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Phosphorus Availability with Alkaline/ Calcareous Soil

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SUMMARY

Phosphorus is an important and essential nutrient for all plants. Availability of P in high pH soils, especially those with excess lime, is relatively poor. Lowering pH is not an economical option for most crops and, as such, other strategies must be employed to enhance P uptake by roots, including: relatively high P fertilizer rates, concentrated P fertilizer bands, complexed P fertilizer, slow release fertilizer P, cation complexing P fertilizer, in-season P fertilizer application, and balancing P with other nutrients.

INTRODUCTION

Phosphorus (P) is an essential nutrient required by plants for normal growth and development. The availability of P to plants for uptake and utilization is impaired in alkaline and calcareous soil due to the formation of poorly soluble calcium phosphate minerals. Adding fertilizer Phosphorus at "normal" rates and with conventional methods may not result in optimal yield and crop quality in these soils common in arid and semi-arid regions. Several fertilizer P management strategies have been found to improve P nutrition for plants grown in alkaline and calcareous soil. Research results show that relatively high P fertilizer rates are required for crops grown in alkaline soil, with increasing rates needed as lime content in these soils increases. Concentrated P fertilizer bands improve P solubility with resulting yield increases, even when applied to crops grown in soil with relatively high soil test P concentrations. Applying organically complexed P in the form of bio solids or as a mixture of liquid P and humic substances can also enhance P nutrition and result in yield increases. Application of slow release and cation complexing specialty fertilizer P materials has also been shown to effectively increase yields in calcareous soil. In-season applied P through the irrigation water can deliver P to plant roots when deficiencies are observed, but the effectiveness and results are less than with P incorporated into the soil. Finally, it is important to maintain a proper balance of P with other nutrients for general plant health and to avoid excess nutrient induced deficiencies of other nutrients. In some cases, these methods are relatively new and need further refinement with regard to rates, timing, and technique; but all are potential methods for improving P supply to plants grown in alkaline and calcareous soil.

Phosphorus Nutrition

Phosphorus (P) is an essential macronutrient, being required by plants in relatively large quantities (~0.2 to 0.8%). Potassium and nitrogen are the only mineral nutrients required in larger quantities than P. Providing adequate P to plants can be difficult, especially in alkaline and calcareous soil. Alkaline soil is defined as soil with pH greater than neutral, typically 7.5 to 8.5. Calcareous soil is defined as having the presence of significant quantities of free excess lime (calcium or magnesium carbonate). Lime dissolves in neutral to acid pH soil, but does not readily dissolve in alkaline soil and, instead, serves as a sink for surface adsorbed calcium phosphate precipitation. The bioavailability of P is strongly tied to soil pH. The formation of iron and aluminum phosphate minerals results in the reduced solubility of P in strongly acidic soil, improving as pH approaches nearly neutral. This maximum solubility and plant availability of P at pH 6.5 declines again as the pH increases into the alkaline range. This effect of reduced P availability in alkaline soil is driven by the reaction of P with calcium, with the lowest solubility of these calcium phosphate minerals at about pH 8. The presence of lime in alkaline soil further exacerbates the P availability problem. The lime in calcareous soil reacts with soil solution P to form a strong calcium phosphate bond at the surface of the lime. These alkaline and calcareous soils are common in arid and semi-arid regions with little rainfall. Soil in regions with a long history of excess rainfall tends to have a low pH due to calcium and other bases being leached from the soil, being replaced by the hydrogen ion found in water. The resulting effect of low P solubility in alkaline and calcareous soil is relatively poor fertilizer P efficiency. Plants grown in these conditions can be stunted with shortened internodes and poor root systems due to P deficiency. Deficiency symptoms are sometimes observed as a darkening of the leaf tissue, although it is more common to observe yield loss with no readily seen symptom

Simply adding fertilizer P at "normal" rates and with conventional methods may not result in optimal yield and crop quality. Several fertilizer P management strategies have been found to improve P nutrition for plants grown in alkaline and calcareous soil, namely: 1) relatively high P fertilizer rates, 2) concentrated P fertilizer bands, 3) complexed P fertilizer, 4) slow release fertilizer P, 5) cation complexing P fertilizer, 6) in-season P fertilizer application, and 7) balancing P with other nutrients. These methods may be used alone or in various combinations to effectively supply P to plants growing in alkaline and calcareous soil. In some cases, these methods are relatively new and need further refinement with regard to rates, timing, and technique.

Concentrated Fertilizer P Bands

Although not always a replacement for necessary broadcast fertilizer P applications, adding P to soil in a concentrated band often results in further increases in yield and crop quality. The band application results in an overwhelming increase in soil solution P, effectively overcoming (temporarily) the reaction of calcium with soluble phosphate. This practice tends to provide a significant increase in P uptake, especially for early season growth when P availability is most limiting due to low soil temperatures and poorly developed root systems (Mengel and Kirkby, 1987). There is an additive response when banded fertilizer P was applied in conjunction with broadcast/incorporated P for potatoes grown in calcareous soil (2 to 12% lime) with bicarbonate extractable P of 8 to 18 ppm. In some cases, it is recommended to apply banded P even when no broadcast P is necessary (Stark and Westermann, 2003), but banded P should not be seen as a replacement for broadcast P in medium to low testing soils.

Complexed P Fertilizer

Phosphorus availability to plants for uptake can be improved by any means that results in an increase in solubility. Phosphorus bound to organic materials found in biosolid waste or commercially available fertilizer additives has been shown to improve P solubility and, thus, P nutrition in plants. Phosphorus bound in organic materials (such as manure, compost, or industrial biosolids) serves as a slow release source of P for plants. Of course, not all of the P found in these materials is bound by organic materials and, as such, reacts similarly as other forms of inorganic phosphate with the soil. Biosolids can serve as a very good source of nutrients and humic substances, but there are many potential downsides of applying biosolid waste to soil, including: presence of weed seeds, nutrient imbalances, odor, presence of toxins, cost of transportation, compaction of soil due to heavy axle loads, etc.

Slow Release Fertilizer

Another strategy that can improve P availability to plants is slow release fertilizer materials. Adding highly soluble P fertilizer results in a temporary increase in soil solution P concentration at levels that exceed chemical equilibrium constants, forcing precipitation of phosphate minerals. In alkaline soils, calcium phosphate is rapidly formed following fertilizer dissolution. A slow release P fertilizer minimizes formation of calcium phosphate as the soil solution P concentration does not spike at high levels and the P is released in a more timely fashion.

In-Season P Fertilizer Application

Nitrogen fertilizer quickly converts to the nitrate form, which is easily leached or volatilized under conditions with ample soil water. Furthermore, nitrate does not form poorly soluble minerals and, thus, is not subject to solubility problems. Alternatively, P is not typically subject to leaching loss and does not volatilize. And, as mentioned previously, P readily forms poorly soluble soil minerals. Therefore, the chemistry of P does not lend itself to movement in the soil and, as such, it is reasonable to assume that P should be incorporated into the soil zone where roots grow and take up nutrients.

CONCLUTION

From the above information it is concluded that Addition of Phosphorus in combination with ammonium tends to enhance availability of both nutrients. Ammonium and other acidifying fertilizer materials can enhance Phosphorus solubility and uptake by roots. In general, it is also wise to have generally sufficient nutrient levels of other nutrients to promote overall good root development, which is so important for Phosphorus interception and uptake. Excessively high levels of certain nutrients can induce deficiencies of others. High rates of zinc, iron, manganese, and copper can induce deficiencies of Phosphorus and visa-versa. This effect has been observed in many crops. We have taken small baby step for transferring this knowledge to the peoples of society. This information will be useful to the farmers for nutrient management in alkaline and calcareous soil.

REFERENCES

Anderson, F.N. and G.A. Peterson. 1978. Optimum starter fertilizer placement for sugarbeet seedlings as determined by uptake of radioactive 32P isotope. J. Am. Soc. Sugarbeet Technol. 20:19-24.

Hopkins, B.G. and J.W. Ellsworth. 2003. Phosphorus Nutrition in Potato Production. p. 75-86. In L.D. Robertson et. al. (eds.) Proceedings of the Winter Commodity Schools – 2003. Vol. 35. University of Idaho-Cooperative Extension System, Moscow, Idaho.

Hopkins, B.G. and J.W. Ellsworth. 2005. Phosphorus Placement for Sugarbeet in Calcareous Soil. In Press. In L. Murphy (ed.) 2005 Fluid Forum Proceedings. Vol. 22. Fluid Fertilizer Foundation, Manhattan, Kansas.

Hopkins, B.G. and J.C. Stark. 2003. Humic Acid Effects on Potato Response to Phosphorus. p. 87-92. In L.D. Robertson et. al. (eds.) Proceedings of the Winter Commodity Schools – 2003. Vol. 35. University of Idaho-Cooperative Extension System, Moscow, Idaho.

Stark, J.C. and D.T. Westermann. 2001. Developing potato fertilizer recommendations from small plot and on-farm research. In B.D. Brown (ed.) Proceedings of the Western Nutrient Management Conference, Vol. 4: 16-19. Salt Lake City, UT, March 8-9. Potash and Phosphate Institute, Manhattan, KS.