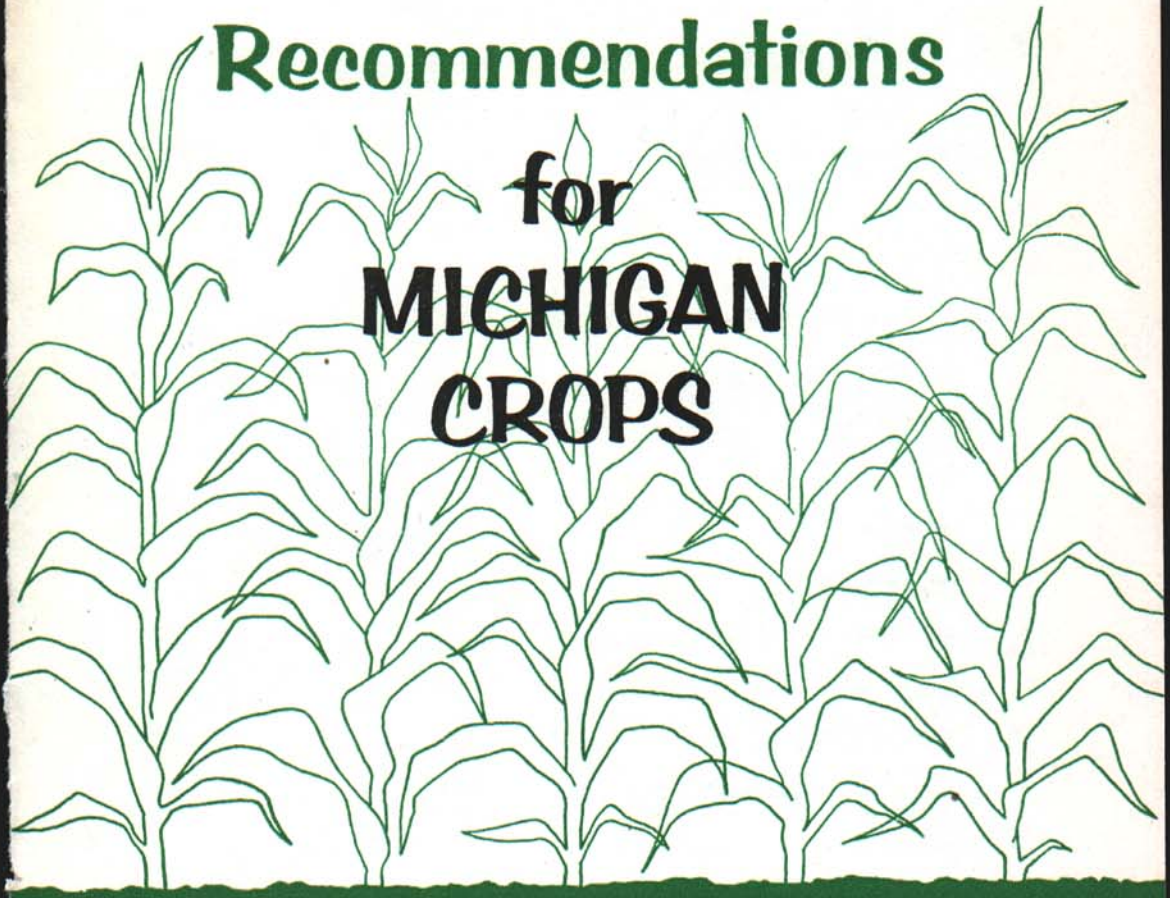
FERTILIZER Recommendations for MICHIGAN CROPS



Prepared by Departments of Soil Science and Horticulture
MICHIGAN STATE UNIVERSITY
Cooperative Extension Service ◆ East Lansing

CONTENTS

HOW TO USE THIS BULLETIN

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

1. For tree fruits, grapes, brambles, strawberries, bush fruits and blueberries—turn to page 33 to 37.

2. For vegetables:

   A. If the soil is a loam, silt loam, or clay loam (Soil management groups 1 and 2), refer to Table 14, page 29. See items 5 and 6 (page 4).
   B. If the soil is a sandy loam or loamy sand (Soil management groups 3, 4, and 5), refer to Table 15, page 30. See items 5 and 6 (page 4).
   C. If the soil is organic (muck or peat), refer to Tables 17 and 18, pages 39, 40. See items 5 and 6 (page 4).

3. For field crops growing on mineral soil:

   A. Where soil tests are available—

   (1) If the soil series is known, turn to the alphabetical list of series in the back of the bulletin. It will show the table listing fertilizer recommendations for field crops. You can get soil series information from published county soil survey reports or maps prepared for individual farms by the Soil Conservation Service. Your county agricultural agent will have a copy of a soil survey map if one is available in your area. On the basis of the soil test, select the column in the fertilizer recommendations table that applies to your field; follow the suggestions in that column for crops you wish to grow.

   (2) If the soil series is not known, select the block in Table 2 that best describes the upper 3 feet of your soil profile. Turn to the fertilizer recommendation table indicated there.

   (3) *If the soil has been tested but neither the soil series nor the soil profile characteristics are known, use the block in Table 2 that best describes the texture and color of the soil sample.*

   (4) If only the soil test results are available, then follow the fertilizer recommendation shown in Table 9, page 19.

   B. Where soil tests are not available—

   (1) If the soil in a field to be fertilized has not been tested but you know the name of the soil series, turn to the alphabetical list of soil series in the Appendix. It will direct you to the proper fertilizer recommendation table. Use column 1 of the recommendation table

if your soil is low or medium in productivity; use column 4 if the soil is in a high state of productivity.

(2) If you do not know the soil series, determine the soil group by the texture and color characteristics—Table 2. It will direct you to the proper fertilizer recommendation table.

(3) It is not advisable to make fertilizer recommendations if the soil group is not known and the soil has not been tested.

4. For crops growing on organic soils:

   Fertilizer recommendations for organic soils depend on actual soil tests. Find the column listing the crop in Tables 17 and 18, then find the position of the approximate soil test in the same column above the crop listing. Follow dotted line to right from the soil test, and read figures in the far right column for the amount of P_2O_5 or K_2O required.

5. Turn to page 15 for the way to apply fertilizer on field crops. Turn to page 24 for vegetable crops growing on mineral soils and page 45 for vegetable crops growing on organic soils.

6. Micronutrients are often needed. If the pH is above 6.5 on mineral soils, read section on page 31. Recommendations for organic soils are reported on pages 41 to 44.

7. Nitrogen recommendations on mineral soils depend upon soil management practices in use. Turn to pages 12 and 13 and Table 6 for instructions.

Fertilizer Recommendations for Michigan

Prepared by staff members of the
Departments of Soil Science and Horticulture

RATIOS AND MINIMUM FERTILIZER GRADES RECOMMENDED

Table 1 shows the ratios and grades of most of the fertilizer materials offered for sale in Michigan. The first figure in the grade is the percentage of *total* nitrogen (N). The second figure is the percentage of phosphate (P_2O_5). The third is the percentage of water soluble potash (K_2O). For example, "0-20-20" fertilizer has a "no nitrogen" guarantee and at least 20 percent phosphate and 20 percent potash. Ratio simply refers to the proportion of nitrogen, phosphate and potash in the fertilizer mixture.

It is impossible to place these three plant nutrients together exactly as they are expressed in the grade percentage figures. For instance, nitrogen in the pure state is a gas. It must be placed in the fertilizer as a salt containing perhaps only 20 percent nitrogen, or as ammonia containing 82 percent nitrogen. Phosphate is usually supplied as superphosphate (monocalcium phosphate) or ammonium phosphate, while potash may be supplied as a salt, such as potassium chloride or potassium sulfate.

Whenever possible, consider using higher grades of the recommended ratios. It may save money and labor. In addition to the recommended grades there are acceptable fertilizer materials that do not show numerical ratios. Examples of such materials are ammonium phosphate (11-48-0), diammonium phosphate (21-53-0) and potassium nitrate (13-0-44). Many others are on the market and are acceptable when used properly.

TABLE 1—Amount of fertilizer required to obtain the same amounts of N, P_2O_5 and K_2O for a particular ratio

Ratio	Grade	Pounds necessary for equal amounts of N, P_2O_5 and K_2O
0:1:1	0-20-20*	100
	0-25-25	80
0:1:2	0-10-20	150
	0-15-30*	100
	0-20-40	75
0:1:3	0-10-30*	100
	0-12-36	83
	0-13-39	77
0:2:1	0-20-10*	100
	0-30-15	67
1:1:1	10-10-10	120
	12-12-12*	100
	15-15-15	50
1:2:1	6-12-6	167
	10-20-10*	100
1:2:2	6-12-12	133
	8-16-16*	100
	10-20-20	80
1:4:1	5-20-5	120
	6-24-6*	100
1:4:2	5-20-10*	100
	6-24-12	83
	8-32-16	63
1:4:4	3-12-12	133
	4-16-16*	100
	5-20-20	80
	6-24-24	67
2:1:1	12-6-6*	100
	14-7-7	86
	16-8-8	75

*Indicates minimum recommended grade.

I. SOIL MANAGEMENT GROUPS

Soil management groups have been worked out cooperatively by the Soil Conservation Service of the United States Department of Agriculture, with the Cooperative Extension Service and the Agricultural Experiment Station, Michigan State University, East Lansing, Michigan. These are basic interpretive soil groupings. They are based on properties of the soil profile to a depth of 3 to 5.5 feet. The soil management groups can be subdivided on the basis of surface texture, slope, degree of erosion, or stoniness, into management units. These units can be regrouped into Land Capability Classes, Subclasses or Units.

The soil management groupings and management units are useful for such specific purposes as recommendations of fertilizer and lime applications, forestry plantings, irrigation or drainage system design, and cropping or conservation practices. The numbers and capital letters assigned to each group indicate the major properties and the inter-relationships of these soil management groups. See Table 2 and the appendix.

The numbers indicate the relative coarseness of the mineral materials in the upper three feet of the soil profile: from 0, the finest textured clays, to 5, the coarsest textured sands. The small letter immediately following the numbers or capital letters indicates the natural drainage under which the soil developed: "a" for well-drained, "b" for imperfectly drained, and "c" for the most poorly drained conditions.

Where capital letters are the first part of the symbol they represent important soil characteristics as follows: G for gravelly or stony soils; M for mucks and peats; and R for rocky soils where the bedrock is close to the surface.

Soil management group designations reported in the appendix may differ from those in Table 2. Those are soils where the upper layer differs from the lower layer. For example, 4/1 is for loamy sand 18 to 42 inches thick over clay; 5/2 is for sand 42 to 66 inches thick over loams and clays; and M/m is for muck 12 to 42 inches thick over marl. Where a letter follows the small letter which indicates the natural drainage and is separated from it by a dash, it indicates other characteristics of the soils important to their use. For example, a small "a" after a dash represents very acid soils; and "h" indicates subsoils which are hardened and cemented.

The L-4a soil management group reported in the appendix includes naturally well-drained soils of loamy sand to sand textures throughout the profile, that were formed on lowlands subject to seasonal overflow. The 3a-a soil management group includes upland mineral soils from sandy

TABLE 2—Soil Management Group identification chart for mineral soils. The fertilizer recommendation table is given for each soil management group.

Texture of the upper 3 feet of the soil profile	Natural drainage and surface color		
	Well-drained light-colored a	Imperfectly drained moderately dark-colored b	Poorly drained dark-colored c
0 Clays (over 55%)			0c* Table 8
1 Clays and silty clays	1a* Table 8	1b* Table 8	1c* Table 8
2 Clay loams or loams	2a* Table 9	2b* Table 9	2c* Table 10
3 Sandy loams	3a* Table 11	3b* Table 11	3c* Table 11
4 Loamy sands or sands with some finer-textured layers	4a* Table 12	4b* Table 12	4c* Table 12
5 Sands	5a* Table 13	5b* Table 13	5c* Table 13
G Gravelly or stony	Ga* Table 12	Gc* Table 12	Gc* Table 12
R Rocky	Ra* Table 11	Rc* Table 11	Rc* Table 11

*Soil management group designations.

loam materials developed under well-drained conditions which are naturally very strongly acid throughout the profile. The M/1c soil management group includes shallow organic soils (mucks and peats) with silty clay or clay 12 to 42 inches below the surface and naturally very poorly drained. The Mc soil management group includes deep organic soils which are naturally very poorly drained.

II. RECOMMENDATIONS FOR MINERAL SOILS

Fertilizers are most effective on well-drained soils with a favorable structure which promotes deep rooting. Too much tillage can injure plant roots or destroy structure and reduce fertilizer efficiency.

The terms "texture" and "structure" are often confused when referring to soil. Texture is the coarseness or fineness of the soil, that is, the percentage in the soil of sand, silt, and clay. Structure is the way these sizes of particles hang together as natural soil aggregates.

Another term sometimes not understood is "pH." This is used to indicate whether the soil is acid (sour) or alkaline (sweet). A soil having a pH of 7.0 is neutral—neither acid nor alkaline. A soil having a pH of 6.0 is mildly acid; pH 5.0 is strongly acid, and so on. On the other hand, pH 8.0 is mildly alkaline. Most well-drained Michigan soils, in their natural state, have a pH lower than 7.0.

Plant nutrients, particularly phosphorus, are most available in soils of pH 6.5 or 7.0. For general field crops, acid soils (indicated by a pH of 6.5 or below) should be limed. However, where the pH is 6.3 to 6.5, increasing the availability of phosphorus may not be sufficient reason for liming if satisfactory yields of alfalfa are being obtained. Avoid raising the pH above 7.0. For vegetables on sandy soils, lime to between pH 6.0 and 6.5.

In general the amount of lime needed to neutralize the acidity of a soil is dependent on the pH and texture of the plow layer. The tons of agricultural lime needed at a given pH for soils of different textures are shown in Table 3. The texture of the plow layer may vary considerably from the overall texture of the soil profile on which the soil management groups are based. For such soils select the desired textural designation.

The lime requirements of samples of acid soils submitted to the state laboratory are determined by measuring the total soluble and exchangeable hydrogen and aluminum. This method is more precise than estimates made from soil pH measurements since it measures total acidity rather than the active acidity of the soil.

Further information on liming is discussed in Extension Folder F-279.

High productivity is linked with a high organic matter level. Fertilizers are not a substitute for organic matter; but, under favorable management, they can help you increase organic matter levels in the soil. Animal manures and crop residues are valuable sources of organic matter. Plan rotations to provide for soil organic matter maintenance.

TABLE 3—Tons of limestone estimated to raise the pH of a six-inch plow layer of different soils to pH 6.5.

Texture of plow layer		pH Range			
		4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4
		Tons of lime recommended*			
Clay and silty clay	1	6	5	4	2½
Clay loams on loams	2	5	4	3	2
Sandy loams	3	4	3	2½	1½**
Loamy sands	4	3	2½	2	1**
Sands	5	2½	2	1½**	½**

*Lime recommendations based on a liming material having 40 to 59 percent passing through a 100-mesh sieve and having a neutralization value of 90 percent.

**It is preferable to recommend 2 tons per acre so as to obtain uniform application.

FARM MANURES

Manures are valuable primarily because of their fertilizer content. They also tend to improve the moisture-holding ability of light soils and improve the structure of heavier soils.

A ton of manure contains about 10 pounds of nitrogen, 5 pounds of phosphate, and 8 pounds of potash. Of this amount, during the first year about 40 percent of the nitrogen, 50 percent of the phosphate, and 100 percent of the potash is available. Thus, for a 10-ton per acre application of manure, figure 40 pounds of nitrogen, 25 pounds of phosphate, and 80 pounds of potash as fertilizer. Crops vary in the utilization of the nutrients from manure as shown in Table 6. Additional information of the value of different manures can be obtained from Circular Bulletin 231, Michigan State University.

BASIS FOR RECOMMENDATION

Fertilizer recommendations are based on many field experiments. However, to find the right amount for any crop, you must consider the crop yield desired and the rate which will result in the best profit per acre for the money spent. The fertilizer needs of a 20-ton sugar beet crop are greater than those of a 15-ton crop. The amount needed for a 120-bushel per acre corn crop is more than double the fertilizer required for a 60-bushel crop. The recommendations in this bulletin are aimed at reasonable yields

when soils are under good management. Good judgment, however, must be followed when using the recommendations as different areas of Michigan vary considerably in length of the growing season and summer temperatures.

Each farm operator should test different fertilizer practices by varying rates, grades, carriers, and placement. After several years of testing he can then better determine his fertilizer requirements.

Soils are classified into series according to their color, texture, organic matter content, structure, thickness, chemical composition and natural drainage. Chemical and physical properties influence crop production goals and fertilizer response. Water-holding capacity is an important consideration, because lack of water often limits crop production. If you irrigate, increase fertilizer rates to reach higher production goals.

If you know the names of the different soil series on your farm, you can locate the proper fertilizer recommendation table to follow from the appendix in which nearly 300 different series are listed alphabetically. Locate the soil series name, then refer to the particular fertilizer recommendation table indicated for specific crops.

SOIL TESTS NOW A VALUABLE AID

Soil tests from samples representative of a field will help tell how much fertilizer to apply so that fertilizer will be eliminated as a risk in the production of the crop. However, plant nutrients are only one of the several factors that determine the crop yields.

Only soil tests obtained by the Bray P_1 (adsorbed) method should be used to select phosphate recommendations in this bulletin. (In this method, the extracting reagent is 0.025 *N* hydrochloric acid and 0.03 *N* ammonium fluoride.)

Crops are classified into two groups depending on response to phosphorus and crop value. This division is shown in Table 4. All soils that test below the high level shown in Table 4 are designated as "low" when using Tables 8 to 15.

The standards reported in Table 5 are ratings used for potassium when soils are extracted with 0.13 *N* hydrochloric acid or with 1.0 *N* ammonium acetate. The hydrochloric acid method is often used in country laboratories. The ammonium acetate method which extracts slightly more potassium is used by the state laboratory.

In general the recommended rates of fertilizer for mineral soils that test "high" are one-half the rates recommended for soils that test "low" or

"medium." Fertilizer rates should be increased for soils that test "very low." You do not need potash fertilizers for soils that test "very high" in potassium except possibly for potatoes and tomatoes.

If the soil has *not* been tested, use column 1 of the appropriate table if the soil is in a low state of fertility judging from yields, and column 4 if the fertility is high.

Your county agricultural agent can give you information on how to collect soil samples and where they can be tested. Information in Extension Folder F-278 also gives instructions on collecting soil samples.

TABLE 4—Soil test standards for phosphorus when determined by the Bray P_1 method.

Fertility Level	Phosphorus test — lbs. per acre	
	Field crops	Sugar beets Vegetable crops Potatoes
Very low	0-9	0-19
Low	10-19	20-39
Medium	20-35	40-69
High	35+	70+

TABLE 5—Soil test standards for potassium when determined by the hydrochloric acid or the neutral ammonium acetate method.

Fertility Level	Field and Vegetable Crops Available Potassium — lbs. per acre.	
	0.13 N HCl method	1.0 N ammonium acetate method
Very low	0-49	0-59
Low	50-99	60-119
Medium	100-149	120-179
High	150-275	180-300
Very High	275+	300+

Nitrogen

The immediate nitrogen needs of a crop growing on a mineral soil depend more on the system of management than on the soil type or test at the time of planting. Bacteria in alfalfa and clover root nodules take nitrogen from the air to build their own bodies. The plant is able to use the nitrogen released in the soil by the bacteria. Because of this "nitrogen fixation" by the legume bacteria, these crops do not usually need nitrogen fertilizer.

Animal manures are relatively high in available nitrogen, unless the product is unusually high in straw or other highly carbonaceous bedding, such as shavings or sawdust. In most cases, however, a small quantity of nitrogen at planting time is desirable, even if animal manure is used.

Table 6 gives estimates for the total nitrogen fertilizer required for corn and other crops. If the season is cool and wet and/or the field is poorly drained, it is usually necessary to apply larger quantities of nitrogen than indicated.

*TABLE 6—Guide for estimating the total pounds of nitrogen (N) fertilizer per acre needed by field crops as affected by previous management. Include in the total the nitrogen applied at planting time**

Plow down or topdress treatment	Corn Plants per acre expected yield			Sugar beets	Small grain	Late potatoes	Beans Soybeans
	10,000 60 bu.	14,000 80 bu.	18,000 100 bu.	18 tons		300 cwt.	25 bu.
Legumes and 8 tons of manure per acre	5	5	10	10	10	25	10
Legumes—no manure	10	10	40	20	10	55	10
8 tons of manure per acre	25	50	80	60	30	95	20
No legumes—no manure	55	80	110	90	50	125	40

*Add 20% nitrogen to recommendations if soils are very low in organic matter. Subtract 20% if soils are high in organic matter (dark-colored).

Most calculations assume 70 pounds of nitrogen from a good legume sod and 4 pounds for each ton of manure. To determine fertilizer requirements, subtract these additions from the "no legume-no manure" crop requirements. E.g., if 100-bushel corn is desired on legume sod, use 40 pounds of nitrogen (110—70=40).

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 State Special Bulletin 353, which also describes the methods used in making tests for nitrate in the growing plant.

Deficiencies may be spotted sooner with chemical tests than by observing deficiency symptoms. After growth has started in the spring, a nitrate test will tell whether or not it will pay to topdress wheat. The same is true of oats after 6 inches of growth. Test corn, sugar beets, tomatoes, and potatoes just before each cultivation. Apply nitrogen fertilizer as soon as you notice a deficiency.

Supplemental nitrogen applications probably will not be profitable where other nutrients are lacking. Test soil for phosphorus and potassium if you have not applied adequate fertilizers at planting.

A number of nitrogen materials are offered for sale. Usually the materials are equally effective and should be purchased on a basis of cost per pound of actual nitrogen, convenience of application, and supply. Under special conditions, nitrate fertilizers are preferred especially for plants growing in cold soils or on recently fumigated land.

Time of nitrogen application is important for sandy soils (management groups 3, 4 and 5) especially if they are irrigated. For these sandy soils, delay application until the time the crop has its greatest nitrogen needs. Time of application of nitrogen on fine textured soils (management groups 1 and 2) may be either late fall, spring, or early summer. Do not apply nitrogen on the surface in the fall or winter for spring sown crops on land that is subject to water runoff.

One of the best times to apply nitrogen for summer crops is at time of plowing. This places the nitrogen down in moist soil and saves another trip over the field after plowing which can cause soil compaction. Extra sidedressing of nitrogen may be needed if a heavy crop population has been started or if the season is unusually cool or wet.

METHODS OF APPLYING FERTILIZER

Many methods of applying fertilizer have been tested at the Michigan Agricultural Experiment Station. New materials and a changing net return from the use of fertilizers modify recommendations. Some farmers using large amounts of fertilizer have turned to bulk spreading. This method of application offsets some of the increased costs in bags and processing.

If several fertilizer materials are mixed, they may "set" if not used within a few hours. Caution—bulk mixed fertilizers applied by centrifugal type application can easily segregate into the separate carriers if there is a difference in density and particle size.

Good crops have been observed where most of the nitrogen and potash has been plowed down or drilled in. If this program is followed, use high phosphate grades in bands near the seed. Suitable materials are 8-24-8, 8-32-0 or ammonium phosphate.

Ammonium phosphate is a product obtained when phosphoric acid is treated with ammonia. It consists chiefly of monoammonium phosphate (11-48-0) or diammonium phosphate (21-52-0). Ammonium phosphates are high in total plant-nutrients. They have a salt index four times greater than ordinary superphosphate. You need to use them with care if placed near seed.

Fertilizers applied in liquid forms are gaining popularity. When applied correctly, they are as effective as solid dry fertilizers. Recommended placement of liquid fertilizer is the same as for solid fertilizers. The main advantage of liquid fertilizer is in labor saving. There are no heavy bags to handle, for the liquid is usually pumped from source to applicator. Liquid fertilizers, however, require specialized equipment. Transportation costs per unit of plant-nutrient may be high if the liquid is hauled great distances.

Because of excessive high costs certain liquid fertilizers are advisable only for starter solutions and for small seed beds. A gallon of liquid fertilizer weighs about 10 pounds. **For this reason it requires about 10 gallons of liquid fertilizer to equal the value of 100 pounds of solid fertilizer of the same grade.** Some liquid fertilizers are used for foliar (leaf) sprays. In spite of an increased efficiency in plant absorption over soil application, foliar sprays of the major plant-nutrients are seldom practical because of (a) excessive costs, (b) inability to supply sufficient nutrients (c) possibility of crop injury.

FIELD CROPS

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. To seed bromegrass, either mix the seed with oats (if oats are used as a nurse crop) or with the fertilizer.

Small grains.—The proper place to apply fertilizer for small grains is 1 inch to the side and 1 inch below the seed. Most grain drills apply the

fertilizer directly in contact with the seed. This placement can cause injury when large amounts are applied or when the soil is dry. In general, do not drill in direct contact with the seed more than a total of 100 pounds of plant nutrients ($N+P_2O_5+K_2O$) for sandy soils and 140 pounds per acre for fine-textured soils. If additional amounts are needed, apply in a separate operation.

Small grains growing on certain soils are likely to lodge. On these areas use little or no nitrogen. Barley is especially apt to lodge when excessive nitrogen is applied.

Field beans, soybeans.—Apply 1 inch to the side and 2 inches below the seed. Do not apply directly in contact with the seed. These crops often need manganese fertilizer. Field beans may need zinc. See recommendations on page 31.

Sugar beets.—Apply 3 inches below the seed or 1 inch to the side and 2 inches below the seed. Apply nitrogen early if it appears necessary.

An alternate fertilizer program for sugar beets is to plow down most of the fertilizer. However, use in bands 3 inches below the seed 150 to 200 pounds per acre of a starter fertilizer high in phosphorus.

Corn.—Apply in a single band 2 inches to the side and 2 inches below the seed level. The split-boot applicator found on many corn planters is often not satisfactory for rates above 150 pounds per acre. Plow down or sidedress nitrogen fertilizer as indicated in Table 6.

Potatoes.—Apply up to 800 pounds per acre in bands 2 inches to the side and on the level or slightly below the seed piece. Plow down additional amounts if needed. Many growers find it profitable to sidedress with 50 pounds of nitrogen per acre during the growing season. Irrigated potatoes usually need 50 percent more fertilizer because of higher expected yields.

Fertilizer rates for high yields

The expected crop yields reported in Tables 8 to 13 are based upon averages for good soil management. Where yield goals are higher, additional fertilizer is required. The rates reported in Table 7 are suggested guides to follow. An example on how to use the Table is as follows:

Situation—The yield goal for corn to be grown on a sandy loam soil is 110 bushels per acre. A good legume crop will be turned down and soil tests show low phosphate and potash levels.

Calculations

Nitrogen needed — refer to Tables 6 and 7
For 100 bushels ..... 40 pounds
For additional 10 bushels
(20 x 1) 20 pounds
Total nitrogen 60 pounds

Phosphate needed — refer to Tables 7 and 11
For 80 bushels ..... 60 pounds
For additional 30 bushels
(12 x 3) 36 pounds
Total phosphate 96 pounds

Calculations for the potash needed in this situation will also show 96 pounds.

TABLE 7—Increased fertilizer rates recommended for unit increase in yields of different crops above those listed for each soil management group.

Crop	Unit	Lbs. plant nutrients		
		N	P_2O_5	K_2O
Alfalfa	1000 pounds	0	12	22
Beans and soybeans	10 bushels	10	18	20
Sugar beets	1 ton	8	6	10
Clover	1000 pounds	0	10	19
Corn	10 bushels	20	12	12
Oats and barley	10 bushels	5	8	9
Potatoes	100 cwt.	30	30	60
Rye	10 bushels	7	16	12
Wheat	10 bushels	10	14	10

CLAYS AND SILTY CLAYS

Fertilizer recommendations for field crops growing on light to dark-colored, level to hilly clays and silty clays are reported in Table 8. The main soil management groups are *0c, 1a, 1b,* and *1c.* The *1a group* has light-colored surface soils and bright colored subsoils. The *1b group* has moderately dark-colored surface soils and mottled subsoils with seasonally high water tables. The *1c group* has dark-colored surface soils. It is neutral to alkaline in reaction with naturally poor drainage. St. Clair, Kent, Ontonagon, Napanee, Selkirk, Rudyard, Hoytville, Pickford, Bergland, and Paulding are representative series. Water movement through these soils is very slow.

TABLE 8—Fertilizer recommendations for field crops growing on clays and silty clays. (Soil management groups 0c, 1a, 1b, 1c)

Crop	Expected crop yield per acre	Recommended pounds of $N+P_2O_5+K_2O$ 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	3.5 tons	0+60+30	0+60+0	0+30+30	0+30+15
Alfalfa, after each harvest year	3.5 tons	0+50+50	0+50+25	0+25+50	0+25+25
Barley—oats with legume seeding	40 bu. 65 bu.	15+60+30	15+60+15	15+30+30	15+30+15
Barley*—oats* without legume seeding	40 bu. 65 bu.	20+40+20	20+40+20	20+20+20	20+20+20
Corn*	80 bu.	12+50+25	12+50+12	12+25+25	12+25+12
Field beans*†	23 bu.	12+50+25	12+50+12	12+25+25	12+25+12
Soybeans*†	25 bu.	10+40+20	10+40+10	10+20+20	10+20+10
Sugar beets†*‡	14 tons	25+100+50	25+100+25	25+50+50	25+50+25
Wheat*—rye*	35 bu.	15+60+30	15+60+15	15+30+30	15+30+15
Grass, no legume		50+25+25	50+25+0	50+0+25	50+0+0
Cover crop (fall) oats, rye		10+40+20	10+40+10	10+20+20	10+20+10
Cover crop (summer) Sudangrass, buckwheat, oats		30+30+30	30+30+0	30+15+15	30+15+15

†Where the soil pH is above 6.9 apply fertilizer containing manganese. See page 31.
‡Apply fertilizer containing boron if pH is above 6.5. See page 31.
*Supplemental nitrogen may be needed. See Table 6.

GENTLY SLOPING TO HILLY LOAMS, SILT LOAMS AND CLAY LOAMS

Fertilizer recommendations for field crops growing on light to moderately dark colored, gently sloping to hilly loams, silt loams, and clay loams are shown in Table 9. The main soil management groups are *2a* and *2b*. The *2a group* has light-colored surface soils and bright subsoils. The *2b group* has moderately dark-colored surface soils and mottled subsoils with seasonally high water tables. Miami, Celina, Morley, Onaway, Nester, Conover, Blount, Mackinac, and Kawkawlin are representative series.

TABLE 9—Fertilizer recommendations for field crops on light to moderately dark-colored, gently sloping to hilly loams and silt loams. (Soil management groups 2a, 2b)

Crop	Expected crop yield per acre	Recommended pounds of $N+P_2O_5+K_2O$ 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	3.8 tons	0+80+40	0+80+20	0+40+40	0+40+20
Alfalfa, after each harvest year	3.8 tons	0+50+100	0+50+50	0+25+100	0+25+50
Barley—oats with legume seeding	50 bu. 70 bu.	20+80+40	20+80+20	20+40+40	20+40+20
Barley*—oats* without legume seeding	50 bu. 70 bu.	30+60+30	30+60+30	30+30+30	30+30+30
Corn*	90 bu.	15+60+30	15+60+15	15+30+30	15+30+15
Field beans*	28 bu.	12+50+25	12+50+12	12+25+25	12+25+12
Soybeans*	30 bu.	10+40+20	10+40+10	10+20+20	5+20+10
Sugar beets*‡	15 tons	30+120+60	30+120+30	30+60+60	30+60+30
Wheat—rye with legume seeding	40 bu.	22+90+45	22+90+22	22+45+45	22+45+22
Wheat*—rye* without legume seeding	40 bu.	20+80+40	20+80+20	20+40+40	20+40+20
Grass, no legume		50+25+25	50+25+0	50+0+25	50+0+0
Potatoes*	250 cwt.	40+160+160	40+160+80	40+80+160	40+80+80
Cover crop (fall) oats, rye		10+40+20	10+40+10	10+20+20	10+20+10
Cover crop (summer) Sudangrass, buckwheat, oats		30+30+30	30+30+0	30+15+15	30+15+15

‡Apply fertilizer containing boron if pH is above 6.5 See page 31.
*Supplemental nitrogen may be needed. See Table 6.

LEVEL, DARK-COLORED LOAMS, SILT LOAMS AND CLAY LOAMS

Fertilizer recommendations for field crops growing on nearly level to depressional, dark-colored, naturally poorly drained loams, silt loams, and clay loams are given in Table 10. The principal soil management group, *2c*, is neutral to alkaline in reaction with naturally poor drainage.

Brookston, Pewamo, Parkhill, and Sims are representative soil series. The Wisner, Thomas, Tappan, and Whittemore soils are calcareous at or near the surface. The *2c group* soils are very productive when they are adequately drained and properly fertilized.

TABLE 10—Fertilizer recommendations for field crops on level, dark-colored loams, silt loams, and silty clay loams. (Soil management group 2c)

Crop	Expected crop yield per acre	Recommended pounds of $N+P_2O_5+K_2O$ 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‡, sweet clover	4.5 tons	0+80+40	0+80+20	0+40+40	0+40+20
Alfalfa, after each harvest year‡	4.5 tons	0+60+30	0+60+0	0+30+30	0+30+15
Barley†—oats† with legume seeding	60 bu. 80 bu.	20+80+40	20+80+20	20+40+40	20+40+20
Barley*†—oats*† without legume seeding	60 bu. 80 bu.	30+60+30	30+60+0	30+30+30	30+30+15
Corn*§	100 bu.	20+80+40	20+80+20	20+40+40	20+40+20
Field beans†*§	30 bu.	15+60+30	15+60+15	15+30+30	15+30+15
Soybeans†*	35 bu.	12+50+25	12+50+12	12+25+25	12+25+12
Sugar beets*†‡	20 tons	40+160+80	40+160+40	40+80+80	40+80+40
Wheat†—rye with legume seeding	45 bu.	25+100+50	25+100+25	25+50+50	25+50+25
Wheat*†—rye* without legume seeding	45 bu.	20+80+40	20+80+20	20+40+40	20+40+20
Grass, no legume		50+25+25	50+25+0	50+0+25	50+0+0
Potatoes*†	250 cwt.	40+160+160	40+160+80	40+80+160	40+80+80
Cover crop (fall) oats, rye		10+40+20	10+40+10	10+20+20	10+20+10
Cover crop (summer) Sudangrass, buckwheat, oats		30+30+30	30+30+0	30+15+15	30+15+15

†Where the soil pH is above 6.5 apply fertilizer containing manganese. See page 31.
‡Apply fertilizer containing boron if pH is above 6.5. See page 31.
*Supplemental nitrogen may be needed. See Table 6.
§Zinc needed either applied in the fertilizer or on the foliage if pH is above 7.2. See page 31.

SANDY LOAMS

Fertilizer recommendations for field crops growing on light to dark-colored, level to hilly sandy loams are reported in Table 11. Some of the soils have sand, gravel or bedrock at 24 to 42 inches.

The principal soil management groups are *3a, 3b* and *3c*. The *3a group* has light-colored surface. The *3b group* has moderately dark-colored surface soils and mottled subsoils with seasonally high water tables. The *3c group* has dark-colored surface soils and is neutral to alkaline in reaction with naturally poor drainage. Hillsdale, McBride, Emmet, Fox, Kalamazoo, Locke, Coral, Barry and Ensley are representative series.

TABLE 11—Fertilizer recommendations for field crops growing on sandy loams. (Soil management groups 3a, 3b, 3/1b, 3/1c, 3/2a, 3/2b, 3/2c, 3/Ra, 3/Rc, Ra and Rc)

Crop	Expected crop yield per acre	Recommended pounds of $N+P_2O_5+K_2O$ 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	3.5 tons	0+80+80	0+80+40	0+40+80	0+40+40
Alfalfa, after each harvest year‡	3.5 tons	0+45+90	0+45+45	0+30+90	0+22+45
Barley†—oats† with legume seeding	45 bu. 65 bu.	15+60+60	15+60+30	15+30+60	15+30+30
Barley†*—oats†* without legume seeding	45 bu. 65 bu.	25+50+50	25+50+25	12+25+50	25+25+25
Corn*§	80 bu.	15+60+60	15+60+30	15+30+60	15+30+30
Field beans†*§	24 bu.	15+60+60	15+60+30	15+30+60	15+30+30
Soybeans†*	25 bu.	10+40+40	10+40+20	10+20+40	10+20+20
Sugar beets†*‡ for 3c or 3/2c soils only	16 tons	30+120+120	30+120+60	30+60+120	30+60+60
Wheat†—rye with legume seeding	35 bu.	20+80+80	20+80+40	20+40+80	20+40+40
Wheat†*—rye* without legume seeding	35 bu.	15+60+60	15+60+30	15+30+60	15+30+30
Grass, no legume		50+25+25	50+25+0	50+0+25	50+0+0
Potatoes*†	300 cwt.	50+200+200	50+200+100	50+100+200	50+100+100
Cover crop (fall) oats, rye		10+40+40	10+40+20	10+20+40	10+20+20
Cover crop (summer) Sudangrass, oats, buckwheat		30+30+30	30+30+0	30+15+30	30+15+15

†For 3c soils where the soil pH is above 6.5 apply fertilizer containing manganese. See page 31.
‡Apply fertilizer containing boron if pH is above 6.5. See page 31.
*Supplemental nitrogen may be needed. See Table 6.
§Zinc may be needed for 3c soils if pH is above 7.2. See page 31.

LOAMY SANDS

Fertilizer recommendations for field crops on light to dark-colored, level to hilly loamy sands are shown in Table 12. The principal soil management groups are *4a, 4b,* and *4c.* Also included are soil management group *4/1* which has sands to loamy sands 14 to 42 inches thick over clay or silty clay and soil management group *4/2* representing sands to loamy sands 18 to 42 inches thick over loams to clay loams. *The 4a, 4/1a, and 4/2 soil management groups* have light-colored surface soils and bright subsoils. The *4b, 4/1b, and 4/2b soil management groups* have moderately dark-colored surface soils and mottled subsoils with seasonally high water tables. The *4c, 4/1c, and 4/2c soil management groups* have dark-colored surface soils and subsoils which are mainly gray with a variable amount of mottling. They are usually slightly acid to neutral in reaction with naturally poor drainage. Oshtemo, Boyer, Montcalm, Spinks, Mancelona, Gladwin, Brady, Otisco, Gilford, and Edmore are representative series.

TABLE 12—Fertilizer recommendations for field crops growing on loamy sands. (Soil management groups 4a, 4b, 4c, 4/1b, 4/1c, 4/2a, 4/2b, 4/2c, 4/Ra, 4/Rb, Ga and Gc)

Crop	Expected crop yield per acre	Recommended pounds of $N+P_2O_5+K_2O$ 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	3.0 tons	0+60+60	0+60+30	0+30+60	0+30+30
Alfalfa, after each harvest year‡	3.0 tons	0+30+90	0+30+45	0+30+90	0+15+45
Barley†*—oats*† with legume seeding	35 bu. 60 bu.	12+50+50	12+50+25	12+25+50	12+25+25
Barley†*—oats*† without legume seeding	35 bu. 55 bu.	16+32+32	16+32+16	8+16+32	16+16+16
Corn*	60 bu.	10+40+40	10+40+20	10+20+40	10+20+20
Field beans†*	18 bu.	10+40+40	10+40+20	10+20+40	10+20+20
Soybeans†*	20 bu.	7.5+30+30	7.5+30+15	7.5+15+30	7.5+15+15
Wheat†*—rye* with legume seeding	30 bu.	15+60+60	15+60+30	15+30+60	15+30+30
Wheat†*—rye* without legume seeding	30 bu.	12+50+50	12+50+25	12+25+50	12+25+25
Grass, no legumes		50+25+25	50+25+0	50+0+25	50+0+0
Potatoes*†	250 cwt.	50+150+200	50+150+100	50+75+200	50+75+100
Cover crop (fall) oats, rye		10+40+40	10+40+20	10+20+40	10+20+20
Cover crop (summer) Sudangrass, oats, buckwheat		30+30+30	30+30+0	30+15+15	30+15+15

†For 4c soils where pH is above 6.5 apply fertilizer containing manganese. See page 31.
‡Apply fertilizer containing boron if pH is above 6.5. See page 31.
*Supplemental nitrogen may be needed. See Table 6.

SANDS

Fertilizer recommendations for field crops growing on light to dark-colored level to hilly sands are reported in Table 13. These soils are formed in sands over 66 inches deep; however, some of the poorly drained sands have finer textured materials below 42 inches. The *5a, 5a-h, 5.3a, and 5.7a soil management groups* have light-colored surface soils and bright-colored subsoils. The *5a-h soil management group* has hard cemented subsoils. The *5.3 and 5.7 soil management groups* are extremely droughty and the use of the fertilizers for field crops is generally not recommended.

The *5b and 5b-h soil management groups* have moderately dark-colored surface soils and mottled subsoils with seasonally high water tables.

The *5c soil management group* has dark-colored surface soils and subsoils which are mainly gray with a variable amount of mottling. They are usually slightly acid to neutral in reaction with naturally poor drainage.

The *5a* and *5b* soil management groups are usually acid and low in organic matter. These soils are low in natural fertility, droughty and when cropped, wind erosion is a problem. These limitations account for the low expected crop yields in this table.

Plainfield, Kalkaska, Au Train, Rubicon, Grayling, Saugatuck, Au Gres, Newton, Roscommon and Granby are representative soil series.

TABLE 13—Fertilizer recommendations for field crops growing on sands. (Soil management groups 5a, 5b, 5c, 5/2a, and 5/2b)

Crop	Expected crop yield per acre	Recommended pounds of $N+P_2O_5+K_2O$ 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	2.5 tons	0+45+90	0+45+45	0+30+90	0+22+45
Alfalfa, after each harvest year‡	2.5 tons	0+30+90	0+30+30	0+30+90	0+15+45
Corn* with irrigation	120 bu.	50+100+120	50+100+100	50+50+100	50+50+100
Oats†* without legume seeding	50 bu.	16+32+32	16+32+16	8+16+32	16+16+16
Wheat†*—rye* without legume seeding	25 bu.	12+50+50	12+50+25	12+25+50	12+25+25
Grass, no legumes		30+30+30	30+30+0	30+0+30	30+0+0
Potatoes†* with irrigation	300 cwt.	60+120+240	60+120+120	60+60+240	60+60+120
Cover crop (fall) oats rye		10+40+40	10+40+20	10+20+40	10+20+20
Cover crop (summer) Sudangrass, oats, buckwheat		30+30+30	30+30+0	30+15+30	30+15+15

†Where the soil pH is above 6.5 apply fertilizer containing manganese. See page 31.

‡Apply fertilizer containing boron. See page 31.

*Supplemental nitrogen may be needed. See Table 6.

VEGETABLE CROPS

Most vegetables require high levels of fertility for high yields of satisfactory quality. Fertilizer can be applied to vegetables using one or more of the following methods:

(1) applied at planting time to the green manure or cover crops preceding the vegetable crop,
(2) plowed down,
(3) drilled in after plowing,
(4) placed in bands near the seed,
(5) used in starter solutions,
(6) side or topdressed, and
(7) applied on the leaves (foliar feeding).

Credit any fertilizer applied by any of the above methods to the total amounts recommended in Tables 14 and 15.

Some rules that will help you:

1. Fertilize a green manure crop with a high nitrogen fertilizer for maximum growth. The recovery of the nitrogen applied to a green manure crop will amount to about 30 percent for the first vegetable crop.

2. When using a high phosphorus fertilizer, place in bands near the seed if possible; phosphorus is essential for small seedlings, and band placement reduces soil phosphorus fixation. Examples are 8-24-8, 5-20-10, 11-48-0, or 8-32-0.

3. If phosphate is to be sideplaced, drill in or plow down a fertilizer high in nitrogen and potassium. This reduces possible injury to small plants or germinating seeds, and helps decompose non-leguminous plant residues.

4. Use starter solutions high in phosphorus for spring planting of transplants. Examples are 15-30-15 or 10-52-17.

5. Sidedress or topdress vegetables and fruiting crops with nitrogen as foliage color indicates.

6. Foliage application is an efficient way to correct or prevent some micronutrient deficiencies. It is not recommended for applying major plant nutrients because of excessive costs, inability to supply sufficient nutrients and possibility of plant injury.

Here are some typical recommendations for growing vegetables on soils of low fertility (column 1 in the recommendation tables).

ASPARAGUS (NEW PLANTING) — Plow down 500 pounds of 8-16-16 per acre and apply 20% phosphate fertilizer at the rate of 150 pounds per

acre down the trench before setting plants. Later, sidedress with 30 pounds of nitrogen per acre during cultivation. Repeat the 8-16-16 and nitrogen application for several years.

ASPARAGUS (ESTABLISHED PLANTING) — Alternate applications of nitrogen at the rate of 30 to 50 pounds one year, with 300 to 500 pounds of 12-12-12 per acre on alternate years, applied at the end of harvesting season on soils with medium phosphorus and potassium test. Eliminate nitrogen application if manured.

LIMA BEANS, SNAP BEANS — Apply fertilizer 2 inches to the side and 2 inches below the seed. Do not apply directly in contact with the seed. Use 5-20-10 for clay loams and 5-20-20 for sandy loams. Apply at the rate of 300 pounds per acre. Sidedress beans with urea or ammonium nitrate a few days before flowering (if foliage is light green). Manganese is often needed if pH of soil is above 6.5.

PEAS — Broadcast or drill 2 inches to side of the seed 400 pounds per acre of 12-12-12 on sandy loams, or 8-16-8 on clay loams.

CARROTS, HORSERADISH, PARSNIPS — Drill in before seeding or apply in a band 1 inch to side and 2 inches below the seed. Use 5-20-20 on sandy loams at the rate of 500 pounds per acre. Topdress with 50 pounds of nitrogen per acre after plants are well started.

RADISHES, TURNIPS — Drill in 12-12-12 or 12-6-6 at the rate of 400 pounds per acre. Boron may be needed at the rate of two pounds per acre.

TABLE BEETS, RUTABAGAS — Drill in before seeding or apply in a band 1 inch to the side and 2 inches below the seed. Use 5-20-10 for clay loams and 5-20-20 for sandy soils with ¼ percent boron in each. Apply at the rate of 600 pounds per acre.

BROCCOLI, CABBAGE, BRUSSEL SPROUTS, CAULIFLOWER — Plow down 30 to 50 pounds of nitrogen per acre with stubble or grain cover crops. For sandy soils, plow down, or drill in after plowing, 600 to 800 pounds per acre of a 5-20-20 containing ¼ percent boron. Band 200 pounds — if possible — of a 5-20-20 fertilizer near the plants or seeds. Use 5-20-10 containing ¼ percent boron for clay loams. Use four ounces of sodium molybdate per acre for cauliflower.

Use a high nitrogen starter solution for transplants (for amounts see page 27). Sidedress cauliflower two or three times for a total of 100 pounds of nitrogen per acre.

SWEET CORN — Plow down 30 to 50 pounds of nitrogen per acre with stubble, grain, or grass sod. Apply fertlizer in a single band 2 inches to the side and 2 inches below the seed. Use 5-20-10 at the rate of 500 pounds

per acre for clay loams, and 5-20-20 at 400 pounds per acre for sandy loams. Sidedress with about 60 to 80 pounds of nitrogen when plants are 10 to 20 inches tall.

CUCUMBERS — For pickling cucumbers, plow down 30 to 50 pounds of nitrogen per acre with a stubble, grass, or grain cover crop. Drill in 400 pounds of a 5-20-10 per acre for loams and clay loams and 5-20-20 for sandy loams. If fertilizer is placed in a band 2 inches to the side and 2 inches below the seed, do not apply more than 300 pounds per acre. Sidedress with 30 to 40 pounds of nitrogen per acre if the soil is very wet or if the foliage becomes light green or yellow green.

MUSKMELON, WATERMELON — At planting time, fertilize rye or rye grass used for green manure crop with 300 pounds of a 10-10-10 fertilizer per acre. For sandy soils, drill in, 3 or 4 inches deep, 700 pounds per acre of 5-20-20 fertilizer after plowing. Use a 5-20-10 at similar rates for clay loams. Lower rates — 400 pounds — must be used if the fertilizer is placed in a band several inches to the side and below the seed. Sidedress with 50 pounds per acre of nitrogen three weeks after plants have emerged, or after transplanting.

TOMATOES — Plow down or drill in 3 or 4 inches deep one-half to two-thirds of the fertilizer recommended in the tables. This would amount to 800 pounds per acre of a 5-20-10 on clay loams and 600 pounds per acre of 5-20-20 on sandy loams. Apply 200 to 300 pounds per acre of similar grade in bands 3 to 4 inches to the side and several inches below at planting time, or sidedress. Use starter solutions high in phosphate on transplants. Apply additional nitrogen fertilizer when the first fruits are about the size of a half dollar.

RHUBARB — In early spring, apply 5-10-20 or 5-20-20 at 700 pounds per acre. Sidedress with one or two applications of nitrogen at 2-week intervals after growth starts.

MARKET GARDEN — Plow under 600 pounds per acre of fertilizer Broadcast and disk in, or apply in bands 1 inch to the side and 2 inches below the seed at 400 to 600 pounds per acre. If experience has shown that extra nitrogen has been profitable in the past, make one or two applications between the rows during the growing season. Nitrogen recommendations shown in Table 6 for potatoes are a good guide.

HOME GARDEN — Apply 10 to 15 pounds of fertilizer per 1000 square feet before plowing or spading. After plowing, apply similar amounts into the soil several inches deep. Use 5-20-10, 5-20-20, or similar grades.

Use starter solutions when transplanting cabbage, tomatoes, celery, etc. There are high analysis, water soluble fertilizers available in most garden supply stores.

In mid-summer, fertilize with 4 pounds of ammonium nitrate per 1,000 square feet of area. Apply this in a band along the rows, 5 to 6 inches to the side of the plants. To help maintain the organic matter level in gardens, rake in rye or wheat seed in early September. Topdress the grain cover crop sometime during early March with 4 pounds of ammonium nitrate for each 1,000 square feet of land. If you use manure, cut the fertilizer rate in half.

Vegetables in flats and flowers for transplanting

There are several alternate programs. These are:

(1) Use a complete fertilizer such as a 6-24-12 or 8-24-8 at the rate of 2 to 3 pounds per cubic yard (about 20 bushels) of soil mix.

(2) Use a starter solution every day after plants have emerged. The starter solutions are made from all soluble high phosphate formulations such as a 10-50-10 or 10-52-17. Dissolve 2 ounces of the solid fertilizer in 5 gallons of water and apply with a sprinkler can, and apply over 75 to 100 square feet. Rinse plants with water. With this program no fertilizer needs to be added to the soil mix used in plant growing.

(3) Prepare special soil mixes, especially if the soil is steamed or fumigated. A suggested soil mix is 2 parts (by volume) of sand and 1 part of peat. To each cubic yard of the mixture add 6 ounces of potassium nitrate, 4 ounces of potassium sulfate and 2.5 pounds of 20 percent superphosphate. If acid peat (below pH 5.0) is used, add 6 pounds of finely ground limestone.

Starter Solutions

Starter solutions can be used on your home garden. Stir one-half cup dry fertilizer, such as a 5-20-10 or 10-20-10, into 3 gallons of water. Apply 1 cup of the solution to 10 feet of row or around transplants. (Use this solution in addition to the recommended rates of dry fertilizer.) You can buy commercial starter solution mixtures such as a 15-30-15 or 10-52-17. Follow the manufacturer's directions when using these concentrated fertilizers.

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

TABLE 14—Fertilizer recommendations for vegetable crops growing on loams, silt loams and clay loams (assuming no farm manure or legumes plowed down)

Crop	Recommended pounds of $N+P_2O_5+K_2O$ and boron plus nitrogen sidedressing, per acre			
	(1) Phosphorus low Potassium low	(2) Phosphorus low Potassium high	(3) Phorphorus high Potassium low	(4) Phosphorus high Potassium high
Asparagus	40+60+60	40+60+0	40+0+60	40+0+0
Lima† and snap beans†	25+100+50	25+100+25	25+50+50	25+50+25
Peas†	40+80+40	40+80+20	40+40+40	40+40+20
Carrots, horseradish, parsnips	30+120+60 + 50 N	30+120+30 + 50 N	30+60+60 +50 N	30+60+30 +50 N
Spinach†	70+70+70	70+70+35	70+35+70	70+35+35
Turnips, radishes†	50+50+50	50+50+25	50+25+50	50+25+25
Table beets, rutabagas	30+120+60 2 Boron* + 50 N	30+120+30 2 Boron + 50 N	30+60+60 2 Boron +50 N	30+60+30 2 Boron +50 N
Broccoli, cabbage, brussel sprouts	40+160+80 1 Boron* +75 N	40+160+40 1 Boron + 75 N	40+80+80 1 Boron +75 N	40+80+40 1 Boron +75 N
Cauliflower	50+160+100 3 Boron* +100 N	50+160+50 3 Boron +100 N	50+80+100 3 Boron +100 N	50+80+50 3 Boron +100 N
Sweet corn	25+100+50 + 70 N	25+100+25 + 70 N	25+50+50 +70 N	25+50+25 +70 N
Cucumbers, slicing	30+120+60 + 50 N	30+120+30 + 50 N	30+60+60 +50 N	30+60+30 +50 N
Cucumbers, pickling	20+80+40 +40 N	20+80+20 + 40 N	20+40+40 +40 N	20+40+20 +40 N
Muskmelons	40+120+80 + 40 N	40+120+40 + 40 N	40+60+80 +40 N	40+60+40 +40 N
Home and market gardens	50+200+100 + 60 N	50+200+50 + 60 N	50+100+100 +60 N	50+100+50 + 60 N
Tomatoes, eggplant, peppers	50+200+100 + 60 N	50+200+50 + 60 N	50+100+100 + 60 N	50+100+50 + 60 N
Lettuce†, Endive†	60+120+60	60+120+30	60+60+60	60+60+30
Pumpkins, squash	20+80+40 +40 N	20+80+20 +40 N	20+40+40 +40 N	20+40+20 +40 N
Rhubarb	60+120+120 + 60 N	60+120+60 + 60 N	60+30+120 +60 N	60+30+30 +60 N

*Pounds of elemental boron.
†Crops may need manganese if pH is above 6.5. See page 31.

TABLE 15—Fertilizer recommendations for vegetable crops growing on loamy sands and sandy loams (assuming no farm manure or legumes plowed down)

Crop	Recommended pounds of $N+P_2O_5+K_2O$ and boron plus nitrogen sidedressing, per acre			
	(1) Phosphorus low Potassium low	(2) Phosphorus low Potassium high	(3) Phosphorus high Potassium low	(4) Phosphorus high Potassium high
Asparagus	20+40+60 +30 N	20+40+0 +30 N	20+0+60 +30 N	20+0+0 +30 N
Lima† and snap beans†	20+80+80 +30 N	20+80+40 +30 N	20+40+80 +30 N	20+40+40 +40 N
Peas†	50+50+50	50+50+25	50+25+50	50+25+25
Carrots, horseradish, parsnips	25+100+100 + 50 N	25+100+50 + 50 N	25+50+100 +50 N	25+50+50 +50 N
Spinach†	70+70+70	70+70+35	70+35+70	70+35+35
Turnips, radishes†	50+50+50	50+50+25	50+25+50	50+25+25
Table beets,† rutabagas	30+120+120 2 Boron* + 60 N	30+120+60 2 Boron + 60 N	30+60+120 2 Boron +60 N	30+60+60 2 Boron +60 N
Broccoli, cabbage, brussel sprouts	40+160+160 1 Boron* + 80 N	40+160+80 1 Boron + 80 N	40+80+160 1 Boron +80 N	40+80+80 1 Boron +80 N
Cauliflower	50+160+200 3 Boron* +100 N	50+160+100 3 Boron +100 N	50+80+200 3 Boron +100 N	50+80+100 3 Boron +100 N
Sweet corn	20+80+80 +75 N	20+80+40 +75 N	20+40+80 +75 N	20+40+40 +75 N
Cucumbers, slicing	25+100+100 + 50 N	25+100+50 + 50 N	25+50+100 +50 N	25+50+50 +50 N
Cucumbers, pickling	15+60+60 +40 N	15+60+30 +40 N	15+30+60 +40 N	15+30+30 +40 N
Muskmelons, watermelons	35+100+140 + 50 N	35+100+70 + 50 N	35+50+140 +50 N	35+50+70 +50 N
Home and market garden	50+200+200 + 75 N	50+200+100 + 75 N	50+100+200 + 75 N	50+100+100 + 75 N
Sweet potatoes	30+60+120	30+60+60	30+30+120	30+30+30
Tomatoes	50+160+200 + 60 N	50+160+100 + 60 N	50+80+200 +60 N	50+80+100 +60 N
Eggplant, pepper	40+120+160 + 80 N	40+120+80 + 80 N	40+60+160 +80 N	40+60+80 + 80 N
Lettuce†, Endive†	60+120+120	60+120+60	60+60+120	60+60+60
Pumpkins, squash	20+80+80 +40 N	20+80+40 +40 N	20+40+80 +40 N	20+40+40 +40 N
Rhubarb	60+90+150 +60 N	60+90+60 +60 N	60+20+150 +60 N	60+20+60 +60 N

*Pounds of elemental boron.

†Crops may need manganese if pH is above 6.5. See page 31.

MICRONUTRIENTS IN MINERAL SOILS

The mineral soils of Michigan may be deficient in manganese, and/or boron for certain crops, particularly on soils above pH 6.5. Manganese may be needed for oats, beans, soy beans, potatoes, Sudangrass, sugar beets, and spinach. In extreme cases, barley, corn, and wheat may respond to manganese. A deficiency of this element is most likely to occur on dark-colored surface soils with grayish subsoils found in lake bed or glacial outwash areas. Use 5 to 10 pounds of manganese per acre banded with the fertilizer near the seed. Broadcast application of manganese is not recommended.

Boron at the rate of 2 to 3 pounds per acre may be needed for sugar beets, table beets, cauliflower, celery, turnips, and rutabagas. Use 1 to 2 pounds per acre for alfalfa. Lettuce, broccoli, spinach, and cabbage may need 1 pound of boron per acre.

Never apply boron for beans, soybeans, peas, or small grains.

Zinc has been found to be needed for beans and corn grown on alkaline soils of the lake bed areas of eastern Michigan. The deficiency is especially noted on crops growing on spoil banks, over tile lines where calcareous subsoil is mixed in and where high phosphate soil tests are found.

For treatment on known deficient soils, use 3 to 4 pounds of zinc per acre applied in the band fertilizer. Suggested rate as a preventive program is 1 pound of zinc per acre. Coating seed with zinc oxide looks promising but has not had sufficient testing for general recommendation. Foliar sprays have corrected the deficiency on beans but are not recommended for corn.

Micronutrients can be absorbed through the leaves of plants. Where spray equipment is available, cost of material used is greatly reduced. If compatible, (see page 35) the micronutrients can be mixed in a fungicide or insecticide spray. Suggested micronutrient rates as sprays are:

3 to 6 pounds of water soluble manganese sulfate per acre.
1 to 3 pounds of basic copper sulfate per acre.
1 to 2 pounds of zinc sulfate per acre.
0.5 to 2 pounds of borax or soluble borate carrier per acre.
2 ounces of sodium molybdate per acre.
Use a minimum of 30 gallons of water per acre.

The micronutrients can be mixed in the fertilizer by the manufacturer. At present the quantities that can be used are:

(1) manganese — 1.0, 2.0, or 5.0 percent
(2) boron — ⅛, ¼, ½ or 1.0 percent

(3) copper — ½, 1.0 or 2.0 percent
(4) zinc — ½, 1.0 or 2.0 percent
(5) molybdenum — 0.04 or 0.08 percent

In estimating the amount required in a mixed fertilizer, follow the recommendations shown in Table 16.

TABLE 16—Percentage of micronutrients suggested in mixed fertilizer as related to the amount of fertilizer applied and micronutrient needed.

Fertilizer Applications Pounds/Acre	Pounds of micronutrient per acre desired									
	Manganese			Boron			Copper or Zinc			
	5	10	20	1	2	3	1	2	4	6
	%	%	%	%	%	%	%	%	%	%
100	5	*	*	1	1	*	1	2	*	*
200	2	5	*	½	1	1	½	1	2	2
400	1	2	5	¼	½	½	½	½	1	2
600	1	2	5	¼	½	½	†	½	½	1
800	†	1	2	⅛	¼	¼	†	†	½	1
1000	†	1	2	⅛	¼	¼	†	†	½	½
1200	†	1	2	⅛	⅛	¼	†	†	†	½
1500	†	1	1	†	⅛	¼	†	†	†	½
2000	†	†	1	†	⅛	⅛	†	†	†	†

*Amount required is greater than that possible in mixed fertilizer by Michigan regulations.
†Minimum percentage permitted in fertilizer could exceed desired quantity. Farmers should use split application of fertilizer to obtain desired amount.

MAGNESIUM

Magnesium deficiency may occur in acid soils with a sandy loam, loamy sand, or sand plow layer with a subsoil as coarse or coarser in texture than the plow layer and similar soils limed with calcic limestone or marl. Responsive crops are cauliflower, muskmelons, potatoes, peas, and corn. Magnesium deficiency is a common disorder in greenhouse tomatoes.

Dolomitic limestone should be applied to acid sandy soils which have less than 75 pounds of exchangeable magnesium per acre. At least 1,000 pounds of dolomitic limestone should be used. On sandy soils which are not acid and have less than 75 pounds of exchangeable magnesium per acre, soluble magnesium fertilizers may be needed. The suggested rate is 50 to 100 pounds of magnesium (Mg) per acre. Magnesium sulfate, sulfate of potash-magnesium, or magnesium oxide are all satisfactory carriers of magnesium.

Magnesium can be applied as a foliar spray. Suggested rates per acre are 10 to 20 pounds of magnesium sulfate in 100 gallons of water.

Magnesium deficiency in crops may be induced by high rates of potassium and sodium materials. When soil tests indicate that the ratio

of the pounds of exchangeable potassium to exchangeable magnesium is greater than 4 to 1, crops should be watched for possible magnesium deficiency.

PLANTS SHOW STARVATION SYMPTOMS

For better results from fertilizer, watch for 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 nutrient deficiencies and with different species of plants.

For many years these deficiency symptoms have been studied under controlled conditions. The appearance of a starved plant may indicate just what nutrient shortage is causing its unhealthy condition. You can become familiar with these symptoms and decide for yourself when your plants are lacking plant nutrients. Green plant tissue tests will verify the symptoms of starvation. There may still be time to use fertilizer profitably on that particular crop, or the information may help you select the fertilizer for the next crop.

To obtain additional information on deficiency symptoms, write for Michigan Agricultural Experiment Station Special Bulletin 353, from the Bulletin Office, Michigan State University, East Lansing, Michigan.

TREE FRUITS

(Apple, cherry, pear, peach, plum)

General Nutrient Needs

Nitrogen is the most important nutrient in tree fruit production and is usually the only fertilizer element that should be applied annually to Michigan orchards.

Potassium is second only to nitrogen. It is used in relatively large quantities by growing, producing fruit trees. Generally the stone fruits in Michigan are more subject to potassium deficiency than apples or pears.

Phosphorus is utilized in only small amounts by fruit trees. Fruit trees in Michigan have not responded to phosphorus applications.

Lime has not proven of direct value in Michigan fruit orchards except to correct magnesium deficiency or stimulate cover crop growth in orchards located on very acid soil. If lime is applied, use *only* dolomitic (high magnesium) lime.

Micronutrient deficiencies have been few and of minor consequence in Michigan orchards. Manganese and zinc may be needed in certain orchards,

but for the most part, Michigan fruit growers need not be concerned about micronutrients as a necessary part of their fertilizer program.

Determining Nutrient Needs

Leaf analysis is the best way to determine fertilizer needs of established fruit trees. A leaf analysis service is available to Michigan fruit growers. You can obtain information on leaf analysis from county extension offices or by writing to the Department of Horticulture, Michigan State University, East Lansing, Michigan.

Apples and pears — For established apple and pear trees, use only nitrogen until need for other nutrients has been determined. Apply enough to supply 2 to 3 ounces of actual nitrogen for each year of tree age up to 1 to 2 pounds of actual nitrogen per tree. Do not apply more than 1 pound of actual nitrogen per tree to dwarf, semi-dwarf or closely planted trees.

Peaches, cherries and plums — In the early years, use about the same amount of nitrogen as suggested for apples and pears; do not apply more than 1 pound actual nitrogen per tree at any time. Other nutrients should be applied when the need has been determined.

Apply 1 to 2 tons of dolomitic limestone per acre when pH is below 5.0 and if evidence of magnesium deficiency is present or if cover crops fail to grow.

Foliar sprays of urea, Epsom salts, and some micronutrients have been very useful under special conditions. So-called liquid complete sprays are usually uneconomical in cost and of no more benefit than soil applications of the same materials.

The following sprays are suggested only when needed:

Urea—May be used on apples and pears. Not recommended for cherries and peaches. Use 5 pounds per 100 gallons in early cover sprays.

Magnesium—Use Epsom salts in early cover sprays. Use 10 pounds per 100 gallons.

Iron—Iron sulfate, iron citrate or iron chelates. Use according to manufacturer's recommendations.

Manganese—Manganese sulfate in early cover sprays, or as after-harvest sprays. Use 5 pounds per 100 gallons.

Boron—Borax or other soluble borates as:

(1) soil application, (2) early cover spray, or (3) after harvest spray. Use 2 to 4 ounces borate per tree on soil, or 2 to 3 pounds per 100 gallons in after-harvest spray.

Zinc—Zinc oxide in early cover sprays or zinc sulfate as after harvest spray. Use 2 to 3 pounds of zinc oxide per 100 gallons in early cover sprays or 5 pounds zinc sulfate per 100 gallons in after harvest spray. Add hydrated lime in amounts equal to zinc sulfate.

Spray Compatibility

Unless compatibility with insecticides and fungicides is known, apply nutrient sprays separately. If you do want to combine them, try the combination on a small area before using it widely.

Urea—compatible with most pesticides, except karathane and lime sulfur.

Magnesium sulfate (Epsom salts)—compatible with most pesticides. Not compatible with arsenate and copper sprays and should not be mixed with materials having wetting properties.

Boron (Borax or soluble borates)—compatible with most pesticides. Not compatible with arsenate sprays.

Iron—iron sulfate, citrate or chelates should not be applied with most pesticide materials.

Zinc (Zinc oxide or zinc sulfate)—apply as separate spray.

Manganese (manganese sulfate)—compatible with copper sulfate, wettable sulfur, parathion, and lead arsenate. Other compatibilities unknown.

Solutions at Planting Time

On soils testing low for potassium, use a solution of 1 ounce of sulfate of potash per 3 gallons (2 pounds per 100 gallons). Apply 1 to 3 gallons per tree immediately after planting.

Nitrogen solutions have been beneficial on light sandy soils. Use nitrate or urea nitrogen equal to 1 ounce per 3 gallons (2 pounds per 100 gallons) of sodium nitrate or potassium nitrate. Apply 1 to 3 gallons per tree immediately after planting.

Solutions of hydrated dolomitic lime may be used on soils low in magnesium and calcium. Solutions containing 1 pound of hydrated dolomitic lime per 10 gallons may be used at a rate of 2 gallons per tree.

Cover Crop Fertilizer

Fertilizer applications to cover crops or sods should be based on soil tests. Apply enough of needed ratio to furnish about 20 pounds of nitrogen per acre on loamy soils and about 30 pounds of nitrogen per acre on

sandy soils. Reduce nitrogen in relation to legume content of cover. If cover is all legume, omit nitrogen in fertilizer. For further information, consult the recommendations in this bulletin for the specific crop. (See tables 8 to 13.

SMALL FRUITS

Grapes

Apply straight nitrogen fertilizer in the spring, in amounts to supply 40 to 50 pounds of nitrogen per acre.

For normal, healthy vineyards, apply in the fall 50 to 60 pounds of potash (K_2O) per acre. If a potassium deficiency is present, apply 100 to 200 pounds of potash per acre until the condition is corrected.

Strawberries

Before planting—Conduct a green manuring program for 1 or 2 years before planting. Such a program should include fertilizers and lime for the best growth of the green manure crops being used. Consult recommendations in this bulletin for specific crops.

If no green manuring program was conducted before planting, a 1:4:4 ratio fertilizer in amounts to supply 25 to 35 pounds of nitrogen per acre should be worked into the soil about 10 days before setting plants in the spring. If plants are set out in the fall, make this application very early in the spring (before growth starts).

Starter solutions—Apply only to plants set out early in the season (before April 15 in Southern Michigan; before May 1 in Northern Michigan). A soluble fertilizer with a ratio of about 1:5:1 is best. For more information, consult Extension Folder F-194, "Starter Solutions."

After planting—Apply a 1:0:0 or 1:1:1 ratio fertilizer about 2 weeks after setting the plants if growth is weak. Use enough to supply 30 to 35 pounds of nitrogen per acre. Repeat this application in 3 or 4 weeks if vigor is still low.

During fruiting—Applications of fertilizer are seldom needed during the spring of the first fruiting year. Too much nitrogen at this time can result in soft berries which decay rapidly. If plants lacked vigor during the previous fall, use nitrogen fertilizers in amounts carrying not over 10 pounds of actual nitrogen per acre. This can be applied through irrigation or as urea sprays. On beds of very low vigor, make two such applications 10 days apart.

After harvest—Apply a complete fertilizer when the crop is to be harvested for another year. Immediately after harvest, use a 1:1:1 ratio

fertilizer to supply 60 to 100 pounds of nitrogen per acre. As fruiting season approaches, use the applications suggested above.

Blueberries

Blueberries are sensitive to nitrates and chlorides contained in certain fertilizers. Therefore, blueberry fertilizers should contain only ammonium salts or urea as their source of nitrogen, and sulfate of potash as a source of potassium. Blueberries grow best on soils having a low pH (4.0 to 5.5), and lime should not be applied unless the pH is 3.8 or lower, or magnesium deficiency has been found. Consult your local extension agent or Horticulture Department for corrective measures.

Newly-set fields—Apply complete (2:1:1) fertilizer with caution. Use 1 ounce of a blueberry fertilizer per plant if soil fertility is low. Apply in a band 6 inches or more away from the plants.

Established fields—Apply blueberry fertilizer in sufficient amounts to supply 60 to 75 pounds of nitrogen per acre for mineral soils and 20 to 40 pounds per acre on organic soils. Apply as early as possible in the spring. Broadcast fertilizer, or apply it with a drill between the rows.

Mineral soils low in organic matter—Use ammonium sulfate to supplement the applications of 2:1:1 fertilizer. If plants lack vigor, use ammonium sulfate at a rate of 60 to 70 pounds per acre (1 ounce per plant) during the first and second years. Increase the amount 30 to 35 pounds per acre each year until a maximum of 240 to 280 pounds per acre is being applied. Apply supplemental ammonium sulfate in late June.

OTHER SMALL FRUITS

(Brambles, gooseberries, currants)

Apply complete fertilizer to brambles, gooseberries and currants before growth starts in the spring. Use 2 ounces of a 1:1:1 ratio fertilizer around newly-set plants. In the second year, use enough 1:1:1 ratio fertilizer to supply 25 to 30 pounds of nitrogen per acre. In following years, use enough 1:1:1 ratio fertilizer to supply 50 to 60 pounds of nitrogen per acre.

If leaf scorch (potassium deficiency) appears, apply enough potash fertilizer to furnish 150 to 200 pounds of potash per acre. Repeat annually until leaf scorch disappears. Gooseberries and currants need sulfate of potash to avoid possible chloride injury.

For further information on fruit crops, see Extension Folder F-224, "Fertilizers For Fruit Crops."

III. RECOMMENDATIONS FOR ORGANIC SOILS

In several county soil surveys, organic soils are classified either as mucks or peats. **Carlisle, 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 somewhat, except that **Greenwood** peat is always very acid. Organic soils usually do 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 lower crop yields. **Greenwood** peat must be limed for the production of all crops except blueberries. Even blueberries may benefit from limestone if the soil pH is below 4.0.

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 this case, lime after deep plowing. When organic soils require lime, the magnesium content of the soil is generally low, so the use of dolomitic limestone is advisable.

The amount of ground limestone required for organic soils 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 12 tons.

Sulfur is often applied to lower the pH value of nearly neutral or alkaline organic soils. Rates of 200 to 1,000 pounds per acre are recommended depending upon the degree of alkalinity. Five hundred pounds of sulfur per acre will reduce the pH of the top 6 inches approximately 0.3 unit in the absence of free marl or limestone. Response to sulfur may be expected from many crops when the soil pH is 6.0 or above. Sulfur will reduce the pH of the soils so that blueberries can be grown. This practice is not recommended on a commercial scale if the pH is above 5.8.

Since organic soils which have never been fertilized are almost always low in phosphorus and potassium, make only the pH test on the plowed layer. Also test the underlying soil at a depth of 18 to 24 inches. After the soil has been well fertilized for 2 or 3 years, determine the available phosphorus and potassium, along with the pH, in a sample taken at a depth of 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 the soil tests every few years is advisable. Send package and information to your soil testing laboratory.

Effect of Time of Sampling

In the case of newly reclaimed organic soils or soils which have not been heavily fertilized, there is little change in the soil test from one time of the year to another. With soils that have been heavily fertilized, however, the time of obtaining the samples is important. Up to 50 percent of the potassium may be leached out of the soil between early fall sampling and time for cropping in the spring. Determination of the available nitrogen generally is not worthwhile except during the growing season.

FERTILIZER RECOMMENDATIONS FOR ORGANIC SOILS

The pounds of phosphate and potash fertilizer recommended as indicated by the soil test are shown in Tables 17 and 18. You will need to determine the recommended grade and rate as well as the quantity of nitrogen and minor elements needed.

TABLE 17—Phosphate fertilizer recommendations for organic soils based upon available soil phosphorus using Bray P_1 method.

Available soil phosphorus Pounds of "P" (per acre)				Pounds P_2O_5 per acre recommended
			15	200
		10	30	160
		20	40	130
	10	40	60	100
5	20	60	80	75
15	40	80	110	50
30	60	100+	140+	30
50+	75+	—	—	20
blueberries	alfalfa	cabbage	broccoli	
buckwheat	asparagus	carrots	cauliflower	
clover	barley	cucumbers	celery	
grass	beans	endive	onions	
oats	corn	lettuce	tomatoes	
rye	mint	parsnips		
soybeans	peas	potatoes		
pasture	radishes	pumpkins		
	sudangrass	spinach		
	sweet corn	sugar beets		
	turnips	table beets		
	wheat			

To use this table, look for the crop grown. Then find position of the approximate soil test in the same column above crop listing. To determine amount of phosphate fertilizer needed, follow line to right column and read figure just opposite soil test.

Example: Recommend 100 pounds per acre of phosphate for broccoli if soil test is 60 pounds per acre.

If no soil test is made and soils are low in fertility, use amounts suggested for 20 pounds of available phosphorus.

Recommendations in this table assume you will use the proper placement of fertilizer.

TABLE 18—Potash fertilizer recommendations for organic soils based upon soil test using 1N ammonium acetate method.

Available soil potassium Pounds of "K" per acre					Pounds K_2O per acre recommended
				80	600
				200	500
			80	300	400
		75	160	400	300
		140	220	450	250
	75	200	300	500	200
	150	250	350	560	160
50	200	300	400	620	130
100	250	350	450	700	100
150	280	380	480	750	80
200	310	410	510	800	60
250	350	450	550	825	40
275	375	475	575	850	20
300	400	500	600	900	0
barley	beans	alfalfa	broccoli	celery	
blueberries	clover	asparagus	cauliflower		
grass	corn	cabbage	onions		
oats	mint	carrots	potatoes		
rye	peas	cucumbers	sugar beets		
pasture	soybeans	lettuce	table beets		
wheat	sudangrass	parsnips	tomatoes		
	sweet corn	radishes			
	turnips	spinach			

If no soil test is made and soils are low in fertility, use the amounts of potash suggested for 100 pounds of available potassium per acre.

Test soil annually if little or no potash is recommended, because potash reserve can change greatly. Leaching may be serious following flooding or heavy rainfall.

Soils of low fertility usually test about 20 pounds of phosphorus and 100 pounds of potassium per acre. Use fertilizer recommendations for these values if you do not have a soil test made and the soil is low in fertility.

The information in the tables does not recommend a typical grade. The person making recommendations must determine what grade of fertilizer and how it is to be applied.

Usually the fertilizer requirements for most organic soils can be supplied by the use of 5-20-20, 5-10-20, 0-10-30, or 5-10-30 grades. Potash can be plowed down or drilled in and a high phosphate fertilizer can be used near the row.

Nitrogen requirements are related to drainage, soil temperature, and depth of the organic layer. A high water table or a low soil temperature limits decomposition of the organic matter. Crops growing under these conditions may require the use of nitrogen: (1) organic layers less than 18 inches deep, (2) soil with a pH less than 5.0, (3) periods after heavy rainfall. Spring-planted crops on most adequately drained soils require 25 to 50 pounds of nitrogen per acre. Crops planted in late spring or early summer usually require less nitrogen.

Several crops may require a small amount of nitrogen for early growth on well-drained muck, but they 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 6-24-12 mixture as a row application, and to a 0-10-30 or 60 percent potash drilled over the field at a depth of 3 to 4 inches before planting.

MICRONUTRIENTS

Organic soils are often low in manganese, boron, copper, molybdenum and zinc. Consider an application of these elements as good insurance against the possibility of a deficiency. High value crops, particularly, should be fertilized with micronutrients if conditions indicate possible need.

Since most rapid soil test methods for micronutrients are not sensitive enough to measure critical deficiency levels, you should base quantity used on the crop to be grown, soil pH, and, in the case of copper and zinc, past treatment.

In estimating the amount required in a mixed fertilizer, follow the recommendations shown in Table 16, page 32.

Micronutrients can be absorbed through the leaves of plants. Where spray equipment is available, cost of material used is greatly reduced. Suggested rates as sprays are discussed on page 31.

Manganese

Manganese deficiency is likely to occur on organic soils with a pH of 5.8 or above, and is most severe on cold wet soils. Such a deficiency can be corrected by the application of manganese salts or by the addition of enough sulfur to acidify the soil. Use manganese salts for immediate results; sulfur, for a more lasting effect. Very acid soils that have been limed usually show a greater need for manganese fertilization than do soils naturally high in lime.

Crops listed in Table 19 are grouped according to the degree of response to treatment with manganese.

TABLE 19—Crop response to micronutrients (organic soils)

Crop	Micronutrient response			
	Manganese	Boron	Copper	Others
Alfalfa	Low	High	High	
Asparagus	Low	Low	Low	
Barley	Medium	None	Medium	Zinc
Beans	High	None	Low	Zinc
Blueberries	Low	None	Medium	
Broccoli	Medium	Medium	Medium	Molybdenum
Cabbage	Medium	Medium	Medium	Molybdenum
Carrots	Medium	Medium	High	
Cauliflower	Medium	High	Medium	Molybdenum
Celery	Medium	High	Medium	
Clover	Medium	Medium	Medium	Molybdenum
Cucumbers	Low	Low	Medium	
Corn	Medium	Low	Medium	Zinc
Grass	Medium	None	Medium	
Lettuce	High	Medium	High	Molybdenum
Oats	High	None	High	
Onions	High	None	High	Zinc, molyb-denum
Parsnips	Low	Medium	Medium	
Peas	High	None	Low	
Peppermint	Low	None	Low	
Potatoes	High	Low	Low	
Radish	High	Medium	Medium	
Rye	None	None	None	
Spearmint	Medium	None	Low	
Soybeans	High	None	Low	
Spinach	High	Medium	High	Molybdenum
Sudangrass	High	None	High	
Sugar Beets	Medium	High	Medium	
Sweet corn	Medium	Low	Medium	
Table beets	Medium	High	High	
Turnips	Medium	High	Medium	
Wheat	High	None	High	

*TABLE 20—Manganese needed for organic soils —elemental basis**

Crop response	Pounds per acre		
	pH 5.8-6.4	pH 6.5-7.2	pH 7.3-8.0
High	10	20	40†
Medium	5	10	20
Low	0	5	10

*Manganese not recommended if pH is below 5.8.
†More practical to disk in 500 pounds of sulfur per acre and use 20 pounds of manganese per acre.

The amount of manganese suggested for crops as affected by pH is shown in Table 20. Soil fixation can be very great, particularly when the fertilizer is broadcast. For this reason, place the manganese in bands near the seed. If manganous oxide is used as manganese carrier, use only with acid forming fertilizers. Manganese must be applied yearly, since often there is no carryover in the available form.

Boron

The need for fertilizing with boron on organic soils depends on the crop grown (see Table 19). It is generally applied broadcast or drilled in before seeding and should not be banded near the seed. Corn, barley, and beans are frequently injured by boron applications.

The availability of boron in the soil is affected by the lime content. For this reason, the amounts suggested in Table 21 are greater on high-lime soils. In estimating boron needs, expect some residual effect for the succeeding crop. However, this will not injure sensitive crops if recommended rates are applied. It may be necessary to use quantities greater than those suggested in Table 21 for table beets.

TABLE 21—Boron recommendations for organic soils—elemental basis

Crop response	Pounds per acre	
	pH 5.0-6.4	pH 6.5-8.0
High	3	5
Medium	1	3
Low	0	1

Copper

Acid peaty soils are usually low in copper but liming will not decrease its need. The carriers used for fertilizers are usually either the sulfate or oxide forms. Copper applied to organic soils is not easily leached, nor is it much used by the crop. For this reason, no further copper fertilization is needed if a total of 20 pounds per acre has been applied to low or medium responsive crops and 40 pounds per acre for high responsive crops.

Additional copper will be needed if soil erosion is serious or the field is plowed deeply. In many instances, the copper level in the soil is ample because of repeated applications of copper fungicide dust or spray. Crops listed in Table 19 show the degree of response to copper fertilization, and data in Table 22 show copper recommendations.

*TABLE 22—Copper recommendations for organic soils—elemental basis (Native soil pH)**

Crop response	Pounds per acre		
	pH 5.4 or less	pH 5.5-6.4	pH 6.5 or higher
High	6	4	2
Medium	4	2	0
Low	2	0	0

*Double rates for fields that never received copper.

Zinc

Zinc deficiency is more likely to occur on nearly neutral or alkaline organic soils. Onions, beans, and corn are affected under Michigan conditions. Apply 3 to 4 pounds of zinc annually for 2 or 3 years. Limited tests show that seed treatment will help prevent a zinc deficiency.

Molybdenum

Molybdenum deficiency has been noted on lettuce, spinach, cauliflower, cabbage, and onions. The organic soils that need molybdenum are below pH 5.5. Soils with high iron content also show a need for molybdenum.

The recommended rate of molybdenum is about 0.3 pound per acre applied in the fertilizer band near the seed. Foliar spray applications of 2 ounces of sodium molybdate per acre may be helpful. Recent information shows that seed treatment at rate of ½ ounce of sodium molybdate per acre can prevent a deficiency. For seed treatment dissolve the ½ ounce of sodium molybdate in 3 tablespoons of water. Mix with seed for one acre. Dry seed with "Arasan" fungicide.

Sodium-Magnesium

Sodium and magnesium are secondary elements that may benefit certain crops. Sodium applied in the form of ordinary salt will help sugar beets, table beets, and celery, especially when the soil is low in available potash. It is, however, necessary to include potash in the fertilizer. Suggested rates of salt are 500 pounds per acre.

Magnesium deficiency is a problem in certain celery varieties. For these varieties, apply Epsom salts (magnesium sulfate) weekly to the foliage of the plant at the rate of 10-20 pounds per acre. Soil applications are not effective. Magnesium deficiency has seldom been noted on other crops growing on organic soils. It could be a problem where naturally very acid soils are limed with calcic limestone, or where excess amounts of potash fertilizer have been used.

TYPICAL RECOMMENDATIONS ON ORGANIC SOILS OF LOW FERTILITY

Broccoli, cabbage, and cauliflower

Drill in 4 inches deep 600 to 800 pounds of 0-10-30 or 5-10-30 per acre for cabbage and 1,000 pounds per acre for cauliflower and broccoli. These crops need a sidedressing of 30 to 100 pounds of nitrogen fertilizer depending upon drainage and weather conditions. Cauliflower needs ½% boron and 0.04% molybdenum in the fertilizer if the soil pH is 5.8 or above. If below pH 5.8, use ¼% boron and 0.08% molybdenum.

Carrots, parsnips

Drill in or plow down 5-10-30 containing ⅛% boron and ½% copper at the rate of 800 pounds per acre.

If soils are extremely low in fertility, use combination fertilizer and seeder drill. Plow down 600 pounds of 5-10-30 containing ¼% boron and ½% copper. Use in band 1 inch to the side and 2 inches below the seed, 6-24-12 at the rate of 200 pounds per acre. Do not use larger rates in band near seed as this can cause misshapen roots. Plow down placement is preferred especially for fresh market carrots.

Celery

For the early crop, disk in or drill in 5-10-20 at the rate of 1,500 to 2,000 pounds per acre. Use 5-10-30 at similar rates for the late crop. Use ¼% boron in the fertilizer for rates of 1,000 to 2,000 pounds per acre. If less than 1,000 pounds, use ½% boron. Use 1% manganese in the fertilizer if the soil is above pH 6.5.

Sidedress one to three times during the growing season at the rate of 50 pounds of actual nitrogen per acre per application. The number of applications will depend upon the season, drainage and type of muck. Color of plant and plant tissue tests will help determine your nitrogen needs. Avoid excessive rates of ammonium nitrogen in the spring, especially if the soil is fumigated. Under these conditions use only sodium nitrate or calcium nitrate. Ammonia type fertilizers can be used after June 15.

Certain celery varieties need magnesium applied as a spray. Use Epsom salts (magnesium sulfate) at the rate of 10 pounds per acre per week. If this rate does not correct the magnesium yellowing, then step up rate to 20 pounds. Calcium is needed to prevent blackheart disorder and is applied as calcium chloride at the rate of five to ten pounds per acre weekly.

Corn (field or sweet)

Plant population goals should be 18,000 to 20,000 plants per acre. Plow down 200 pounds per acre of 60% potash containing ½% boron.

Use in bands 2 inches to the side and below the seed, 6-24-12 containing ½% copper and ½% zinc at rate of 200 to 250 pounds per acre. If the soil pH is above 6.5, use 2% manganese and 1% zinc in the row fertilizer. Sidedress with 50 to 80 pounds of actual nitrogen if plants are not dark green in color in late June.

Head lettuce, spinach

Disk in or plow down 200 pounds of potash per acre. Use in band 2 to 3 inches below the seed and 1 inch to the side 400 pounds of 6-24-12 containing ⅛% boron and ½% copper per acre. In addition, if the pH is 5.8 to 6.4 use 1% manganese in the row fertilizer. If the pH is above 6.4 then use 2% manganese. Molybdenum seed treatment may be needed on acid mucks.

Onions

Plow down or disk in 300 pounds of 60% potash per acre. Apply in bands 2 to 3 inches below the seed 500 pounds of 6-24-12 containing ½% copper (2% copper for new land). Use 1% manganese in the band fertilizer if the pH is 5.8 to 6.4 and 2% manganese if the pH is above 6.4. These band rates are suggested for 18-inch row spacings. If rows are wider, reduce rates proportionally and increase broadcast application. Topdress onions in June with 200 pounds of pelleted ammonium nitrate or 150 pounds of urea per acre.

If all the fertilizer is applied broadcast, then disk in 1,200 pounds of a 5-20-20 fertilizer containing the needed micronutrients.

Peppermint and spearmint

In the spring, apply broadcast or drill in 400 to 500 pounds per acre of a 5-20-20 fertilizer. Topdress in June with 60 pounds of actual nitrogen per acre when the foliage is dry. Use only pelleted materials. Immediately follow the nitrogen application with a drag or finger tooth harrow so as to knock off any nitrogen pellets adhering to plants. Spearmint needs 2% manganese in the fertilizer if pH is above 6.5.

An alternate program so as to obtain winter hardy roots is to top-dress mint stubble after harvesting with 200 pounds of 0-10-30 fertilizer per acre. In the following spring broadcast 200 pounds of 6-24-12 fertilizer.

Potatoes

Plow down either 500 pounds of 50% potassium sulfate or 400 pounds of 60% potassium chloride. (The sulfate form will give tubers a higher specific gravity test. Chippers, however, report that color is better using the chloride form.) In addition, use in bands near the seed piece, 400 pounds of 6-24-12 or 500 pounds of 5-20-5 per acre. Two percent manganese is needed

in the row fertilizer if the soil pH is above 6.0. Manganese can also be applied on the foliage at the rate of 5 pounds of manganese sulfate per acre per spray, applied about four times during the growing season.

If no fertilizer is used in row, then broadcast and disk in or plow down 1,000 pounds of 0-10-30 or 5-10-30.

Avoid excess nitrogen fertilizer so as to help prevent excess tops and to mature the crop in fall. Extra nitrogen, however, may be needed if soil is extremely acid, season is cool and wet or field is poorly drained. Nitrogen levels can be checked using a tissue test on base of the leaf petiole. Chemicals used for the test can be purchased from your county agricultural agent.

Table beets, swiss chard

Disk in or plow down 700 pounds of a 5-10-30 fertilizer containing ½% boron and ½% copper. Use 1% manganese if soil pH is 5.8 to 6.4 and 2% manganese if pH is above 6.4. Plowing down 500 pounds of table salt is helpful if soils are low in potassium.

Turnips, rutabagas, radishes, cucumbers

Drill in or disk in 500 pounds of 5-10-30 per acre. Use ¼% boron in fertilizer for radishes and ½% boron for turnips and rutabagas. If soil pH is above 6.0, use 2% manganese in the fertilizer for all crops.

Beans, soybeans

Disk in or plow down 300 to 400 pounds of a 0-10-30 fertilizer. If pH is above 6.0, plow down 150 to 200 pounds of 60% potash and band place near seed 150 to 200 pounds of 20% superphosphate containing 5% manganese per acre. Additional manganese may be needed for soybeans and can be applied as a spray on affected plants with 6 pounds of manganese sulfate in 15 gallons or more of water per acre. Use 2% zinc in row fertilizer for beans if the pH is above 6.5.

Sugar beets

Plow down 400 pounds of 60% potash per acre. Use in bands three inches below the seed or one inch to the side and two inches below the seed 300 pounds of a 6-24-12 containing ½% boron and ½% copper. Use 1% manganese in the fertilizer if the pH is 5.8 to 6.4 and 2% if the pH is above 6.4.

APPENDIX

Fertilizer recommendation tables to use for soil series in Michigan.

Soil Series	Soil management group†	Fertilizer table	
		Field crops	Vegetables
Abscota	L-4a	12	15
Adolph	3c	11	15
Adrian	M/4c	17, 18	17, 18
Ahmeek	3a-a	11	15
Alcona	3a	11	15
Algansee	L-4c	12	15
Alger	3a	11	15
Allendale	4/1b	12	15
Allouez	Ga	12	15
Alpena	Ga	12	15
Amasa	3a-a	11	15
Angelica	2c	10	14
Antrim	4a	12	15
Arenac	5/2b	13	15
AuGres	5b	13	15
AuTrain*	5a-h	13	15
Bach	2c	10	14
Bannister	4/2c	12	15
Baraga	Ga	12	15
Barker	2a	9	14
Bark River	2a	9	14
Barry	3c	11	15
Belding	3/2b	11	15
Bellefontaine	3a	11	15
Bentley	4a	12	15
Bergland	1c	8	14
Berrien	5/2a	13	15
Berville	3/2c	11	15
Bibon	5/2a	13	15
Blount	2b	9	14
Blue Lake	4a	12	15
Bohemian	2a	9	14
Bono	1c	8	14
Bowers	2b	9	14
Boyer	4a	12	15
Brady	4b	12	15
Brant	4/2a	12	15
Breckenridge	3/2c	11	15
Brevort	4/2c	12	15
Bridgman*	5.3a	13	15
Brimley	2b	9	14
Bronson	4a	12	15
Brookston	2c	10	14
Bruce	2c	10	14
Brule	L-2c	10	14
Burleigh	4c	12	15
Burt	3/Rc	11	15
Butternut	2c	10	14
Cadmus	3/2a	11	15
Capac	2b	9	14
Carbondale	Mc	17, 18	17, 18
Carlisle	Mc	17, 18	17, 18
Casco	4a	12	15
Celina	2a	9	14
Ceresco	L-2c	10	14
Champion	3a-a	11	15
Channing*	5b-h	13	15
Charity	1c	8	14
Chatham	3a	11	15
Cheneaux	4b	12	15
Chesaning	4/2b	12	15
Cohoctah	L-2c	10	14
Coldwater	3b	11	15
Coloma	4a	12	15
Colwood	2c	10	14
Conover	2b	9	14
Constantine	4a	12	15
Coral	3b	11	15
Coventry	3a	11	15
Crosby	2b	9	14
Croswell	5.0a	13	15
Crystal Falls	Ra	11	15
Danby	L-2c	10	14
Dawson*	Mc-a	17, 18	17, 18
Deer Park*	5.3a	13	15
Deford	4c	12	15
Detour	Gc	12	15
Diana	Gc	12	15
Dighton	2a	9	14
Dillon	5c	13	15
Dowagiac	3a	11	15
Dresden	3a	11	15

*Practicability of fertilizers doubtful.

†Modifying symbols used after dash in soil management groups:

a — Naturally very strongly acid soils.

h — Subsoils are hardened and cemented.

Soil Series	Soil management group†	Fertilizer table	
		Field crops	Vegetables
Dryden	3a	11	15
Duel	4/Ra	12	15
East Lake	5.0a	13	15
Eastport*	5.3a	13	15
Echo	5.0a	13	15
Edmore	4c	12	15
Edwards	M/mc	17, 18	17, 18
Eel	L-2a	9	14
Elmdale	3a	11	15
Elo	2a-a	9	14
Emmert	Ga	12	15
Emmet	3a	11	15
Ensley	3c	11	15
Epoufette	4c	12	15
Essexville	4/2c	12	15
Ewen	L-2a	9	14
Fabius	4b	12	15
Fox	3a	11	15
Freesoil	3a	11	15
Froberg	1a	8	14
Fulton	1b	8	14
Gaastra	2b	9	14
Gagetown	2a	9	14
Gay	3c	11	15
Genesee	L-2a	9	14
Gilchrist	4a	12	15
Gilford	4c	12	15
Gladwin	4b	12	15
Glendora	L-4c	12	14
Gogebic	3a-a	11	15
Granby	5c	13	15
Graycalm	5.0a	13	15
Grayling*	5.7a	13	15
Greenwood*	Mc-a	17, 18	17, 18
Griffin	L-2c	10	14
Guelph	2a	9	14
Hagener	5.0a	13	15
Hartwick	5.0a	13	15
Hessel	Gc	12	15
Hettinger	2c	10	14
Hiawatha	5.0a	13	15
Hillsdale	3a	11	15
Hodunk	3a	11	15
Houghton	Mc	17, 18	17, 18
Hoytville	1c	8	14
Huron	1a	8	14
Ingalls	4b	12	15
Ionia	3a	11	15
Iosco	4/2b	12	15
Iron River	3a-a	11	14
Isabella	2a	9	15
Jeddo	2c	10	14
Johnswood	3a	11	15
Kalamazoo	3a	11	15
Kalkaska	5.0a	13	15
Karlin	4a	12	15
Kawkawlin	2b	9	14
Kendallville	3/2a	11	15
Kent	1a	8	14
Kerston	L-Mc	17, 18	17, 18
Keweenaw	4a-a	12	15
Kibbie	2b	9	14
Kinross	5c	13	15
Kiva	4a	12	15
Kokomo	2c	10	14
Lacota	3c	11	15
Landes	L-2a	9	14
Lapeer	3a	11	15
Leelanau	4a	12	15
Lenawee	2c	10	14
Linwood	M/3c	17, 18	17, 18
Locke	3b	11	15
London	2b	9	14
Longlois	2a	9	14
Longrie	3/Ra	11	15
Lorenzo	4a	12	15
Lupton	Mc	17, 18	17, 18
Mackinac	2b	9	14
Macomb	3/2b	11	15
Mancelona	4a	12	15
Manistee	4/2a	12	15
Marenisco	4a-a	12	15
Markey	M/4c	17, 18	17, 18
Marlette	2a	9	14
Matherton	3b	11	15
Maumee	5c	13	15
McBride	3a	11	15
McGregor	3b	11	15
Melita	5/2a	13	15
Menominee	4/2a	12	15
Metamora	3/2b	11	15
Metea	4/2a	12	15
Miami	2a	9	14
Montcalm	4a	12	15
Moran	3/Ra	11	15
Morley	2a	9	14

*†See footnotes, page 48.

Soil Series	Soil management group†	Fertilizer table	
		Field crops	Vegetables
Morocco	5b	13	15
Moye	4b	12	15
Munising	3a-a	11	15
Munuscong	3/1c	11	15
Mussey	4c	12	15
Nappanee	1b	8	14
Negaunee	3/Ra	11	15
Nekoosa	5.0a	13	15
Nester	2a	9	14
Newaygo	3a	11	15
Newton	5c	13	15
Nunica	2a	9	14
Oakville	5.0a	13	15
Ockley	2a	9	14
Ocqueoc	4a	12	15
Ogden	M/1c	17, 18	17, 18
Ogemaw*	5b-h	13	15
Ogontz	3/2c	11	15
Omega*	5.7a	13	15
Onaway	2a	9	14
Onota	3/Ra	11	15
Ontonagon	1a	8	14
Oshtemo	4a	12	15
Otisco	4b	12	15
Ottawa	5/2a	13	15
Ottokee	5.0a	13	15
Palms	M/3c	17, 18	17, 18
Palo	3b	11	15
Parkhill	2c	10	14
Parma	3/Ra	11	15
Paulding	0c	8	14
Pelkie	L-2c	10	14
Pence	4a-a	12	15
Perrin	4a	12	15
Perth	1b	8	14
Peshekee	Ra	11	15
Pewamo	2c	10	14
Pickford	1c	8	14
Pinconning	4/1c	12	15
Plainfield	5.0a	13	15
Pleine	3c	11	15
Posen	3a	11	15
Randville	4a-a	12	15
Richter	3b	11	15
Rifle	Mc	17, 18	17, 18
Rimer	3/1b	11	15
Rodman	Ga	12	15
Rollin	M/mc	17, 18	17, 18
Ronald	3c	11	15
Roscommon	5c	13	15
Roselawn*	5.3a	13	15
Rousseau	4a	12	15
Rubicon*	5.3a	13	15
Rudyard	1b	8	14
Ruse	3/Rc	11	15
Saganing	4c	12	15
Sanilac	2b	9	14
Saranac	L-2c	10	14
Satago	3/Rc	11	15
Sauble*	5.3a	13	15
Saugatuck*	5b-h	13	15
Saverine	3/2b	11	15
Sebewa	3c	11	15
Selkirk	1b	8	14
Seward	3/2a	11	15
Shelldrake*	5.3a	13	15
Shoals	L-2c	10	14
Sigma	4b	12	15
Sims	2c	10	14
Sisson	2a	9	14
Skanee	3b-a	11	15
Sleeth	2b	9	14
Sloan	L-2c	10	14
Spalding*	Mc-a	17, 18	17, 18
Spartan**	5.0a	13	15
Spinks	4a	12	15
Stambaugh	3a-a	11	15
St. Clair	1a	8	14
St. Ignace	Ra	11	15
Strongs	5.0a	13	15
Summerville	Ra	11	15
Sumner	4a	12	15
Sunfield	3a	11	15
Superior	1a	8	14
Tahquamenon*	Mc-a	17, 18	17, 18
Tappan	2c	10	14
Tawas	M/4c	17, 18	17, 18
Tedrow	4b	12	15
Thackery	2a	9	14
Thomas	2c	10	14
Tobico	5c	12	15
Toledo	1c	8	14
Tolfree	2c	10	14
Tonkey	3c	11	15
Traunik	5b	13	15
Traverse	3b	11	15
Trenary	2a	9	14

*†See footnotes, page 48.

**Formerly Sparta.

Soil Series	Soil management group†	Fertilizer table	
		Field crops	Vegetables
Trout Lake*	5b-h	13	15
Tula	3b	11	15
Tuscola	2a	9	14
Twining	2b	9	14
Tyre	4/Rb	12	15
Ubly	3/2a	11	15
Vilas*	5.3a	13	15
Volinia	3a	11	15
Wainola	4b	12	15
Waiska	Ga	12	15
Wakefield	2a-a	9	14
Wallace*	5a-h	13	15
Wallkill	L-2c	10	14
Warners	M/mc	17, 18	17, 18
Warsaw	3a	11	15
Wasepi	4b	12	15
Washtenaw	L-2c	10	14
Watton	2a	9	14
Wauseon	3/1c	11	15
Wea	2a	9	14
Weare	5.0a	13	15
Westland	2c	10	14
Whittemore	2c	10	14
Willette	M/1c	17, 18	17, 18
Winegars	4b	12	15
Wisner	2c	10	14

*†See footnotes, page 48.

Cooperative extension work in agriculture and home economics. Michigan State University and the U. S. Department of Agriculture cooperating. N. P. Ralston, Director, Cooperative Extension Service. Michigan State University, East Lansing. Printed and distributed under Acts of Congress, May 8 and June 30, 1914.

2P2R-2:65-5M-WE