Montana

Potassium Response on High-Potassium Soils Leads to New Soil Test

By Earl O. Skogley

Montana research over several decades has indicated that crop response to potassium (K) fertilization can occur on western soils that test very high in extractable K. A new resin soil test may be able to diagnose these K-responsive soils and improve the accuracy of response prediction for other nutrients as well.

DURING the early 1970s we studied the K response situation for Montana soils and crops. We did not expect many K responses on small grains and forages grown in this area. These crops have only moderate K requirements and nearly all Montana soils tested "high" in extractable K. We were amazed to discover that various crops responded from 25 to over 70 percent of the time when K was included in a balanced fertilizer program with nitrogen (N) and phosphorus (P). These responses were truly K responses, and not chloride (Cl) responses that have also been reported for some soils in this region.

Potassium Availability

Studies to develop an improved soil test for K revealed that no chemical extractant would provide values that related well to crop response in the field for our kinds of soils and climatic conditions. A search of the literature provided good clues to explain this lack of correlation. Two processes are responsible for most of the K that becomes plant-available . . . that is, K ions present at a plant root surface.

Water taken up by the plant contains dissolved K ions that are transported with the water, a process termed mass flow. With Montana conditions, generally no more than 50 percent of plant K is accounted for by this process. More K required by the plant must reach the plant root by diffusion movement of K ions in soil solution from areas of higher to areas of lower concentration. Because the plant root removes K from its immediate surroundings, K diffuses toward the root. Root extension into new soil volumes is also highly important, but mainly as it allows these other processes to be effective. Soil test results from chemical extraction relate mainly to exchangeable K . . . that K **may** become available . . . but they tell little about the processes that regulate K availability.

Improved Soil Test Correlations

We discovered that the best relationships between soil test values and crop response were provided by ion-exchange resin extraction of soil samples. A resin capsule method was developed to simplify this approach. Use of resin capsules allows diffusion-regulating characteristics of soils to be reflected in soil test values. Results also reflect K concentration in soil solution. This relates strongly to mass-flow of K to plant roots. Thus, this approach pro-

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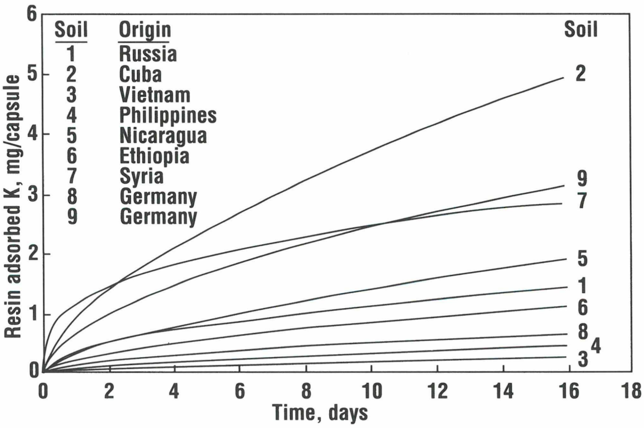

Figure 1. Resin adsorption of K from soils of worldwide origin.

vides a methodology that allows separation of soils based on their abilities to deliver K to growing plant roots.

Recent results from resin capsule extraction of soil samples from throughout the world indicate that this method works well on an extremely broad array of soils, ranging from coarse to fine textures and from calcareous to strongly acid soils (**Figure 1**). The K supplying capacity of these soils varies greatly, even though many have similar amounts of chemically extractable K.

While studying K, it quickly became obvious that the resin capsule approach could be developed to solve most of the problems inherent in chemical-extraction soil testing for other nutrients as well. The method is sensitive to processes that control availability at the plant root surface, so it provides more accurate values. By using mixed-bed (both cation and anion adsorbing) ion-exchange resins, a "universal" extractant is provided. The method works on soils of all natures, so it is possible to "standardize" soil testing, worldwide. Finally, field-fresh soil samples are used, with only pure water being added to the sample. Numerous error-prone steps in soil testing are eliminated by this simple methodology.

We have studied the methodology for K, P, N (both nitrate and ammonium are measured), sulfur (S), calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), boron (B), chloride (Cl), and some of the heavy-metal soil contaminants. Simultaneous, independent adsorption of these elements has been shown.

Data shown in **Figure 2** illustrate the sensitivity of the methodology to fertilizer management. In this experiment with rice, annual fertilizer applications were made, as indicated, for more than 20 years. Where no fertilizer was added on this low-P soil, available P remains low, but not as low as when N, or N plus K were added. Somewhat increased plant growth with these nutrients depletes the soil's already low supply of

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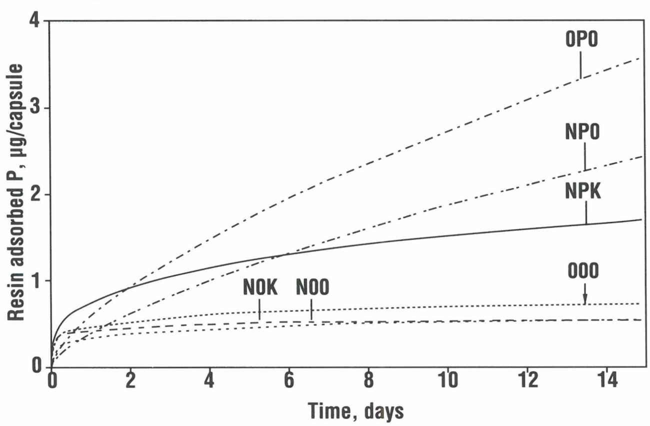

Figure 2. Resin adsorption of P as influenced by long-term fertilization.

Data for figures provided by Dr. A. Dobermann, International Rice Research Institute, Philippines.

Table 2. Influence of Cu fertilization on Cu levels in Coastal bermuda forage.

Copper rate, lb/A	Forage Cu concentrations, ppm	
	Cutting 1	Cutting 2
0	6.1	5.7
1	17.3	23.9
2	23.6	8.4
4	47.1	15.2

Lee County, C. Marek Farm (1992)

Although the Cu levels reported in **Table 2** do not exceed the maximum tolerable Cu level suggested for beef cattle, the banded liquid Cu resulted in levels much higher than the normal ranges considered adequate in ruminant diets. There is a fine line between Cu deficiency and toxicity in both plants and animals. The 1 lb/A Cu rate increased Cu levels in the plant at the first and second cutting, and levels appear to be sufficient (but not toxic) for both Coastal bermudagrass and cattle under most conditions.

Summary

Copper is an important nutrient for both livestock and forage production. Although forage production may not be noticeably affected at a certain Cu level, the same level may be deficient for cattle production. Utilization of Cu in forages by the animal can also be negatively influenced by high levels of molybdenum (Mo), sulfur (S) and Iron (Fe). Further research is needed in order to investigate these interactions and their effects on forage and cattle production. ■

COPPER deficiency in cattle may include several symptoms, such as scouring and dull, dry hair. Black animals may show a reddish-brown color.

New Soil Test . . . from page 21

P. Where P was added over many years, but plant growth was limited by deficiencies of N or K, soil levels of P were very high. When a balanced N-P-K fertilizer program was used, the amount of P is moderate, reflecting a build-up of plant-available P, but not an excess, due to high plant yields and P removal by the crop. All of these effects are clearly shown by resin capsule data. This type of sensitivity to fertilizer management has been demonstrated for other elements as well.

Summary

Laboratory soil testing of K (and several other nutrients) will likely never be extremely well correlated to crop response in the field. Variables that influence diffusion (especially soil water content and temperature) are not accounted for in results obtained in the laboratory, regardless of the method. However, it is clear that the resin capsule methodology provides a new, improved approach to soil testing. ■