Soil Specific Phosphorus and Potassium Recommendations – Critical Values

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Objectives and relevance:
The soil test critical value is the target soil test level for optimum crop growth. When soil test levels are below the critical value crop yield and/or quality may be restricted by nutrient availability in the soil.

University of Missouri soil test recommendations for phosphorus (P) assign a critical value of 40 to 45 lbs soil test P, depending on crop selection. Recommended potassium (K) critical value is based on crop selection and soil cation exchange capacity (CEC). For example, the critical value for corn is: 225 + (5 X CEC).

Two projects previously funded by the Fertilizer and Agricultural Lime Fund have indicated that soils in Missouri differ in the amount of P and K that is needed to raise soil test levels on a per unit soil test increase basis. Application of the equivalent of 230 lbs P_2O_5/acre raised soil test 24 lbs. P/acre on a Putman soil from the claypan region compared to 52 lbs P/acre for a Creldon soil from the Ozark region of Missouri. Average increase in soil test P for 4 Ozark soils was approximately double that of 3 soils from the clay pan region. Similar differences have been observed among build-up requirements for potassium. Differences among soils are related to region of the state, clay content and initial soil test level. We are currently working to integrate results of these previous studies into soil-specific build-up recommendations for P and K.

Differences in buildup rates among Missouri soils raises the distinct possibility that soils also differ in critical value. The same mineralogical and chemical properties that cause one soil to need double the P to raise soil test a specific number of units may also affect the soil test level needed to provide optimum growth potential.

We are seeking funds for a greenhouse experiment to measure critical values for crop response on a subset of soils previously shown to differ in build up requirements for P or K. If we find significant effects of soil type on critical value in this 1-year greenhouse project we will submit a proposal next year to run field trials on a larger number of soils with the objective of incorporating soil specific critical values into Missouri's soil test recommendation system. An extensive field trial will be expensive and run at least 2 years. This greenhouse project will be used to assess if the expense of a field-based assessment of Missouri's phosphorus recommendations is warranted.

Procedures:
- Four soil types will be selected for both the phosphorus and potassium tests. The selected soils have a wide range of build-up requirements for potassium or phosphorus as determined in a previous project funded by the Fertilizer and Agricultural Lime research program (Table 1).

Table 1. Proposed soils for P and K tests. Terms in parentheses designate the region of the state.

Phosphorus selections	Increase with 230 lb P_2O_5/acre		Potassium selections	Increse with 300 lb K_2O/acre
	lb/acre			lb/acre
Creldon sil (Ozarks)	52		Creldon sil (Ozarks)	198
Higginsville sil (Loess)	50		Barco loam (Osage)	148
Sharkey c (Bootheel)	27		Commerce sicl (Bootheel)	98
Putnam sil (Claypan)	24		Mexico sil (Claypan)	105

- For each soil, a very low or low testing site will be located and a bulk sample from the top 6 inches of the soil profile will be obtained. This will require working with NRCS and regional extension staff to locate low testing soils and to confirm the sampled location is the correct soil type. Each soil will be sieved and air-dried in the greenhouse. Locating and obtaining sufficiently low testing soil of the target soil types will take place from February through mid April, 2003, depending on weather conditions.
- Phosphorus or potassium will be added to each collected soil to establish a range of soil test levels into the high range in spring 2003. Target soil test levels will range up to 60 lbs per acre for phosphorus and 375 lbs per acre for potassium. The soils will be put through a regime of wet-dry cycles to allow the added phosphorus and potassium to equilibrate with the soil as follows:
    - After all soils are collected and air-dried, each soil will be divided into 10 containers. Phosphorus or potassium will be added to each soil in increments to establish 10 levels of soil test phosphorus or potassium. The rates will be calculated based on the buildup rates observed in previous studies. After phosphorus or potassium addition the soils will be mixed thoroughly and wetted to near field capacity. The soils will then be allowed to air dry. The soil will be re-wetted to near field capacity and allowed to air-dry a second and third time.
    - After three wet-dry cycles the high and medium rate containers will be sampled and analyzed for the soil test level of the target nutrient. The soils will be then continue through another three wet-dry cycles.
    - At the end of the sixth wet-dry cycle the high and medium rate containers will be resampled and analyzed for the soil test level of the target nutrient. This process will continue until there is evidence that soil test levels for each treatment have reached a stable value. After all soils have been equilibrated, soil test levels will be determined in duplicate for all treatments.
    - Equilibration and final soil test will be complete by the end of September 2003.
- Soil from each stabilized soil test level will be divided into four 6-inch pots. Wheat will be planted in half the pots and soybean in the other half. Pots will be watered from the top with a complete nutrient solution minus the test nutrient (phosphorus or potassium). Soybean pots will be inoculated with *Bradyrhizobium japonicum* and the nutrient solution will also be nitrogen free.
- Total number of pots for each nutrient will be 160 (4 soil types X 10 soil test levels X 2 crops (wheat or soybean) X 2 replicates).
- Plants will be grown in the greenhouse 4 to 6 weeks starting in early October. At harvest, plants will be clipped at soil level, dried at 60 ^{o}C, and weighed.

- Regression analysis will be used to establish the response of yield to soil test level. Cate-Nelson procedures will be used to test if a single critical value bests describes the 4 soils or the sums of squares is significantly improved when each soil has a unique critical value.

Timeline:

February – April:	Locate, obtain and air-dry soils for project
Mid April:	Set up greenhouse for drying samples and apply treatments
April – August:	Equilibrate soils with wet-dry cycles
September - October:	Determine soil test levels of all treatments and set up greenhouse for plant experiment
October – November:	Run greenhouse study
November – mid December:	Analyze data and write final report

Transfer strategy:
All three investigators are members of the Soil Fertility Working Group responsible for University of Missouri soil test recommendations. Results of this experiment will be used to confirm our current approach or form the basis for new interpretations of University of Missouri phosphorus and potassium recommendations. Field tests will be required if significant differences are noted among critical values for different soil types. Funding for field tests, if needed, will be requested in a new proposal next year. Results will also be incorporated into Lory and Scharf's extension programming.

Budget:

Research specialist	0.45 FTE	salary	$13,500
		benefits	$ 3,375
Materials			$ 1,325
Analysis			$ 1,200
Travel			$ 600
Total			$20,000

Budget narrative:
The research specialist (0.45 FTE) will be required to locate and collect soils, set up the greenhouse for drying samples, establish treatments, tend the soils through the wet-dry cycles, and setup, tend and harvest the greenhouse study. University of Missouri estimates fringe benefits as 25% of salary.

Materials include greenhouse fees and costs ($900), water filters ($200), and pots ($250). Soil analysis is for 80 samples used to locate suitable soils and monitor the equilibration phase of the experiment and 160 samples (80 treatments X 2 replicates) to establish soil test level at the start of the pot study. Cost per sample is $5. Travel cost is to locate and obtain low testing soils selected for the study from around the state.