Potato Fertilizer Recommendations
Best Management Practices for Potatoes
Michigan State University Extension Service
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BEST MANAGEMENT PRACTICES FOR POTATOES

Potato Fertilizer Recommendations

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INTRODUCTION

This report summarizes all of the lime and fertilizer recommendations for potatoes issued by the Michigan Cooperative Extension Service and the Agricultural Experiment Station. Most of these recommendations can be found in MSU Extension bulletin E-550, Fertilizer Recommendations: Vegetable and Field Crops in Michigan. More information on liming can be found in MSU Extension bulletin E-471, Lime for Michigan Soils. Additional information on secondary and micronutrients can be found in MSU Extension bulletin E-486, Secondary and Micronutrients for Vegetable and Field Crops. Further information on nitrogen fertilizer management can be found in MSU Extension bulletin WQ 09, Nitrogen Management Strategies for Potato Producers. All of these bulletins are available from your local Cooperative Extension Service office. These recommendations have been developed over the past 50 years from many experiments. We are grateful to the potato growers of Michigan for sponsoring much of this research through their support of the Michigan Potato Industry Commission.

LIME RECOMMENDATIONS

Soil acidity is extremely important to plant growth and nutrient availability. Potatoes grow best at pH 5.2 to 6.5. Below pH 5.0, aluminum and manganese toxicities occur, reducing both growth and tuber yield.

The lime requirement of acid soils is determined by measuring both solution and exchangeable hydrogen and aluminum. At Michigan State University, the SMP buffer method is used to measure the lime requirement. The degree of acidity is reported on the soil test report as lime index.

Potatoes should be limed to pH 6.0. Table 1 gives lime recommendations based on the lime index and a 9-inch plow layer. Growers need to take several precautions to prevent potato scab, which is often promoted by the addition of limestone. Growers are advised to use scab-tolerant varieties when they are available Do not apply more than 1 ton of lime within 6 months of potato planting, and do not exceed 2 tons of lime in any one application.

TABLE 1. Tons of limestone needed to raise the soil pH of mineral soils to pH 6.0 as determined by the lime index method.

Lime index	*Lime recommendation (9-inch plow depth) tons/acre*
69	0.0
68	1.2
67	1.9
66	2.7
65	3.5
64	4.3
63	5.1

To convert lime recommendations to a depth of plowing other than 9 inches, divide the above rates by 9 and multiply by the depth of plowing (number of inches).

Apply lime in the fall after potato harvest and preferably one or more years before potatoes are to be grown in the rotation. Use finely ground limestone when it is available – large granules of limestone have been known to cause localized scab infections.

NITROGEN RECOMMENDATIONS

Nitrogen (N) is essential for all living plants. It is the basic element of amino acids and proteins. Nitrogen is the most critical nutrient – it has the greatest effect on yield and tuber quality. Inadequate N can drastically reduce yields. Excess N can reduce tuber quality by lowering specific gravity, and it is a potential contaminant of groundwater. Nitrogen is the most mobile nutrient in soil and requires skillful management, particularly on sandy soils, to provide adequate available N to the plant throughout the growing season while avoiding contamination of groundwater.

Nitrogen Fertilizer Rates

MSU does not have a soil test for determining N fertilizer needs. Research is currently being done on a soil nitrate test that can be used just before planting so that growers can adjust their standard N fertilizer recommendation. At present, N fertilizer recommendations are based on expected yield goal and then adjusted for varietal differences and N fixed by previous legume crops (Table 2). Russet Burbank is the only variety for which MSU nitrogen recommendations differ. Because of its long growing season and demonstrated higher N requirement, Russet Burbank should receive an additional 40 lb of N per acre above the standard recommendation.

TABLE 2. Nitrogen fertilizer recommendations for potatoes.

Yield goal	N recommendation
cwt/acre	lb/acre
300	150
350	170
400	180
450	200
500	210

For Russet Burbank, add 40 lb of N to the recommendations.

Nitrogen Credits

Nitrogen credit for legumes such as alfalfa and clovers should be based on the kind of legume and the percent stand when plowed under. Use the following formula for determining the amount of N credit for a previous alfalfa crop.

N credit (lb/A) = 40 + .6 x percent stand

For legumes other than alfalfa, use half the rate determined by the formula.

Credit should also be given for high levels of organic matter. Reduce the standard N recommendation by 20 to 40 lb per acre for soils with 2 to 4 percent organic matter, 40 to 80 lb of N per acre for soils with 4 to 8 percent organic matter, and 80 to 100 lb for soils with greater than 8 percent organic matter.

Growing potatoes on soils that have been manured is not recommended because of problems associated with potato scab disease and the difficulty in assessing the N availability from manure.

Nitrogen Fertilizer Efficiency

Nitrogen fertilizer efficiency can be improved by supplying N fertilizer several times throughout the growing season. Fertilizing to achieve maximum efficiency usually requires applying some N at planting or before emergence, some at hilling time and some through the irrigation system. Apply approximately one-third of the recommended N at planting, one-third at hilling, and one-third through the irrigation system. The amount applied through the irrigation system should be applied no later than July 15. Later N applications are inefficiently utilized and may contaminate groundwater.

Apply no more than 60 lb of N or 800 lb of starter fertilizer in bands 2 inches to the side and 2 inches below the seed pieces at planting. Excess N and K at planting can cause salt injury to young seedlings, particularly if dry soil conditions persist.

Foliar applications of N, P and K are not recommended. Soil applications are preferred because they allow for seasonlong uptake of these nutrients and because the amount of N, P or K that can be absorbed through the leaf tissue is very limited. Potatoes have large requirements for these nutrients; therefore it is impractical to try to feed them through the leaves. Applying nutrients through the irrigation system is not considered a foliar application because the amount of water applied washes nearly all of the nutrients off the plant leaves.

Nitrogen Fertilizer Sources

Most N fertilizer sources perform equally well as long as they are applied properly. Ammonium sources such as urea (46-0-0), ammonium sulfate (21-0-0-18S), diammonium phosphate (18-46-0), monoammonium phosphate (11-48-0) and ammonium polyphosphate (10-34-0) are preferred sources at planting time because all of the N is in the ammonium (NH_4+) form. Excess rain one to two days after these materials are applied will not cause the ammonium N to be leached from the soil profile because it is held on the clay and organic soil particles. As the soil warms, the ammonium will be converted to nitrate, which is subject to leaching. Anhydrous ammonia, another ammonium source, has also been shown to be equally effective but very little ammonia is used today on potatoes. Applying ammonia to dry, sandy soil may be undesirable because the cation exchange capacity of these soils is low which may allow the ammonia to escape from the soil before it is absorbed.

The use of ammonium nitrate (33-0-0), N solution (28-0-0) or calcium nitrate (18-0-0) at planting time is less desirable because the nitrate (NO_3) portion of these materials is subject to leaching loss immediately after application.

All of the above sources of N, except the phosphate materials, may be used at hilling time. Phosphorus is most efficiently utilized if applied in a band at planting time. Urea and N solutions should be incorporated into the soil by cultivation or irrigation within 24 hours to minimize any loss of N by ammonia volatilization. Do not broadcast urea when the plant foliage is wet, because it will burn the leaves.

N solution (28 percent) is the preferred source for application through the irrigation system because of its convenience. Dry sources of N such as urea, ammonium sulfate and ammonium nitrate can be dissolved in water and applied through the irrigation system. Anhydrous ammonia should not be applied through the irrigation system because of ammonia losses to the atmosphere.

Ammonium sulfate (21 percent), when banded at planting time and again at sidedress time, has been shown to reduce, but not control, potato scab disease. Good irrigation management at tuber initiation and use of scab-tolerant varieties has the greatest potential for educing potato scab. The use of ammonium sulfate in addition to good irrigation management and tolerant varieties may further reduce scab in badly infested fields.

PHOSPHORUS RECOMMENDATIONS

Potatoes are rather inefficient at making use of soil phosphorus (P). As a result, potato responses to P fertilizers have frequently occurred at relatively high soil test levels (300 to 500 lb P per acre). For instance, yield responses have been observed at the Montcalm Research Farm, where the soil test showed 481 lb per acre. Limited studies have been conducted on soils testing higher than 500 lb P per acre. On-farm P demonstrations in 1988 on soils testing 900 to 1,000 lb P per acre showed no noticeable growth or yield differences due to P fertilizer. Phosphorus contamination of Michigan lakes has recently become a public concern. Nonpoint source P contamination from agricultural land is often blamed for much of the P addition to these lakes. Because of the concerns about additional P contamination of Michigan lakes and the lack of good response data on higher testing soils, MSU does not recommend P fertilizer on soils testing above 600 lb P per acre.

Phosphorus Fertilizer Rates

MSU P fertilizer recommendations based on P soil test level and yield goal are given in Table 3. One hundred hundredweight (cwt) of potatoes remove approximately 13 lb of P_2O_5 per acre. MSU recommends more P than is removed at low soil test levels, maintenance amounts at medium soil test levels, and less than is removed at high soil test levels.

Recommendations vary, depending on the yield goal. Higher yields require higher rates of P fertilizer than lower yields because of greater removal. Studies conducted by MSU show that P fertilizer has no significant effect on tuber solids.

TABLE 3. Phosphorus (P_2O_5) recommendations for potatoes grown on mineral soils.

Soil test	Yield goal, cwt/acre		
	300	400	500
lb P/acre	Phosphorus recommendation lb P_2O_5/acre		
100	80	85	90
200	50	50	55
300	30	30	35
400	20	20	20
500	0	20	20
600	0	0	20

Phosphorus Fertilizer Placement

Most of the P fertilizer added to soil is precipitated out in an unavailable form – only small amounts remain in soil solution. For this reason, band applications alongside the seed pieces are more efficient than broadcast applications. Any P fertilizer that is applied to potatoes should be applied in bands 2 inches to the side and 2 inches below the seed pieces at planting time.

Soil pH and texture greatly affect phosphorus availability. The availability of P is greatest in sandy soils at pH 6.5. Most potatoes are grown on acid soils where soluble P fertilizer is readily precipitated as iron and aluminum phosphate. The P soil test level in sandy soils can easily be raised by P fertilizer additions, but fine-textured soils require moderate additions of P fertilizer to raise the P soil test level.

Phosphorus Sources

The most common P fertilizers are diammonium phosphate (18-46-0), a dry solid, and ammonium polyphosphate (10-34-0), a liquid. They are the common ingredients in bulk blended and liquid mixed starter fertilizers. Monoammonium phosphate (11-48-0), another solid material, is sometimes used in bulk blends, but because of its added expense, it is used less frequently. All sources are rated equal if applied in the same manner. Liquid 10-34-0 has the advantage of being easy to handle, and it can be easily mixed with 28 percent N solutions to obtain a lower P analysis starter, which is needed on many potato fields. Liquids that can be pumped also have the advantage of allowing lower application rates than solid fertilizer. The primary disadvantage of using liquid fertilizers is their incompatibility with certain inorganic micronutrient sources, such as manganese sulfate.

POTASSIUM RECOMMENDATIONS

Potassium (K) is very similar to N in that it can greatly affect potato tuber quality. High rates of K fertilizers will lower specific gravity (percent solids). Complicating the issue is the fact that potatoes have a high requirement for K. Five hundred hundredweight (cwt) of potatoes will remove approximately 300 lb of K_2O per acre. Because most potatoes are grown on sandy soils in Michigan and sandy soils do not hold large amounts of K, growers must pay a great deal of attention to K fertilization. Soil testing is the key to determining the amount of K fertilizer to apply.

Potassium Fertilizer Rates

Potassium fertilizer recommendations based on K soil test level and yield goal are given in Table 4. MSU recommends more K than is removed at very low soil test levels, maintenance amounts at low to medium soil test levels, and less than is removed at medium to high soil test levels. Recommendations also vary with yield goal. Higher yields require higher rates of K fertilizer than lower yields because of greater removal.

Potassium Fertilizer Placement

Potassium fertilizer may be applied broadcast before planting or banded at planting time. Do not apply more than 100 lb of K_2O per acre banded at planting time. Large amounts of K salts in this location can cause salt injury to young plants. If more than 100 lb of K_2O is needed based on the soil test, it should be applied before planting. Potash (0-0-60) may be applied in the fall of the year on fine- and medium-textured soils. Fall applications will reduce the amount of chloride available during the growing season, which should have a positive effect on tuber quality. Fall applications of potash on loamy sand or sand soils, however, is not recommended because some can be potentially lost over winter by leaching. Topdress applications of potash after planting are not recommended.

TABLE 4. Potassium (K_2O) recommendations for potatoes grown on mineral soils.

Soil test	Yield goal, cwt/acre		
	300	400	500
lb K/acre	lb K2O/acre		
sandy loams and loamy sands			
50	280	330	380
100	230	280	330
200	130	180	230
300	30	80	130
400	0	0	30
500	0	0	0
loams, clay loams and clays			
50	280	350	410
100	220	280	350
200	100	160	220
300	0	30	100
400	0	0	0

Potassium Fertilizer Sources

Potassium chloride, also known as muriate of potash (0-0-60), is the cheapest and most common source of K fertilizer. It is used in most bulk blend starter fertilizers and for direct application. Some research has shown that potassium sulfate and potassium nitrate will have less effect on tuber specific gravity than potassium chloride, although all these materials will reduce specific gravity at high rates of application. Under good irrigation management and moderate rates, very little difference in tuber quality has been observed in the field. Because of the higher cost of potassium sulfate and potassium nitrate and the lack of consistent improvement in tuber solids, these sources of K are not recommended over potassium chloride.

SECONDARY NUTRIENT RECOMMENDATIONS

Calcium (Ca), magnesium (Mg) and sulfur (S) are secondary nutrients essential for plant growth. They are required in smaller amounts than the major nutrients N, P and K but in larger amounts than micronutrients.

Calcium

Well-limed soils usually contain adequate levels of available Ca. Even soils needing lime to correct soil acidity usually contain sufficient Ca for most crops. The poor growth of plants on acid soils is usually due to excess soluble manganese, iron and/or aluminum rather than calcium deficiency. The amount of exchangeable Ca in soil is usually related to the clay content. Hence, lower exchangeable Ca levels usually occur on sandy soils.

The Ca content of soil water usually varies from 8 to 450 ppm and averages near 30 ppm. Assuming a ratio of 400 to 1 as the amount of water to produce 1 pound of dry matter, even the lowest reading of 8 ppm would supply sufficient Ca to the root. Nevertheless, localized Ca deficiency in potato tubers has been associated with internal brown spot (IBS) and increased susceptibility to soft rot disease in tubers. Limited research on Atlantic potatoes shows that gypsum (calcium sulfate) applied in the row was able to reduce IBS, though it did not reduce the incidence to an acceptable level. Calcium in these studies did not significantly affect specific gravity, hollow heart, chip color or tuber yield. Gypsum in these studies was applied at rates of 500 and 750 lb per acre. It is doubtful that the same kind of results could be obtained with low rates of Ca (less than 100 lb).

Wisconsin research has shown that potatoes may benefit from Ca fertilizer additions when soils test less than 700 lb of exchangeable Ca per acre. Most of these soils will also benefit from lime (calcium carbonate), which also raises the soil pH. Further research in Michigan is needed to determine when supplemental Ca should be applied, how much and what source. With our present knowledge, it is difficult to recommend supplemental Ca for tuber quality enhancement as a general practice.

Magnesium

Magnesium (Mg) deficiency is most likely to occur on acid, sandy soils or soils that have been limed with calcitic lime or marl. Potatoes are quite responsive to Mg, and growers should pay more attention to Mg soil test levels. Magnesium can also get out of balance with K. Overfertilization with K fertilizer can create a Mg deficiency.

The MSU fertilizer recommendation program uses three criteria to determine when to recommend Mg on mineral soils: (1) if the soil test level is below 75 lb per acre; (2) if K exceeds Mg (calculated as a percentage of the total exchangeable bases as indicated on your soil test); and, (3) if Mg represents less than 3 percent of the total exchangeable bases. When any of the three criteria indicates a need for Mg, you must then examine your soil's lime requirement. When lime is needed, the recommendation is to use dolomitic limestone to provide Mg. When no lime is called for, the recommendation is to use 50 to 100 lb of soluble Mg per acre broadcast or 10 to 20 lb per acre in the row at planting. Magnesium sulfate (epsom salts), potassium-magnesium sulfate (Sul-Po-Mag or K-Mag), and finely ground magnesium oxide are all satisfactory Mg sources.

Magnesium may also be applied as a foliar spray, but soil applications are preferred to give seasonlong uptake. Suggested foliar rates per acre are 10 to 20 lb of magnesium sulfate in at least 30 gallons of water.

Sulfur

Though sulfur (S) is an essential nutrient, field studies with several responsive crops on many sites throughout Michigan have not shown any benefit from sulfur applications. Potatoes are less responsive to sulfur than many other crops. (See the discussion above on ammonium sulfate under the section on N fertilizer sources with regard to its use in reducing potato scab disease.)

MICRONUTRIENT RECOMMENDATIONS

Deficiencies of manganese (Mn), zinc (Zn), copper (Cu) and boron (B) are the only micronutrient deficiencies recognized in potatoes in Michigan. Manganese and Zn deficiencies can occur in both organic and mineral soils. Copper and B deficiencies are recognized only in organic soils. Potatoes are classified as having a high response to Mn, medium response to Zn, and low response to Cu and B. Iron (Fe) and molybdenum (Mo) deficiencies do not occur in Michigan.

Manganese Recommendations

Manganese (Mn) deficiency in potatoes is most often associated with the lake-bed and organic soils of Michigan. The availability of Mn is largely determined by the soil pH. Therefore, Mn fertilizer applications should be based on soil pH and a Mn soil test. Manganese deficiency does not occur in mineral soils unless the soil pH is above 6.2. On organic soils, Mn deficiency is seldom found unless the soil pH is above 5.8. One ppm of 0.1 N HCl extractable Mn is normally sufficient for potatoes grown on acid sandy soils (soil pH). (See Table 5 for Mn recommendations based on the soil pH and Mn soil test level for mineral and organic soils.) As the soil pH increases, Mn availability rapidly decreases. Thus, higher soil test levels are needed at higher soil pH's to prevent a deficiency. Likewise, more Mn fertilizer is recommended at higher pH levels for a given Mn soil test level.

TABLE 5. Manganese fertilizer recommendations for potatoes.

MINERAL SOILS				
Soil test	Soil pH			
	6.0	6.5	7.0	7.5
ppm	lb Mn/acre			
4	0	3	6	9
8	0	0	4	8
12	0	0	3	6
16	0	0	0	5
20	0	0	0	3
24	0	0	0	2
28	0	0	0	0
ORGANIC SOILS				
Soil test	Soil pH			
	5.8	6.2	6.6	7.0
ppm	lb Mn/acre			
4	0	5	8	11
8	0	3	7	10
12	0	2	6	9
16	0	0	4	8
20	0	0	3	6
24	0	0	2	5
28	0	0	0	4
32	0	0	0	3
36	0	0	0	2
40	0	0	0	0

When Mn is needed, the best placement is in the starter fertilizer banded at planting time. Broadcast applications of Mn fertilizer are totally ineffective. Foliar applications of Mn have been successfully used to correct Mn deficiencies. Use 1 lb of Mn as manganese sulfate in a foliar application when the plants are small and 2 lb on larger plants. Several foliar applications of Mn may be necessary to adequately correct a severe deficiency. It is impractical to try to build up soil test levels of Mn with Mn fertilizers. If Mn deficiency occurs, it will be necessary to apply Mn fertilizers every year unless the soil pH drops.

Manganese Fertilizer Sources

Only inorganic sources of Mn are recommended. Manganese chelates are ineffective on organic soils and usually too expensive to be used at the same rate as inorganic sources on mineral soils. They do not have greater availability than inorganic sources. Manganese sulfate is the most common source of Mn fertilizer. Granular manganese oxide is not recommended unless it has been finely ground.

Zinc Recommendations

Zinc fertilizer applications to potatoes should be based on soil pH and a Zn soil test. Zinc deficiency does not occur in mineral or organic soils when the soil pH is below 6.7. One ppm of 0.1 N HCl extractable Zn is normally sufficient for potatoes grown on acid, sandy soils (soil pH). (See Table 6 for Zn recommendations based on the soil pH and Zn soil tests.) As the soil pH increases above 6.7, Zn availability rapidly decreases. Thus, higher soil test levels are needed at higher soil pH's to prevent a deficiency. Likewise, more Zn fertilizer is recommended at higher pH levels for a given Zn soil test.

TABLE 6. Zinc fertilizer recommendations for potatoes grown on mineral and organic soils.*

Soil test	Soil pH			
	7.0	7.2	7.4	7.6
ppm	lb Zn/acre			
2	2	3	4	5
4	1	2	3	4
6	0	1	2	3
8	0	0	1	2
10	0	0	0	1
12	0	0	0	1
14	0	0	0	0

*Recommendations in this table are for band application of an inorganic zinc carrier. When using zinc chelates, divide these rates by 5.

When Zn is needed, the best placement is in a starter fertilizer banded at planting time. Alternatively, a broadcast application of 25 lb of elemental Zn per acre may be used to correct the soil Zn levels for a longer period of time. Soil test levels of Zn can also be built up with repeated low rates of Zn fertilizer over time.

Foliar applications of Zn may be used if, for some reason, soil applications of Zn were not made and the possibility of a deficiency exists. Because plants require very small amounts of Zn, foliar application is possible; however, soil applications usually provide longer Zn availability. For foliar applications, use 0.25 lb of Zn as zinc sulfate in 30 gallons of water when plants are small and 0.5 lb of Zn for larger plants.

Zinc Fertilizer Sources

In the fertilizer industry, both inorganic and organic Zn sources are used. Inorganic zinc sulfate is the most commonly recommended Zn fertilizer. Granular zinc oxide is not recommended unless it has been finely ground. Both inorganic sources are blended with solid starter fertilizer. Zinc chelates are normally used with liquid starter fertilizers. True chelates, such as Zn-EDTA and Zn-NTA, are recommended at one-fifth the recommended rate of inorganic sources because of their greater availability in soil. Some chelates, such as natural chelates found in wood extracts, are not as good as the true chelates.

Copper Recommendations

Copper (Cu) deficiency occurs in Michigan only on acid, peaty soils. A single application of 20 pounds of Cu per acre to these organic soils when they are brought into production will usually correct the problem. (See Table 7 for Cu recommendations to be used in starter fertilizers.) These recommendations are based on 1.0 N HCl extractable Cu levels and crop responsiveness to Cu fertilizer. Foliar applications of Cu have also been used successfully. In many instances, the Cu level in soil is ample because of repeated applications of Cu fungicide dust or spray.

TABLE 7. Copper fertilizer recommendations for potatoes grown on organic soils.

Soil test	Copper recommendation
ppm	lb cu/acre
2	3
5	2
10	2
15	1
20	0

Copper Fertilizer Sources

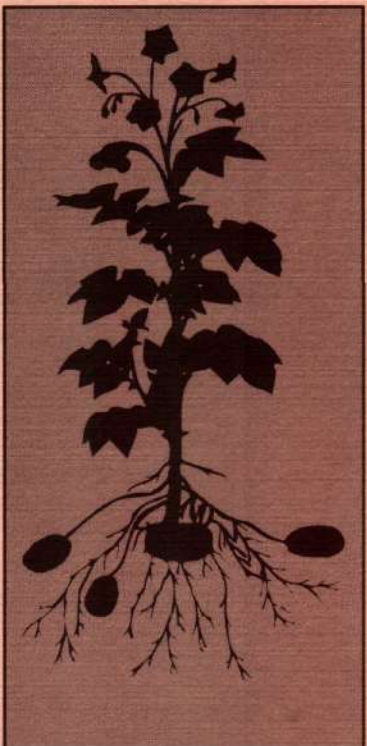
Copper sulfate and copper oxide are the most commonly used Cu fertilizers. Foliar applications of Cu sulfate at 0.5 to 1 pound of Cu per acre in 30 gallons of water have been used successfully. Use the lower rate on small plants and the higher rate on larger plants.

Boron

Boron (B) deficiency in potatoes is not recognized on mineral soils in Michigan, though it is known to affect netting of Russet Burbank potato tubers in Western states. Potatoes are considered to be a low responsive crop and sensitive to B fertilizer. On organic soils, 0.5 lb of B is recommended if the soil pH is above 7.0.

Iron

All Michigan soils contain adequate amounts of available iron (Fe) for potatoes. High Fe availability in organic soils usually creates problems of iron-induced Mn deficiency. Acid, sandy soils (pH) usually contain large amounts of both Fe and Mn and need to be limed to prevent toxicities from these elements.



This is one of a series of **Best Management Practices for Potatoes** bulletins designed to assist Michigan potato growers. These bulletins, a joint effort of the MSU Cooperative Extension Service and the Michigan Agricultural Experiment Station, are based on information and recommendations made possible through research supported wholly or in part by the Michigan Potato Industry Commission.

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