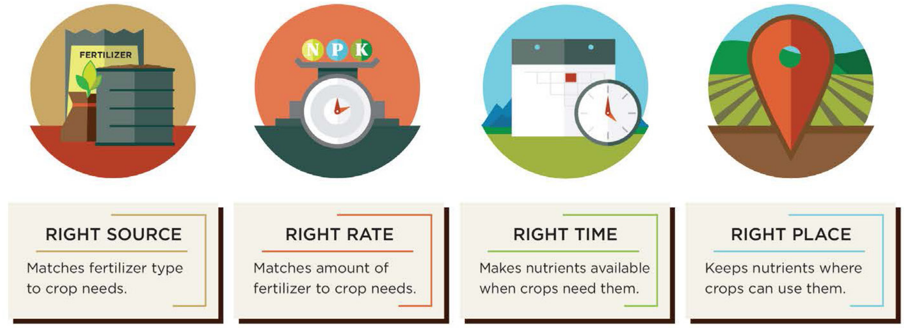
nutrient stewardship

This article is part of a series from The Fertilizer Institute highlighting some of the latest 4R research.



4R practices for fertilizer management in potatoes

Phosphorus is a key nutrient for the development of the potato plant and tubers. The status of P in the plant, deficient or sufficient, is closely related to yield. With the high value of a potato crop and the influence of proper phosphorus nutrition on plant and tuber development, the 4Rs and especially timing of phosphorus availability are critical to maximizing yield per acre. Earn 0.5 CEUs in Nutrient Management by reading this article and taking the quiz at www.certifiedcropadviser.org/education/classroom/classes/676.

By Sally Flis, Ph.D., CCA, Director of Agronomy, The Fertilizer Institute, Washington, DC

Selecting the right suite of 4R practices is key in every cropping system. While much of the discussion is often around corn and soybean systems, selecting the right source of fertilizer at the right rate, at the right time, and in the right place for economic, environmental, and social benefits also applies to crops like potatoes. In 2017, potatoes were planted on 906,700 ac in the United States (USDA-NASS, 2018). Idaho is the number one potato-producing state, supplying 34% of the potatoes in the U.S. in 2017, with an economic value of $975 million (USDA-NASS, 2018). Phosphorus is a key nutrient for the development of the potato plant and tubers. The status of P in the plant, deficient or sufficient, is closely related to yield (Thornton et al., 2008). Daily uptake ranges from 0.3 to 0.5 lb P/ac and increases rapidly during tuber initiation, continuing as the tuber grows until the plant reaches maturation (Stark et al., 2004). With the high value of a potato crop and the influence of proper phosphorus nutrition on plant and tuber development, the 4Rs and especially timing of phosphorus availability are critical to maximizing yield per acre.

Nutrient management challenges in potato production

Phosphorus solubility in the field is challenged by the soil's characteristics, including pH, cation exchange capacity, and cation solution concentrations for Al, Fe, Mn, Ca, and Mg. Potatoes remove 0.12 lb P/cwt tubers harvested compared with 0.35 lb/bu for corn and 0.73 lb P/bu of soybeans (IPNI, 2012). However, potatoes have a relatively high nutrient demand in part due to a shallow, inefficient rooting system. Depending on the soil test concentration of phosphorus, recommended rates of P_2O_5 fertilizer in Idaho range from 0 to 440 lb/ac where the maximum rate of P_2O_5 recommended for corn grain in Idaho is 120 lb/ac (University of Idaho, 2009). Additionally, the response to P fertilization varies depending on the variety or potato grown (Thornton et al., 2008; Love et al., 2005). When increasing rates (0, 100, 200, and 300 lb/ac) of monoammonium phosphate (MAP, 11–52–0) were broadcast-applied in the spring prior to potato planting on four different potato varieties, only three of the varieties had a significant increase in petiole phosphorus levels with increasing phosphorus application (Thornton et al., 2008). Two of the varieties tested, Ranger Russet and 6LS, had a greater response to increased phosphorus rate compared with Russet Burbank and Shepody (Thornton et al., 2008). Understanding the differences in variety, plant root structure, and nutrient uptake timing is important when determining a fertilization strategy.

In-season applications of phosphorus in potato, often through fertigation, can be an effective means to increasing plant phosphorus uptake and petiole phosphorus concentration.

Potatoes are often grown in semi-arid regions of the United States, like Idaho, that commonly have alkaline soils. The combination of high pH in the soils and the tendency for them to be calcareous reduces the availability of phosphorus in the soil (Hopkins et al., 2010). Low soil phosphorus availability in the semi-arid regions creates a challenge to provide enough phosphorus for potatoes throughout the growing season. Phosphorus application rate recommendations in these areas are based on phosphorus concentration in the soil, free lime or calcium carbonate concentration in the soil, and expected yield per acre (University of Idaho, 2009). Potatoes perform best when adequate P is applied and incorporated into the soil prior to planting and crop phosphorus status is monitored through the growing season (Hopkins et al., 2010).

Precision management of phosphorus

In corn management systems, precision nutrient management often starts with fertilizer placement in the field, based on a grid or zone management system. In a crop like potatoes, precision nutrient management is more often related to timing and frequency of in-season applications and the source of the nutrient applied. For example, testing the potato petiole phosphorus concentration is a good indicator of the status of the potato plant, and research indicates that maintaining the phosphorus concentration above 0.22% is sufficient to satisfy both vegetative and tuber growth requirements through the season (Stark et al., 2004). Petiole sampling for phosphorus should begin at, or shortly after, tuber initiation, and continue at weekly intervals (Stark et al., 2004). In-season applications of phosphorus, often through fertigation, can be an effective means to increasing plant phosphorus uptake and petiole phosphorus concentration. Research shows petiole phosphorus concentrations respond to the added phosphorus within 10 to 14 days of application (Hopkins et al., 2010; Stark et al., 2004). Precision in-season management with tools like petiole analysis can be combined with grid or zone soil sampling and yield mapping to maximize nutrient use efficiency across the field.

Single versus split phosphorus applications

Research has demonstrated increased yield and tuber quality when nitrogen applications are split. Studies indicate 25 to 50% of the nitrogen should be applied early in the season, and the remainder of the nitrogen should be applied through fertigation or controlled-release nitrogen fertilizers (Hopkins et al., 2010; Stark et al., 2004). Plant response to split nitrogen applications and the use of fertigation have led to producers split-applying phosphorus and other nutrients as well, with little research to back up improved performance (Hopkins et al., 2010). Considering the variation in response across potato varieties for nitrogen and phosphorus uptake, testing the response of the potato plant to split phosphorus applications is critical.

Research was conducted using Russet Burbank potatoes comparing pre-plant phosphorus, all in-season phosphorus, and split phosphorus applications in Idaho (Hopkins et al., 2010). The split application was done as half of the phosphorus pre-season and the remainder in three evenly divided in-season applications through fertigation. The in-season applications of phosphorus were done through fertigation in three equal applications. All phosphorus application methods were compared with a no-phosphorus control treatment.

Petiole phosphorus concentrations did increase in the fertigated treatments compared with the untreated control, indicating that phosphorus applied in season is taken up by the plant (Hopkins et al., 2010). Research has consistently shown that low plant phosphorus concentrations can be corrected by in-season applications, and in-season phosphorus applications will be more effective when roots are near the surface (Stark et al., 2004). Despite the strong relationship of phosphorus concentration in the petiole to phosphorus status of the plant, the yield response to split phosphorus applications was not significantly different from a single pre-season incorporated application of phosphorus or the untreated control treatment for U.S. No. 1 and total potato yield (Hopkins et al., 2010). Marketable yield was significantly higher than the untreated control when phosphorus was split-applied, but when all phosphorus was applied in season, marketable yield was not different from the untreated control (Hopkins et al., 2010). A single application in season of phosphorus fertilizer at 20 to 40 lb/ac can increase total phosphorus uptake by 4 to 5 lb P/ac (Westermann, 1986). It is important to monitor the phosphorus status of the plants through the growing season to avoid deficiency and allow for corrective applications when needed.

Conclusions

The economic and nutritional value of a crop like potatoes is important to U.S. agriculture. Understanding the differences in how and when phosphorus is taken up in a crop like potatoes versus corn is critical to making the best 4R nutrient management decision. Recognizing the differences in nutrient uptake among potato varieties is also important to creating an effective plan. As with all phosphorus applications, regardless of the crop being grown, knowing the soil characteristics and nutrient concentrations is critical to providing adequate available phosphorus to the growing crop.

References

Hopkins, B.G., J.W. Ellsworth, A.K. Shiffler, T.R. Bowen, and A.G. Cook. 2010. Pre-plant versus in-season application of phosphorus fertilizer for Russet Burbank potato grown in calcareous soil. J. Plant Nutr. 33(7):1026–1039. doi:10.1080/01904161003728693

Love, S.L., J.C. Stark, and T. Salaiz. 2005. Response of four potato cultivars to rate and timing of nitrogen fertilizer. Am. J. Potato Res. 82:21–31.

Thornton, M., D. Beck, J. Stark, and B. Hopkins. 2008. Potato variety response to phosphorus fertilizer. Proc. of the Idaho Nutrient Management Conf., Jerome, ID. https://bit.ly/2IGexR3

Stark, J., D. Westermann, and B. Hopkins. 2004. Nutrient management guidelines for Russet Burbank Potatoes. Bull. 840. University of Idaho Extension. https://bit.ly/2EwNxze

University of Idaho. 2009. Idaho nutrient management. http://www.extension.uidaho.edu/nutrient/

USDA-NASS. 2018. The Idaho, Oregon, and Washington combined potato crop valued at $1.83 billion for 2017. https://bit.ly/2T1ti5z

Westermann, D.T. 1986. Phosphorus nutrition of potatoes. Presentation at the January 30 Idaho Potato School in Pocatello, ID. https://bit.ly/2XmAKH8

doi:10.2134/cs2019.52.0204