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Fine-tuning Soil/Plant Needs Critical In Potato Production

Western scientists probe into factors affecting potato crop needs for potassium.

Summary: *Potato growers should seriously consider a maintenance approach to potassium (K) fertilization in an attempt to avoid high corrective rates required to overcome K deficiencies that might occur in-season. Higher rates of K should be split applied with at least 50 percent of the K being applied during the fall with the remainder at the time of planting. Maintenance levels of K should especially be made for sandy, coarse-textured soils. The goal of a K fertilization program is to provide sufficient available K to the potato plant to achieve 6 to 8 lbs of K_2O/A/day during the entire tuber bulking stage.*

The purpose of this study will be to focus on two primary factors that influence potato crop needs for potassium (K) in the Pacific Northwestern region of the United States. We will take a look at each aspect and draw some conclusions.

Soils

First of all, soil contributes greatly to K availability. In western agricultural soils, particularly Idaho, K has declined more than any other nutrient. Many soils that had soil test K concentrations of greater than 400 ppm in the mid-1960s are now in the range of 100 to 200 ppm. As recently as last year, soil test K levels have been observed in the 20 to 30 ppm range. Historically, many of these soils have had a tremendous crop requirement for K. That requirement has not diminished and cannot be maintained without additional K fertilizer being applied.

To make accurate and reliable K recommendations, we need to determine the magnitude of selected K fractions and their interrelationships to each other and the standard soil test K concentrations. This is especially true as one compares current academic recommendations for K and those apparently higher K fertilization rates that are being reported by many growers. To help understand the relations between various soil fractions,

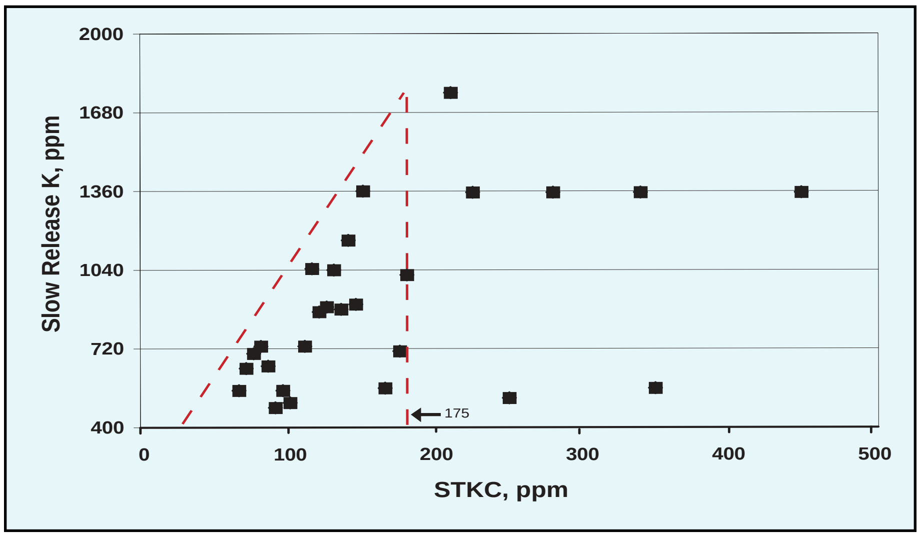

Figure 1. Relationship between STKC and slow-release K from soil extracts.

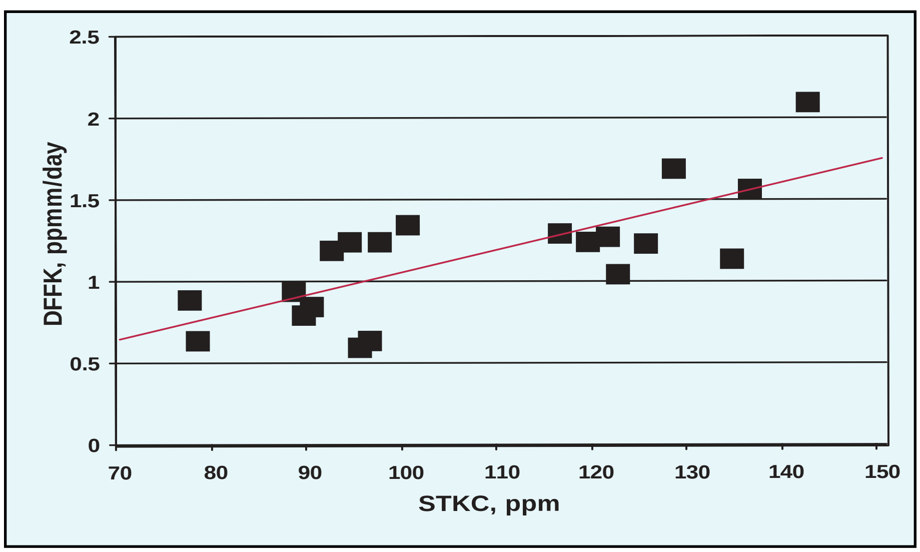

Figure 2. Relationship between STKC and K diffusion rate (DFFK) estimated by the Unocal® procedure.

the interaction between them and soil K recommendations, samples of several soils were collected throughout the Pacific Northwest (PNW).

Soil Test K concentration varied from less than 80 ppm to over 400 ppm, while slow release K ranged from about 500 ppm to nearly 800 ppm (Figure 1). There appears to be an upper concentration limit for the slow-release K fraction when the soil test K concentration (STKC) reached 175 to 200 ppm. A linear line can be drawn along the upper points downward to where STKC is zero, and crosses the y-axis at about zero for slow-release K. Those samples that have a STKC of greater than 250 ppm may have recently had soluble K applied to them or were recently manured. It is not known how easily fertilizer K that has been applied to a field can reenter the interlayer mineral lattice and become part of the slow-release K fraction of the soil. It would be important to note that when K is applied to a soil it can displace Ca, Mg, or Na on the exchange complex. This relationship may impact the availability of these ions to growing plants. This would normally be a transient relationship, but it could exist around a dissolving K fertilizer granule in the soil-solution system.

The STKC was also related linearly to the K diffusion rate (DFFK) estimated with the Unocal® procedure for the five experimental fields (Figure 2). For a STKC concentration of 150 ppm, the calculated diffusion rate would be 1.77 ppm K/day or about 6.4 lbs K/day for an acre-foot of soil. An available classification would rank this rate as low and predict a response to K fertilization. Even if the plant's roots were able to extract 50% of the K supplied to the soil solution by this mechanism, it would barely be able to keep up with K tuber demands since tubers growing at 700 cwt/acre/day require about 3 lbs K/A-day.

Sodium bicarbonate should extract all the soluble and most of the exchangeable K fractions within the soil. It did not appear to extract a significant portion of the non-exchangeable K, as there was no apparent relationship to slow release K. Slow release K concentrations on native, uncropped silt loam soils in the PNW were at least 1,200 ppm. Whenever crop history entered the equation the slow release K fraction was much smaller. This was particularly true of the coarse- textured soils. Isotherm slopes were also smaller for these sandy soils, which indicates that K fertilization response will occur on sandy coarse-textured soils at a higher STKC than for silt loam soils. There is also an indication that leaching of available K will take place on sandy soils where excess irrigation water is applied. A portion of the applied K will also be fixed in the slow release K fraction, since the equilibria among solution, exchangeable, and non-exchangeable K forms are reversible. This means that plants may actually recover only small amounts of fertilizer K that is applied during a given season during that season of application. This may necessitate even larger amounts of K fertilizer applications for adequate plant growth on these soils.

Table 1. Final fertilizer K recommendations comparing 1987 rates (K_2O) developed from 1992-95 field experiments in southern Idaho.

Soil test K (ppm)	lbs K_2O/A (1987)	lbs K_2O/A (1992-95)
25	250	600
50	200	500
75	150	400
100	100	300
125	50	200
150	0	100
175	0	0

Potato tuber yield responses to K fertilization were related to STKC during a set of field experiments conducted during 1992 and 1995. The original fertilizer K guides for Idaho, Oregon, and Washington had a critical STKC of 150 ppm. The Idaho guide had these values established since the 1960s. Their work indicated that the critical STKC should be raised to 175 ppm K and that much higher K fertilization rates were needed for economically profitable potato production to be achieved. Assuming that $NaHCO_3$ will extract all soluble and most of the exchangeable K fractions, and that added K fertilizer contributes to only those two fractions, about 380 lbs/A of K would be required to change the STKC 100 ppm in an acre of soil. However, if conversion of any of the added K fertilizer to a non-exchangeable form might occur, the increase of K fertilization would be even higher. An adjustment of the fertilization rate of K was made by using the relationship between the isotherm slope and the STKC, and solution K concentrations. The adjusted rates are higher than those derived from the field studies or using the mass balance approach. Part of the difference between these two comparisons occurs because all of the soil particles and surfaces are exposed during isotherm equilibrium, while in the field studies only the soil around the dissolving fertilizer particle would be exposed to higher K concentrations.

Plant

Plants differ in the ability to take up K from a given soil. This is associated with a given plant's root system and surface area of the root. When the potato plant is K deficient it becomes stunted, the younger leaf tissue develops a leathery surface, and leaf margins turn downward. Marginal scorch will occur with necrotic spots or necrosis along the leaf margins.

Most growers make split applications of K for potato production. While making these applications they should be aware of the critical tissue K concentrations required and the fundamental nutrient status of the potato plant. Potassium status can be defined as the ratio between the total plant K uptake divided by the tuber K uptake rate. When this ratio or balance is greater than 1.0, there is more K uptake than required for tuber growth. When the ratio is less than 1.0, uptake is less than that required for tuber growth. Mobile nutrients will be translocated out of the vegetative portions of the plant to the developing tubers. This approach can be used for mobile nutrients and especially applied as a K fertility factor for Russet Burbank potatoes or other varieties commonly produced in western agriculture.

The problem with excessive K in the plant is that this excessive K can be translocated to the tubers, causing a decrease in dry matter because of increasing water content. Low K concentrations, on the other hand, decrease tuber dry matter via metabolic reduction in starch formation as well as reducing photosynthate needed for growth.

Conclusions

Soils. K fixation could be as high as 27 percent of the applied K at relatively low STKC. It is our recommendation that potato growers seriously consider a maintenance approach to K fertilization in an attempt to avoid high corrective rates required to overcome soil K deficiencies that might occur in-season. It is also recommended that higher rates of K should be split applied with at least 50 percent of the applied K being applied during the fall with the remainder at the time of planting (see Table 1). Of those higher concentrations, the bulk of the K fertilizer applied for potatoes in the spring should be as K_2SO_4. Maintenance levels for K application should especially be made for sandy coarse-textured soils that might have soil CECs of less than 10 meq/100 g of soil.

Plant. Optimum tuber concentration for highest dry matter is 1.8 percent on a dry matter basis of 22 percent. At this concentration, 0.48 lb K_2O/A is required to grow 100 lbs of fresh weight tubers. This relates to at least 3.4 lbs K_2O/day for tuber growth during bulking. An additional concern is the efficiency of the K fertilizer applied. Our data indicate that K efficiency is between 30 and 40 percent. This could result in a crop availability of between 6 to 8 lbs of K_2O/A/day to meet the demands of the tuber and the plant. Therefore, the goal of a K fertilization program for potatoes is to provide sufficient available K to achieve this concentration during the entire tuber bulking stage.

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