NUTRIENT MANAGEMENT FOR POTATO PRODUCTION

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Optimum potato growth and profitable production depend on many management factors, one of which is ensuring a sufficient supply of nutrients. There are 14 soil-derived elements or nutrients considered to be essential for growth of plants. When the supply of nutrients from the soil is not adequate to meet the demands for growth, fertilizer application becomes necessary. Potatoes have a shallow root system and a relatively high demand for many nutrients. Therefore, a comprehensive nutrient management program is essential for maintaining a healthy potato crop, optimizing tuber yield and quality, and minimizing undesirable impacts on the environment.

The goal of this presentation is cover nutrient management tools and options to help improve potato nutrition. While it is recognized that specific nutrient demands and responses will often differ with variety and growing conditions, the general approach for determining nutrient needs will be the same. The topics addressed include soil testing, tissue analysis, and nutrient management strategies.

Soil testing

Fundamental to any effective nutrient management program is a reliable soil analysis and soil test interpretation. Samples should be representative of the area to be fertilized and generally should be taken in the top 6-8 inches. The soil test will help to determine whether lime or nutrients are needed and if so, what rate should be applied. A typical soil analysis for potatoes should include pH, organic matter, P, K, Ca, Mg, Zn, and B. Soil nitrate tests can be done but are generally most accurate when used in dry climates on finer-textured soils and when taken to a depth of 2 feet. Other nutrients such as S, Mn, Fe, and Cu can be determined if a problem is suspected. While the actual soil test results should be fairly similar from one lab to the next, extractants may differ and interpretations may vary widely. For most accurate fertilizer recommendations, soil test interpretations should be based on local or regional research.

<u>Soil pH</u>: One of the more important chemical properties affecting nutrient use is soil pH. Optimal soil pH for nutrient availability is between 6 to 7. Many soils used for potato production have become increasingly more acid over time due to use of ammonium containing fertilizers and leaching of cations from the rootzone. Acid conditions are generally favored for potatoes in order to minimize the incidence of common scab (*Strepotmyces scabies*), which is most widespread when soil pH is above 5.5. Use of liming amendments is often avoided to minimize scab. Controlling scab in this manner, however, can result in a soil pH that will cause nutrient imbalances. Once soil pH drops below 4.9, nutrient deficiencies and toxicities become more common. In particular, Mn and Al toxicity and P, K, Ca, and Mg deficiencies may occur in these low pH soils. The problem may not be prevalent through the entire field, but may occur in smaller areas

where the soil consists of higher sand or lower organic matter content. In some cases, grid sampling a field for pH may be useful to identify areas that need correction. If corrective measures need to be taken, lime the soil to a pH of 5.5 during the years when potatoes are not grown. Use of scab resistant varieties is also recommended so that pH can be maintained in a more optimal range.

Tissue analysis

Tissue analysis has been used for many years as an additional nutrient management tool to: 1) diagnose a nutrient deficiency or toxicity, 2) to help predict the need for additional nutrients (primarily nitrogen), and 3) monitor the effectiveness of a fertilizer program. The basis behind tissue analysis is that maximum yield and quality are associated with an optimum range of nutrient in the tissue sampled. If the level of nutrient falls outside this range then, then corrective measures should be taken. The most common tissue used for nutrient analysis in potato is the petiole (leaf stem and midrib) of the fourth leaf from the shoot tip. It is critical that this tissue stage is collected because younger or older tissue will have different nutrient concentrations and can lead to erroneous interpretations. For sampling, approximately 30 to 40 leaves should be collected and the leaflets stripped off and discarded. Petioles are then sent to a laboratory for analysis. Most diagnostic criteria for tissue analysis are based on a sample taken during the tuber bulking stage. Samples taken too early in the season or soon after a fertilizer application may not accurately reflect the true nutritional status of the plant if uptake of applied fertilizer by roots has not occurred. For irrigated potatoes, tissue analysis should begin about one week after final hilling and at least four days after a fertigation.

Nutrient Management Strategies

Nitrogen (N): Of all the essential elements, N is the one most often limiting for potato growth. Application of fertilizer N is usually necessary to ensure profitable potato production because soil N is largely tied up in organic matter and not readily available for uptake. Both N rate and timing can have important impacts on yield and quality.

Factors to consider when deciding on the rate of N to apply include: variety, yield potential or goal, growing season, soil organic matter content, and previous crop. If manure is used, then an estimate of N availability from the manure should be incorporated into the overall N applied. In general, early maturing varieties and those grown for early markets require less N than late maturing varieties. Too high a rate of N will delay tuber initiation and maturity leading to excessive vine growth at the expense of tuber growth. Delayed maturity can result in tubers with lower specific gravity. High N will induce vigorous foliage, which can lead to an increase in vine rot diseases. On the other hand, lack of N can increase the early blight infestations. Controlling early blight with proper use of fungicides will, in some years, reduce the N requirement. In other years, use of fungicides increases yield potential and hence N requirement is the same or higher when early blight is controlled. Generalizations on foliar disease incidence and N requirement are difficult to make.

In general, split applications of N are recommended for potatoes from both a production and an environmental standpoint. A portion of the N should be applied preplant or planting and the remainder at emergence and hilling. Nitrogen uptake by the potato plant is highest during the tuber bulking stage. Split applications will generally improve N use efficiency by reducing leaching losses due to excessive rainfall and providing available N when it is needed for tuber growth. Applications of N after hilling should be based on petiole nitrate analysis.

Many studies have been conducted to identify what source of N is best for potato production; however, interactions with variety, application method, and growing conditions make it difficult to draw a general recommendation on N source. Common N sources used with success include ammoniated phosphorus sources as starter fertilizer followed by sidedress applications of urea, ammonium nitrate, urea-ammonium nitrate solutions, or ammonium sulfate. Care should be taken not to band high amounts of ammonium containing fertilizer close to the seed piece as ammonia toxicity may result, especially on high pH soils. Ammonium nitrate is a quickly available N source and used frequently on early maturing varieties. It is also the most susceptible to leaching. Urea needs to be incorporated or irrigated in, otherwise N loss due to ammonia volatilization may result. Ammonium sulfate also provides sulfur and is the most acidifying N fertilizer. On a nitrogen basis, the cost of ammonium sulfate is double that of urea. However, if sulfur is also needed, then ammonium sulfate is an economical source to use. Specialty N sources such as calcium nitrate can be effective, but are many times the cost of urea.

<u>Phosphorus (P)</u>: Phosphorus is important in enhancing early crop growth and tuber set and promoting tuber maturity. Experiments conducted over a 6-year period in Minnesota revealed a consistent response to banded P fertilizer applied at rates of 100 to 150 lb P_2O_5/A in lower P testing soils (Bray P less than 25 ppm). Inconsistent response to P fertilizer was found in high P testing soils (Bray P greater than 25 ppm). In about 50% of the studies, a positive response to P was found on high testing soils. In some cases, the positive response may have been due to low pH (5.3 or less), which tends to tie up P. In the other 50%, the response was not significant. On average, some P fertilizer appears to be necessary for potatoes to reach maximum yields in sandy soils of central Minnesota. It is recommended that studies need to be conducted on a local basis to determine potato response to P fertilizer.

<u>Potassium (K)</u>: Potatoes take up significant quantities of K and this nutrient plays important roles in tuber yield and quality. Soils tests have been found to be very useful in predicting K responsive soils. On low K testing soils, which require high K fertilizer application rates, both broadcast and banded applications can be used. Potassium chloride (0-0-60) is the most economical K source, but it has a high salt index and may cause salt problems if banded at rates higher than 200 lb K_2O/A. Low K is associated with an increased incidence of internal black spot bruising. Specific gravity may be reduced with high rates of potassium chloride, while potassium sulfate (0-0-50) at equivalent K rates has less of an effect on specific gravity. In season applications of K fertilizer tend to increase bulking, but will usually lower specific gravity.

Calcium (Ca), magnesium (Mg), and sulfur (S): In general, most soils contain sufficient amounts of secondary nutrients for potato production. However, acid sandy soils low in organic matter may require addition of one or more of these nutrients. Use of dolomitic lime as the liming source for acid soils will provide both calcium and magnesium.

Calcium plays an important role in maintaining tuber quality in storage and reducing internal tuber disorders due to water or temperature stress. Addition of Ca to soils having less than 400 ppm extractable Ca may improve tuber yield and quality. In some situations, localized Ca deficiency may occur on high testing Ca soils and can result in tuber storage and internal breakdown problems. These problems are the result of inadequate transport of Ca in the tuber caused by water or temperature stress. Addition of calcium on high testing soils is recommended only if the potatoes are to be stored and storage problems have been encountered. Calcium sulfate (gypsum) and calcium nitrate are two Ca sources that can be used to increase tuber calcium concentrations. Gypsum can be applied at or before planting. Calcium nitrate should be incorporated into the hill as a sidedress application after emergence.

Magnesium deficiency can be a problem in soils where high rates of potassium fertilizer have been used. Response is likely if soil test Mg is less than 50 ppm. Magnesium sulfate or potassium-magnesium sulfate are the most common Mg sources available.

Sulfur requirements can often be met from soil organic matter breakdown. Rainwater and irrigation water contain some sulfate and can also provide a significant proportion of the sulfur needed for growth. Ammonium sulfate and potassium sulfate are common sources used to supply sulfur when a need is indicated from soil or tissue tests. Elemental sulfur is not an immediately available form and must be oxidized by soil bacteria to sulfate before it is can be used by the plant. The oxidation of sulfate forms sulfuric acid and will have an acidifying effect on the soil.

Micronutrients – zinc (Zn), boron (B), copper (Cu), manganese (Mn), nickel (Ni), iron Fe) chlorine (Cl), molybdenum (Mo): Micronutrients are needed in much lower quantities than the nutrients discussed above. In general, most soils contain sufficient amounts of micronutrients to meet plant needs; however, a deficiency can cause serious reduction in yields. Application of micronutrients is recommended only if a need is indicated by soil and/or tissue tests. High pH soils can limit availability of Fe, Zn and Mn. In organic soils, Cu and Mn may be limiting. Foliar application is the recommended method to correct deficiencies of these micronutrients. In many cases, pesticide sprays contain enough Cu and Zn to meet plant demands of these nutrients. Boron may be limiting in sandy soils; however, potatoes have a low demand for B and responses to applied B are not common. In addition, excessive B applications can be toxic. If B is needed, soil application is recommended because B applied to the foliage is not readily transported to the tuber. Potato responses to Ni, Cl, and Mo are not well documented.