

Can Topsoil Thickness Help Determine Crop Phosphorus and Potassium Nutrient Needs?

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A premise of precision agriculture for variable-rate fertilizer application is that the soil's nutrient supplying capacity for crop growth is different for various locations within a field. In practice, this principle is applied by soil sampling at different locations within the field (such as sampling by soil type or grid soil sampling and mapping) and applying fertilizers as determined by the soil test results.

Another aspect of the crop nutrient pool that might also be quite different within fields is variation in the nutrient pool with soil depth. Typically, for immobile nutrients such as with P and K, soil samples are taken from the surface 6 to 8 inches...referred to as the plow layer. Early developers of soil testing programs found that

with many soils, immobile nutrients accumulate near the soil surface. This fact along with the difficulty in deep soil sampling resulted in sampling strategies directed at and calibrated with the surface plow layer. If, for any given location within a field, nutrient levels vary greatly below that soil-sampled depth, soil test results may not be a good predictor of the soil's nutrient supplying capacity.

Research is evaluating the importance of topsoil thickness along with soil test results for predicting crop nutrient needs. Studies in Missouri have focused on phosphorus (P) and potassium (K) nutrition of corn and soybeans grown on claypan soils. Higher soil test levels of K are beneficial where topsoil is thin.

Previous work in Missouri has shown how soil electrical conductivity can be used to measure topsoil thickness for claypan soils (*Better Crops with Plant Food*, 1997, No. 4, pages 6 to 8). In this work topsoil thickness was defined as

the soil depth from the surface to the high-clay Bt horizon. The topsoil is generally considered to be much more fertile than soil in the "clay-

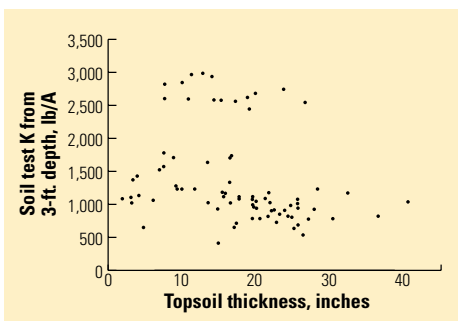


Figure 1. Soil test K accumulated over 3 feet of soil from 80 different locations spread over 16 Missouri claypan fields.



Claypan soil field where crop response to variations in topsoil and soil test P and K was studied. While the slope on this field is less than 2 percent, topsoil thickness varies from several inches to over 4 feet deep.

pan.” Further, plant-available water capacity and air-space for root growth are poor in the claypan when compared to the topsoil. The question we considered with this claypan soil research was: Can a more accurate prediction of crop nutrient needs be made by using topsoil thickness along with soil test results? Two studies were conducted to help answer this question.

Topsoil Thickness and Soil Test P and K

In the first study, soil samples were taken from 80 separate locations within 16 claypan soil fields (3 to 6 locations per field) in north-central Missouri. At each field location four deep core sub-samples were taken within an area 10 ft. in diameter, divided in 6-inch increments to a depth of 3 ft., and analyzed using University of Missouri soil test procedures for plant available P and K (Bray P-1 and ammonium acetate extractable K). Topsoil thickness was also measured for each location.

Results showed that soil test K was greatest in the surface 6 inches of soil, but that at some locations subsoil K was also significant. Totalling the soil test K over the 3-ft. profile from these 80 locations illustrated how variable plant-available K can be (Figure 1). Some individual fields appeared to have significant subsoil K (upper group of points in Figure 1 are mostly from three fields). While topsoil depth was a poor predictor of total K in the 3-ft. profile, there was a slight trend for soil

test K to be less with increasing topsoil thickness. This trend may be the result of greater nutrient removal with deep topsoil since, for many years, deeper topsoil translates into greater plant-available water and grain production.

Topsoil thickness and sample depth were helpful in explaining differences in soil test P in the 3-ft. profile (Figure 2). Many locations with deep topsoil also had higher soil test P levels in the surface 6 inches of soil. Soil erosion and deposition downslope of sediment and soil organic matter (major sources of labile P) have contributed to topsoil thickness variations at these sampled locations. This landscape process helps explain why soil test P would be greater with deeper topsoil. Some locations with shallow topsoil showed increasing soil test P in the 24- to 36-inch depth. At these depths, the P is probably from iron (Fe)- or aluminum (Al)-P minerals since soil organic matter is very low in the subsoil. The root-restrictive nature of the claypan horizon probably limits crop use of this deeper, subsoil P.

Crop Response to Variations in Topsoil and Soil Test P and K

In a second study, 108 P and K response plots were established in 1996 at different topsoil-depth locations within a single field. Twelve months later each plot was soil sampled to a depth of 6 inches and analyzed for P and

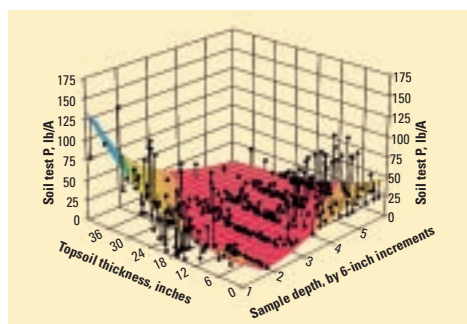


Figure 2. A response surface ($R^2=0.44$) of how sample depth and topsoil thickness affect soil test P. Results from 80 different locations spread over 16 Missouri claypan fields. Points are actual values, and lines from points show deviation from the response surface.

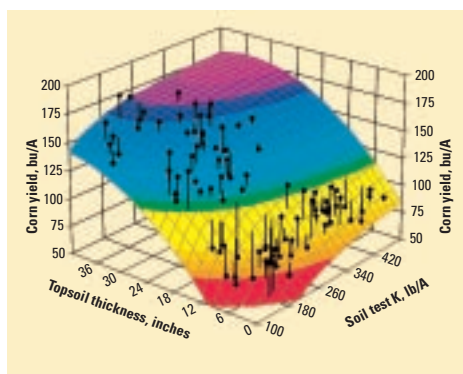


Figure 3. A response surface ($R^2=0.77$) of how soil test K and topsoil thickness affected corn yield. Points are actual values, and lines from points show deviation from the response surface.

K availability. Topsoil depth was also determined for each plot.

In 1996 and 1998, soybean yields ranged from 45 to 65 bu/A and were not affected by topsoil depth or levels of soil test P and K at the 0- to 6-inch depth.

In 1997, variations in corn yield were best explained with topsoil thickness, soil test K (**Figure 3**), and a significant interaction between these two factors. Because of dry conditions during late July and early August, stored soil moisture resulted in large yield differences. With only about 6 inches of topsoil, corn yield ranged from 40 to 60 bu/A. With 2 to 3 ft. of topsoil, yield was about 140 to 160 bu/A. The greatest positive benefit with increasing soil test K was where the topsoil was thin. Because plant K nutrition plays such an important role in water regulation and plant response to water stress, higher levels of soil-test K were needed in thin topsoil areas of the field.

With only one year and site of data showing this topsoil by soil test K interaction response, it is difficult to make an economic projection at this time. However, using the response relationship shown in **Figure 3**, we evaluated, at different topsoil thicknesses, the soil test K level when the rate of yield increase was only one-tenth of a bushel for every 1 lb/A increase in soil test K. Within the same field, the soil test K level to get this specified yield response varied by about 90 lb K/A.

These response values were then compared to the “desired soil test level” using current University of Missouri recommendations (**Table 1**). The University of Missouri recommended desired soil test level is determined using cation exchange capacity (CEC). We used CEC values from the plot areas for this comparison (column 3 of **Table 1**). With shallow topsoil, measured CEC was greater because the surface soil has more clay. That gave a higher desired soil test level. The range in variation in recommended “soil test K” was less than the range in response as shown in

TABLE 1. Optimal soil test K levels from this study compared to current recommendations from the University of Missouri.

Topsoil thickness, inches	Soil test K level for specified yield increase ¹ , lb K/A	Average CEC from study plots, meq/100 g	University of Missouri desired soil test level ² , lb K/A
6	330	18	310
12	314	14	290
18	297	12	280
24	279	11	275
30	260	11	275
36	240	10	270

¹Soil test K level for rate of yield increase of one-tenth of a bushel for every 1 lb/A increase in soil test K.
²Recommended desired soil test level for corn = 220 + 5 (CEC).

Figure 3 and calculated in column 2 of **Table 1**. Thus, using CEC can help predict the need for a variable optimal soil test K level among areas of the field. However, as shown with these results, other information such as topsoil thickness might be more helpful in predicting the variability in crop K needs within fields. Additional research is being done on these plots to determine if crop K needs are being met by subsoil nutrients.

In the future, improved precision fertilization programs may require even more precision in the assessment of nutrients available for crops. This research is indicating that subsoil nutrients vary significantly and may play an important role in meeting crop nutrient needs. In some areas of the U.S., subsoil sampling is currently advocated to assess subsoil nutrients. [BC](#)

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