Fertilizer Recommendation Philosophies[1]

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Soil testing is an important first step to fertilizer (nutrient) management on the farm, and using a calibrated soil test extractant is critical to the success of soil testing and fertility recommendation programs. We explained soil testing and its usefulness in EDIS document SS621, *Soil Testing for Plant-Available Nutrients—What Is It and Why Do We Use It?* (Hochmuth, Mylavarapu, and Hanlon 2014). Once the soil test index is interpreted, a fertilizer recommendation is provided to the farmer that includes the amount of fertilizer to use for the crop and guidelines on fertilizer management. In addition, soil test reports provide information about soil pH and lime requirements. This discussion focuses on phosphorus, potassium, magnesium, and calcium. Even though various soil testing labs may interpret the soil test index similarly, laboratory reports may vary in the fertilizer recommendation. Farmers notice this variation in recommendations when they send the same soil sample to various labs and receive different fertilizer recommendations.

What are the reasons for this apparent discrepancy in fertilizer recommendations? Farmers receive varying fertilizer recommendations depending on which lab they consult because labs (1) employ different chemical methods and procedures to analyze the samples and (2) subscribe to different fertilizer recommendation philosophies. (As we have discussed in previous publications of this series, the different chemical methods for soil tests are specific to the nature of the soils and to the successful field calibration of those methods.) This publication explains the main soil-test philosophies, their basis, and their applications, and explains why one of the three—the Sufficiency Level of Available Nutrient philosophy (SLAN), also called the Crop Nutrient Requirement (CNR) concept—is most likely to be the best to govern fertilizer recommendations in Florida today.

Figure 1. Manually spreading fertilizer on plots for a fertilizer rate and source study with tomato.
Credits: George Hochmuth, UF/IFAS

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Fertilizer recommendation philosophies

The three most widely used fertilizer recommendation philosophies are the following:

1. The *Sufficiency Level of Available Nutrient* (SLAN), also called the Percent Sufficiency concept or the Crop Nutrient Requirement (CNR) concept. In the SLAN approach, the soil test indices are interpreted as *very low*, *low*, *medium*, *high*, or *very high*, and an associated nutrient recommendation (amount) is made. Under SLAN, the operational principle is that soils testing *high* or *very high* in a particular nutrient can supply 100% of that nutrient requirement for maximum crop production and quality in the present season. No fertilizer is required. Soils testing less than *high* or *very high* may require fertilization, and a pro-rated amount of nutrients will be recommended for crops to be grown in soils with those soil test indices.

2. The *Build-Up and Maintenance* philosophy takes the approach of first building up the soil fertility level to the *high* category with additions of specific nutrients whose indexes were interpreted as *medium* or lower per the soil test. This process may take several seasons. In subsequent seasons, a minimal fertilizer recommendation is made (even if the soil tests *high*) to replace nutrients projected to be removed by the crop to be grown. The principle involved is that the soil fertility level should be maintained at the *high* level with constant additions of fertilizer so that yield is never negatively affected. This philosophy uses yield goals provided by the farmer so that crop-nutrient removal values can be calculated. The fertilizer recommendations are made from the calculated nutrient-removal values; this approach does not consider natural contributions from the soil whatsoever. For calculating crop removal of nutrients, a soil test is not even required. Yield and tissue concentration of nutrients can be used to calculate the amounts removed from any particular field.

3. The *Basic Cation Saturation Ratio* (BCSR) concept, also called the Cation Ratio Concept, focuses on the cations, potassium (K), magnesium (Mg), and calcium (Ca), and, in principle, attempts to maintain desired ratios of these cations on the soil cation-exchange complex. With this philosophy, the desirable distribution of exchangeable nutrients is 65% Ca, 10% Mg, 5% K, and 20% H. The resulting desired ratios are 6.5Ca:1Mg, 13Ca:1K, and 2Mg:1K. Past soil test procedures included the use of separate extracting solutions, such as ammonium acetate, to exchange the cations from the soil's matrix, followed by analysis of cations present in the solution. Today, more likely the nutrient cations are measured with the laboratory's main universal soil-test extractant, and the exchangeable H^+ is measured with the buffer solution used to determine the liming requirement. The amounts of cations are summed and the ratios determined. Fertilizer recommendations are made to adjust the ratios in the top soil layer (approximately a six-inch depth). Such ratios can be easily calculated, and the approach will always require additions of nutrients. Natural recycling of nutrients in the soils is not considered.

Figure 2. Incorporating fertilizer for an experiment on fertilizer rate and source for tomato.
Credits: George Hochmuth, UF/IFAS

Varying fertilizer recommendations will have varying impacts on the costs of the fertilizer program on the farm and on nutrient levels in the soil.

Comparing and contrasting the philosophies

Generally, the Build-Up and Maintenance and the Basic Cation Ratio concepts are used by commercial soil-testing laboratories, and the SLAN concept is used by the land-grant university labs. However, this differentiation is not universal.

The BCSR concept was developed in the 1940s (Bear et al. 1945), and some labs have modified the ratios for local use. Since its development, labs have developed considerable databases of exchangeable cation levels in many soils. With the advent of advanced analytical equipment and computer-based ratio calculations, application of the BCSR has become easy and quick. However, studies have shown that high-yielding crops resulted from soils with widely varying ratios of the three basic cations. When cations are present in adequate amounts to meet crop requirement, plants are very effective at absorbing required nutrients from soils of varying cation ratios. As a result, the BCSR approach may result in excessive fertilizer recommendations. Studies have shown that crop yields are not influenced by the soil-exchangeable cation ratios promoted by the BCSR concept (Olson et al. 1982).

There also is a soil type question with the BCSR. Adjusting the percent K saturation for a crop to be grown in soil with a low cation-exchange capacity—for example, a CEC of 3, such as in Florida's sandy soils—would not supply enough K for the crop. Soil K deficiency is a problem frequently compounded by the tendency of fertilizer to leach from sandy soils, and, therefore, it would be difficult to maintain a desired ratio in such a soil.

The Build-Up and Maintenance approach recommends applying at least the amount of nutrients removed by the crop in question. The idea behind this fertilizer recommendation approach is that when the crop is harvested and removed from the field, nutrients associated with the crop are removed from the soil/crop system, and these nutrients should be replaced to maintain the soil in a high nutrient status. One of the potential challenges with this approach is that it depends on crop removal values that, in turn, depend on a farmer's idea of crop yield goals. Studies on yield goals have determined that farmers tend to overestimate their yield potential, and thus crop removal values may be inflated (Schepers et al. 1986). Recommendations based on inflated yield goals will call for excessive fertilizer. Years ago, most farmers owned their land, and making "investments" in fertilizer with high fertilizer applications was viewed as insurance. This approach may have worked in the past (when fertilizers were inexpensive) and in soils with high nutrient-holding capacity that prevented nutrient losses. Today, however, fertilizer is costly, and excessive fertilizer application with the goal of obtaining very high yields poses a risk to the environment.

By definition, a soil that tests *high* in a particular nutrient can supply all of that crop's nutrient needs, but with the Build-Up and Maintenance philosophy, fertilizer is still recommended to account for the nutrients removed. If the crop removal values are inflated, then the soil nutrient level could potentially accumulate beyond the *high* soil test level. Therefore, soil testing is required to prevent excessive nutrient build-up to occur. Some soil testing labs have moved from replacing 100% of the crop removal values to replacing only 50% in order to minimize the chances that they will recommend excessive fertilizer. Although this approach may help reduce the potential environmental impacts associated with nutrient transport, the risks still exist.

Another challenge to the Build-Up and Maintenance concept has to do with the soil type. In sandy soils with low nutrient-holding capacity, it may not be possible to build up nutrients in the soil. In this respect the Build-Up and Maintenance concept has similar limitations to the BCSR approach for fertilizer recommendations. Further, farmers today may be less inclined to add more fertilizer to build the soil reserves for land they do not own.

Both the Build-Up and Maintenance and the BCSR philosophies may be scientifically and economically ill-advised, because both increase the chances that more fertilizer will be recommended than is required by the current crop. Any excessive fertilizer recommendations also carry the associated risks of nutrient transport through leaching or runoff. The most likely situations for using the BCSR and Build-Up and Maintenance approaches to fertilizer recommendations would be for soils with high CEC and high nutrient-holding capacities where the risk of nutrient losses from leaching or surface or subsurface runoff is minimized. Both of these philosophies are considered by some specialists to "fertilize the soil," because their goal is mainly to effect specific changes in the fertility status of the soil with little attention to the crop response.

The Crop Nutrient Requirement approach to fertilizer recommendations is to add only the amount of fertilizer required to fulfill the crop nutrient requirement (CNR) for the current growing season. This concept, also referred to as "fertilizing the crop," accounts for the nutrient-supplying capacity of the unfertilized soil and adds to that capacity with fertilizer only when the soil cannot supply 100% of the CNR. The fertilizer recommendations made for a crop for each soil test index category are based on long-term research trials conducted at different locations and using different varieties and management practices, and these recommendations are believed to be sufficient to provide adequate amounts of nutrients to meet the crop requirements without overfertilizing the crop. Using this approach, there is less interest in building the soil to a *very high* nutrient level. Practitioners of the SLAN approach claim that this method best conserves fertilizer resources, minimizes fertilizer costs to the farmer, and is likely the most protective of the environment. The SLAN approach is sometimes charged with being too conservative and risks not recommending enough fertilizer when truly high yield potential exists. Further it depends on regular, even annual soil testing, which some farmers still need encouragement to practice.

Conclusion

Some studies have been conducted to compare the various philosophies for their impact on yields and fertilizer costs. One of the most comprehensive studies was conducted in Nebraska by R. A. Olson and colleagues (Olson et al. 1982). Though the study was conducted from 1973 to 1980, it still has relevance today because, in part, the same soil testing procedures are in use. These scientists had soils from several locations tested by several labs, including the university lab and several commercial labs. They followed the specific lab's fertilizer recommendations for growing corn and measured the nutrient inputs and crop yields. From the total of 29 studies conducted over several growing seasons and several sites, the scientists found no significant yield differences due to fertilization approach, despite wide variations in fertilizer recommendations, including specific nutrients recommended and rates of nutrient recommended. In the Nebraska study, the appropriately calibrated nutrient-sufficiency fertilizer recommendation resulted in highest yields and minimized fertilizer inputs and costs, as well as impacts on the environment.

In summary, there are at least three main approaches or philosophies to making fertilizer recommendations. Farmers trying to choose the best approach may become frustrated, but the choice becomes easier if we keep in mind two major goals: profitable crop production and a resulting minimal negative impact on the environment. Fertilizer is becoming more costly, both in money spent on crop production and in terms of costs to the environment, such as eutrophication of water bodies from fertilizer run-off. According to research, the adequately calibrated CNR (or SLAN) approach most often calculates the right amount of fertilizer to supply the needs of the current crop and to present the lowest risk of off-site nutrient transport, more so than the BCSR and the Build-Up and Maintenance approaches. If fertilizer recommendations based on a percentage of crop removal values are reduced from 100% to 50% or less, then the Build-Up and Maintenance and the CNR (or SLAN) philosophies become more similar, at least for nutrients for which a soil reserve can be developed. However, CNR needs continual field research to make sure that the fertilizer recommendations keep up with changes in crop production practices, including changing varieties and increasing intensity of production practices.

Other publications in this series on soil testing

Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. *Soil Testing for Plant-Available Nutrients—What Is It and Why Do We Use It?* Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss621.

Hochmuth, G., R. Mylavarapu, and E. Hanlon. 2014. *Developing a Soil Test Extractant: The Correlation and Calibration Processes.* Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/ss622.

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