Soil Fertility Management

J. Camberato and J. Norsworthy

If rotated with highly fertilized crops like cotton, corn, peanuts, or tobacco, soybeans may not respond to applied fertilizer since the crop is such an efficient user of residual nutrients. However, one should not risk low yields caused by nutrient deficiencies, and therefore should apply fertilizer and lime based on annual soil tests from each field planted.

The following are some considerations for maintaining supplies of nutrients in the soil to support high soybean yields.

SOIL SAMPLING

Plant nutrient applications through fertilizer and/or lime are based on representative soil sampling techniques and subsequent lab determination of soil pH and nutrient levels. Clemson University's Agricultural Services Lab provides a quick turnaround for soil analyses and nutrient recommendations on a fee basis. Soil sample boxes, submission forms, and advice on taking samples can be obtained from the local county Extension office. This office will also mail your samples to the lab.

The first step in obtaining a representative soil sample is to separate each field into sample areas of similar management history and soil characteristics. Areas of 2 to 3 acres are considered large enough to justify sampling, but a sample should not represent over 20 acres. A difference in surface color is the most evident feature separating soil types, indicating possible variability in texture, organic matter content, and drainage.

Cropping history is another important factor to consider when defining a sample area. High value crops such as cotton, peanuts, or tobacco may receive high rates of fertilizer, whereas corn, soybeans, wheat, or pasture crops usually receive lesser amounts. Nutrient removal rates by a crop are important in determining residual soil fertility levels. Therefore, sampling across cropping histories will not result in cost-effective use of fertilizer.

Once each sampling area is identified, 10 to 20 soil cores (brush away surface plant residue material) to a 4- to 6-inch depth should be obtained in a zigzag pattern throughout the area to ensure good representation. The soil cores should be placed in a clean plastic bucket and mixed thoroughly, and a subsample should be taken to fill a one-pint sample box (obtain boxes from County agents). It would be helpful to construct an accurate map of the field so that sample areas can be taken the same time each year, preferably in the fall after harvest, to enhance the relevance of annual comparisons.

Note: In most sandy Coastal Plain soils where deep tillage is practiced to break root-restrictive hardpans, a sample of the top 4 inches of subsoil can be used to determine the availability of potassium, sulfur, and magnesium. These nutrients readily leach through the sandy surface layer but are retained in the upper part of the subsoil. The results of subsoil samples can be used to adjust fertilizer recommendations made from the analysis of the A horizon sample.

Soil samples are analyzed for pH and the plant-available contents of potassium, phosphorus, calcium, magnesium, zinc, copper, boron, and manganese. Recommendations to correct soil pH and provide sufficient levels of each nutrient for top yield performance will be made on the soil test report.

These recommendations are based on several years of soil test calibration research conducted in South Carolina and neighboring states. Soil analysis procedures determine the amount of each nutrient available for crop uptake. Nutrient levels on the soil test report are indexed into the following categories:

- VL (very low): Soil is deficient and applied nutrient will significantly increase yields.
- L (low): Nutrient addition will be required for maximum yields.
- M (medium): There will be a response to nutrient application approximately 50 percent of the time.
- H (high) or VH (very high): Nutrient supply in the soil sufficient for top yield performance nutrient addition not likely to increase yields.

SOIL pH AND LIMING

A soil pH too low or too high can adversely affect nutrient availability and hence, soybean growth and yield. The best pH for soybeans grown in most South Carolina soils is 5.5 to 6.5. If soil tests show a low soil pH, lime can be applied to enhance yield potential by:

a) Reducing toxicity of soil aluminum and/or manganese;
b) Improving uptake of phosphorus, potassium, and molybdenum;
c) Increasing availability of calcium and magnesium (with dolomitic lime);
d) Improving nitrogen fixation by Rhizobia bacteria in root nodules.

MANGANESE (Mn) DEFICIENCY

When soil pH is too high, usually over 6.2 on the poorly drained soils in the Atlantic flatwoods of the lower Coastal Plain, a manganese (Mn) deficiency may occur. When soil conditions conducive to Mn deficiency exist, and/or the previous crop has shown deficiency symptoms, Mn can be applied to the soil to prevent a problem in the soybean crop. Applications of 10 to 15 lb of Mn/A broadcast or 4 lb of Mn/A within a band are recommended. The less time the Mn is in the soil prior to planting, the more effective the application will be in preventing the deficiency.

Symptoms of Mn deficiency include interveinal yellowing on young leaves - the veins remain dark green. Tissue tests using the uppermost trifoliate leaf (without the petiole) can also be used. Manganese levels less than 15 ppm from leaf tissue are indicative of a deficiency. If the young soybean crop exhibits symptoms of a Mn deficiency, foliar applications of Mn are effective in alleviating the deficiency. The optimum rate of foliar-applied Mn is 0.1 to 0.2 lb of Mn/A (0.4 to 0.8 lb of manganese sulfate), although 1 to 2 lb Mn/A is a common recommendation. The lowest effective rate is preferred because of lower cost, less likely leaf burn and ease in dissolving the fertilizer. Apply the Mn in at least 20 gal of water/A. This treatment should be repeated if the deficiency reappears.

Another possible way too correct a Mn deficiency is by rotating a high pH field to corn and using recommended rates of acid-forming nitrogen fertilizers. This may lower the pH to a level more optimum for soil uptake of Mn by soybeans. Corn is more tolerant than soybeans of low soil Mn levels. Wheat should not be planted on high pH soils since wheat is extremely susceptible to Mn deficiency, and foliar applications of Mn are not usually effective in correcting the problem.

NUTRIENT REQUIREMENTS AND UPTAKE

The approximate amounts of nutrients removed from the soil by a 60-bushel soybean crop are presented in Table 1. Remember, only the nutrients in the grain are removed from the field. Many of the nutrients left in the stubble are recycled and available to the next crop.

Table 1. Approximate nutrient utilization (lb/A) for a 60-bushel soybean crop*

	Nutrient				
Plant Part	**N**	**P_2O_5**	**K_2O**	**Mg**	**S**
Grain	**240**	**48**	**84**	**17**	**12**
Stubble (leaves, stems, etc.)	**84**	**16**	**58**	**10**	**13**
Total	**324**	**64**	**142**	**27**	**25**

*Source: IMC Plant Food Utilization Guidelines

FERTILIZER RECOMMENDATIONS

To determine how much fertilizer to apply for maximum full-season soybean yields, the recommendations are provided in Table 2. Note that if the soil test rating is H or VH, no fertilizer is recommended.

Table 2. Fertilizer (P_2O_5/K_2O) recommendations (lb/A) for full-season soybeans based on soil test results in South Carolina*****

	Potassium (K_2O)			
Soil Test Rating	**L**	**M**	**H**	**VH**
Phosphorus (P_2O_5)				
VL	**120/100**	**120/50**	**120/0**	**120/0**
L	**100/100**	**100/50**	**100/0**	**100/0**
M	**50/100**	**50/50**	**50/0**	**50/0**
H	**0/100**	**0/50**	**0/0**	**0/0**
VH	**0/100**	**0/50**	**0/0**	**0/0**

*Information from: EC 476, *Nutrient Management for South Carolina*

When double cropping with small grains, all of the fertilizer for both crops can be applied before planting small grain in the fall. Recommendations for fertilizing a small grain/soybean double-cropping system are listed in Table 3. Note: For both full-season and doublecrop soybeans grown in the sandy Coastal Plain soils of South Carolina, apply sulfur in the fertilizer at a rate of 10 pounds per acre.

Table 3. Fertilizer (P_2O_5/K_2O) recommendations (lb/A) for small grain/double-cropped soybean system based on soil test results in South Carolina*****

	Potassium (K_2O)			
Soil Test Rating	**L**	**M**	**H**	**VH**
Phosphorus (P_2O_5)				
VL	**150/150**	**150/75**	**150/0**	**150/0**
L	**100/150**	**100/75**	**100/0**	**100/0**
M	**80/150**	**80/75**	**80/0**	**80/0**
H	**0/150**	**0/75**	**0/0**	**0/0**
VH	**0/150**	**0/75**	**0/0**	**0/0**

*Information from: EC 476, *Nutrient Management for South Carolina*

INOCULATION

The soybean plant is capable of supplying much of the nitrogen for growth through N-fixation in root nodules. Living symbiotically (both organisms receive benefits) in the root nodules of the soybean plant, N-fixing bacteria, *Rhizobium japonicum,* remove nitrogen from the air and provide it to the plant. If nitrate nitrogen is present in the soil, either from manure, sludge, or fertilizer, the bacteria do not fix nitrogen. The plant then preferentially uses the soil nitrogen until it is depleted, at which point the bacteria will again function to provide nitrogen to the plant.

Efficient strains of N-fixing bacteria are common in most South Carolina fields with a recent history of soybean production. Also, strains indigenous to our soils are extremely competitive with introduced strains when forming root nodules. For these reasons, it is very rare that soybeans will respond to a seed-applied inoculant containing *Rhizobium japonicum.* It is important for farmers to maintain an optimum soil pH to ensure effective N-fixing activity. Low soil pH can sometimes cause a deficiency of molybdenum, a minor element critical for the N-fixing process. Molybdenum deficiency can be corrected by liming the soil to the recommended pH range, or by adding a seed treatment of sodium or ammonium molybdate at 2 to 4 oz/bu.

To determine if applying an inoculant will be justified, consider the following "rule of thumb." If the field in question has a recent (within 3 years) history of soybean production, an inoculant is not recommended.

The following precautions are suggested when using an inoculant:

1) If molybdenum and/or a fungicide are used, add these products to the inoculated seed in the planter-box immediately before planting;

2) If an inoculant is needed, purchase fresh material (bacteria only) and keep in a cool place until used. Thoroughly mix with moistened seed.

BORON (B)

Boron is readily leached from soils in environments receiving frequent rainfall; thus, boron deficiency may occur when soybeans are irrigated to optimize productivity. In non-irrigated soybeans, the leaching of boron is minimal. Availability of boron decrease substantially as pH increases above 6.5; hence, alkaline soils are generally low in available boron, inducing boron deficiency. Since soil pH should not exceed 6.5 in production fields, there should be little or no risk of boron deficiency. From trials conducted over several years and locations in South Carolina, Drs. Jim Camberato and William Hair failed to see boron applications increase non-irrigated soybean yields.

Boron applications in irrigated soybeans or at high soil pH should be based on leaf concentrations of boron. Soybean yield will respond positively to foliar applied boron only when concentrations in leaves are 10 ppm or less. In such instances when boron is needed, it should be applied at 0.2 lb/A at the early-pod stage (1/8 to 1/4-inch pods) and can be mixed with an insecticide if needed; however, tank mixing boron or other foliar applied nutrients with Roundup may severely reduce weed control. Boron applied at 0.2 lb/A will cost about $2/acre plus application costs. Applications of boron to plants having boron concentrations greater than 60 ppm may result in yield decreases; therefore, routine use of boron is discouraged.

STARTER FERTILIZER

If soil sample results are medium for phosphorus, or at any level for potassium, there is little evidence that banding of these nutrients near the soybean crop row is more beneficial to grain yield than broadcast applications. When the soil test is low for phosphorus, it is desirable to place one-half the phosphorus close to the crop row in a band. *Note:* To avoid seedling injury, place the fertilizer band 2 inches below and 2 inches to the side of the soybean row. With medium soil test levels, it may be possible to reduce recommended broadcast rates slightly when banding, but additional expense in handling a starter material at planting may offset any savings involved.

When soil test levels for P and K are adequate, and no fertilizer is recommended, there is no evidence to support a yield response to banded applications of starter materials. Unlike corn, which is sometimes planted in cool soils which restrict seedling uptake of nutrients like phosphorus, soybeans are planted in May or June when soils are warm enough for good root growth and optimum nutrient uptake.