AGR-151

Evaluating Fertilizer Recommendations

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Soil testing and making fertilizer recommendations are not the same thing. While soil test results estimate the plant available nutrients in a field, the fertilizer recommendation, which is based on an interpretation of soil test results, determines how much lime and fertilizer are needed by a particular crop species on a particular field. Several philosophies are used in interpreting soil test results for lime and fertilizer recommendations. Each of these philosophies is based on different assumptions about crop needs and how crops respond at different soil test levels and different amounts and ratios of nutrients. For any of these philosophies to have value, they must be correlated to the soil types and climatic conditions present.

Several different philosophies are used in Kentucky depending on who is making the recommendation. Different farm supply dealers, agricultural consultants, and soil test laboratories use different approaches. Because of this, farmers often wonder why they receive such contrasting fertilizer recommendations and what these differences mean in a farming operation. The most common question asked is, "How do these different recommendations affect yield, costs, and subsequent soil tests?" The different lime and fertilizer recommendation philosophies that are often encountered in Kentucky are explained below.

Philosophies

Crop Sufficiency

The crop response is the focus of this philosophy. The expected response of the crop at any given soil test level is what determines the recommended level of each nutrient. The amount of fertilizer recommended is determined from many field trials on different soils over many years. The approach is based on a research data base that adequately predicts a crop response under good or normal conditions. The research base must be sufficient for each crop on the existing soil types under most of the prevailing weather conditions.

Soil Cation Balance

This philosophy focuses on the cation nutrient balance of the soil. The theory behind this philosophy is that the correct nutrient balance results in maximum crop response. This approach is often adopted when wide extremes in soil type are encountered, or the research base for the soil types encountered is not extensive.

Maintenance Fertility

According to this philosophy, the nutrients removed at harvest should always be replaced. This approach is used on soils that test medium and high in Phosphorus (P) and Potassium (K). This method is used in addition to the recommendation made by either the Soil Cation Balance or the Crop Sufficiency approach which use a soil test as a basis for recommendation. A yield response to this extra maintenance fertilizer is usually not expected, but the fertilizer is added in hopes of maintaining soil test levels over time.

Micronutrients by Soil Testing

This concept is based on testing the soil for secondary and micronutrients and makes recommendations based on only this information. Using only a soil test greatly increases the chance of adding a nutrient when it may not be needed. This is significantly different from making recommendations on these nutrients when both a tissue test and soil test are used to determine a deficiency, or when an area or soil type is known to have a consistent problem. This concept is sometimes used with any of the above philosophies.

Combination of Philosophies

It is common to encounter recommendations made from a combination of philosophies. The philosophy that usually exists by itself is the sufficiency philosophy. The maintenance philosophy frequently is used with both the sufficiency and soil cation balance approaches. The philosophy of recommending micronutrients based only on a soil test is sometimes used with all approaches, but is used most commonly with the maintenance and soil cation balance philosophies.

What Does it Mean?

It is likely that most farmers don't know what philosophies are used by the agency, dealer, or consultant making the recommendation. But, most farmers recognize that there is a difference depending on who makes the recommendation. Important questions concerning the recommendations are: (1) Is there a difference in costs; (2) Could there be a difference in yield; (3) How does it affect economic returns; and (4) How will it affect future soil tests. In order to help answer these questions, we began field trials testing these different philosophies in 1977. They have been run in many counties in western Kentucky over the last 15 years and are still continuing.

Field Trials

Table 1 shows the locations, years, crop grown, and philosophies represented. One trial (Caldwell, 1977-79) was located on the University of Kentucky's experiment station at Princeton, Kentucky. All other trials were on farms. Soil samples were taken from the plot area, mixed, and divided into separate samples. The samples were taken to different agencies and fertilizer dealers in the county for analysis and fertilizer recommendations. In only two cases (Caldwell and Calloway) was the same philosophy or combination used by more than one recommender in the county. The determination of the category of the philosophy used by the recommender was based on past history, known philosophy of recommender, and comparison of recommendations. The farmer carried out his normal cultural practices (tillage, variety selection, weed control, planting, etc.), but only the recommended fertilizer was applied and it was broadcast and tilled into the soil, except in Calloway County where the site was no-tilled.

All corn trials were hand harvested and corrected to 15.5% moisture weights. Wheat and soybeans were machine harvested and corrected for moisture. All trials were conducted in a randomized block design with 3, 4 or 5 replications. All prices of fertilizers were taken from local dealers for the year of the experiment, and in most cases, least-cost fertilizer combinations were used, such as 18-46-0 if both N and P were recommended, and zinc sulfate if both Zn and S were recommended.

Results

The different fertilizer recommendation philosophies and combinations used were:

1. Sufficiency
2. Sufficiency + Maintenance
3. Soil Cation Balance + Maintenance
4. Sufficiency + Maintenance + Soil Test Micronutrients
5. Soil Cation Balance + Maintenance + Soil Test Micronutrients

Not all 5 philosophies were represented at each location (Table 1) since the philosophies varied by county. However, the sufficiency philosophy did exist at each location. Therefore, all philosophies or combinations were compared to sufficiency as many times as they occurred together. All the results were averaged in order to reduce the data to a comprehensible basis.

Sufficiency Versus Sufficiency plus Maintenance

These two philosophies could be compared at 5 locations and 8 trial years (Table 2). Both philosophies appeared to function well and had very similar results. Since all locations tested high in P and K, the sufficiency philosophy recommended no P_2O_5 and K_2O, while the maintenance philosophy recommended only estimated replacement amounts of P and K that would be removed.

Except for poorly drained soils, the recommenders using the maintenance philosophy always recommended more N. Although the yield with maintenance was 5 bu/ac higher, it was not a real difference according to statistical analysis. It cost almost $16/ac more to fertilize using the maintenance philosophy. If there is no real difference, then the $16/ac would have to be considered a no interest investment into the fertilizer storage.

Table 1. Trial Locations, Years, Crops, and Fertilizer Recommendation Philosophies Tested

	County	Years	Crop	Philosophies*
1)	Caldwell	1977-79	Corn	S, M, CMR (2)
2)	Henderson	1978	Corn	S, MR
3)	Henderson	1984	Corn	S, M, CM
4)	Hopkins	1986-89	Corn, Soybeans, & Wheat	S, MR, CMR
5)	Calloway	1987	Corn	S, M (2)
6)	Muhlenberg	1987	Corn	S, M, CMR
7)	Christian	1987	Corn	S, M, MR
8)	Christian	1988	Corn	S, CM, CMR

**S = Sufficiency, M = Maintenance, C = Soil Cation Balance, R = Micronutrients*

Table 2. Comparison of the Sufficiency Vs. Maintenance Fertilizer Recommendations in 5 Counties in Western Kentucky. Average of 8 Trial Years.

	Philosophy	
	Sufficiency	Maintenance
Recommendation (lb/ac)[1,3]	150-0-0	174-50-54
Costs ($/ac)	$28.59	$44.50
Corn Yields (bu/ac)[2]	130	135

[1] Recommendation = N - P_2O_5 - K_2O, respectively.
[2] Yield results were significantly different only once and in that case the sufficiency philosophy was better.
[3] All locations tested high in P and K.

Table 3. Comparison of the Sufficiency Vs. Soil Cation Balance (SCB) Plus Maintenance Fertilizer Recommendations in Two Counties in Western Kentucky. Average of 2 Trial Years.

	Philosophy	
	Sufficiency	SCB + Maintenance
Recommendation (lb/ac)[1,3]	182-0-0	182-74-119
Costs ($/ac)	32.41	62.56
Corn Yields (bu/ac)[2]	117	113

[1]Recommendation = N - P_2O_5 - K_2O, respectively.
[2]Yields were not significantly different.
[3]All locations tested high in P and K.

Sufficiency Versus Soil Cation Balance + Maintenance

These two philosophies could be compared at 2 locations and 2 trial years (Table 3). The 2 philosophies gave similar yield results with a significant difference in cost. Both locations were on poorly drained sites, so both N rates were the same. Both locations tested high in P and K, so the sufficiency approach recommended no P_2O_5 and K_2O. The soil cation balance plus maintenance approach recommended more P and K than just replacement of removed nutrients would require. The difference in yield is small and is not statistically different. The costs between the two are great and would be difficult to justify as fertilizer storage in the soil.

Sufficiency Versus Sufficiency + Maintenance + Soil Test Micronutrients

These two philosophies could be compared at 3 locations and 6 trial years (Table 4). Since most of the sites tested medium, the sufficiency philosophy recommended some P_2O_5 and K_2O while the maintenance philosophy added a replacement level above that. The addition of secondary and micronutrients increased the costs significantly. The maintenance plus soil test micronutrient combination increased the costs by $26/ac with the secondary and micronutrients accounting for about $10/ac of the total. The added cost and extra nutrients had no effect on yields. The average yields were almost identical, with no significant difference among them in any of the trials.

Sufficiency Versus Soil Cation Balance + Maintenance + Soil Test Micronutrients

These two philosophies could be compared at 4 locations and 12 trial years (Table 5). Since 1/3 of the sites tested medium, the sufficiency philosophy recommended some P_2O_5 and K_2O while the other philosophy recommended much higher rates. The N recommendation was also significantly higher for corn, which is not uncommon with this philosophy. The costs were greatly different ($41/ac.) with the secondary and micronutrients being responsible for about $10/ac of the extra costs. As before, the extra nutrients had little effect on the yields. Although the average yield was higher with the sufficiency philosophy, it was only statistically better in one of the 12 trial years. It would almost be impossible to economically justify the Soil Cation Balance + Maintenance + Soil Test Micronutrients philosophy.

Table 4. Comparison of the Sufficiency Vs. Maintenance Plus Soil Test Micronutrients Fertilizer Recommendations in 3 Counties in Western Kentucky. Average of 6 Trial Years[1].

	Philosophy	
	Sufficiency	**Maintenance & Micro**
Recommendation (lb/ac)[2,4]		
Corn	165-25-11	170 - 69 - 76 + 5 Mg + 12 S + 0.5 B + 2 Zn
Soybean	0-30-30	15 - 64 - 60 + 10 Mg + 20 S
Wheat	90-0-0	100 - 78 - 122 + 15 S
Costs ($/ac)[1]	$29.86	$55.92
Yield (bu/ac)[1,3]	137.6	137.5

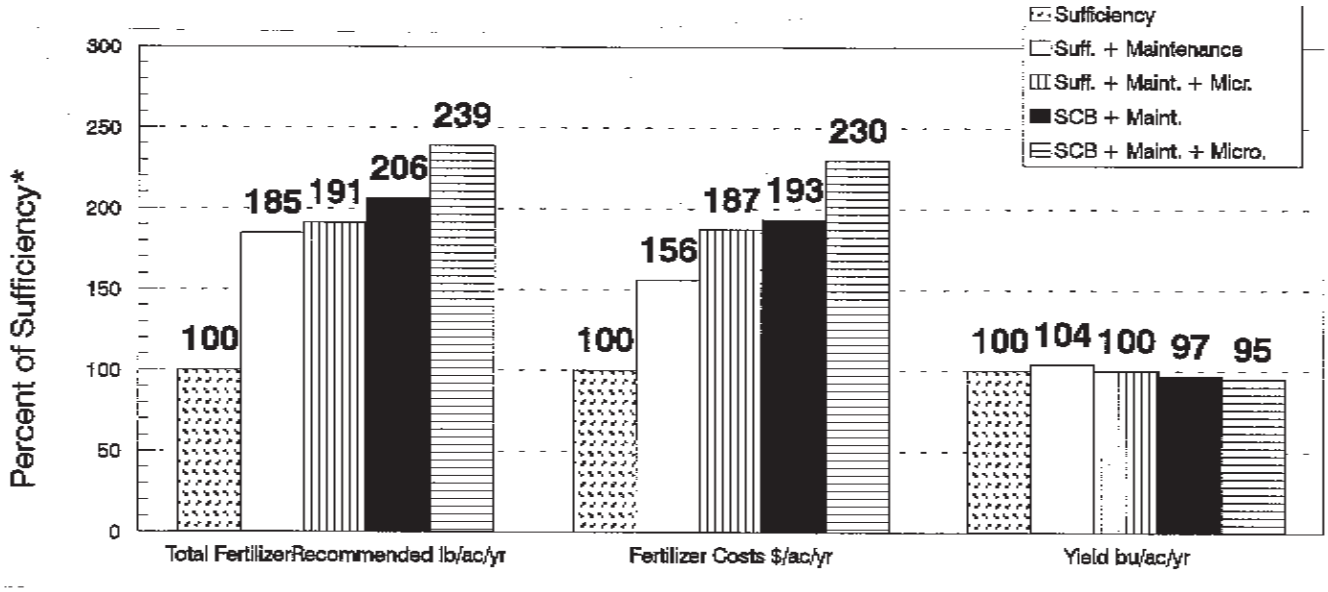
[1] Trial Years = Corn (4), Soybeans (1), Wheat (1). All crops averaged over all years for costs and yield data.
[2] Recommendation = N - P_2O_5 - K_20 + Mg (magnesium) + S (sulfur) + B (boron) + Zn (zinc)
[3] Yields were not significantly different
[4] Soil Test Levels = 4 locations medium and 2 high in P and K.

Table 5. Comparison of the Sufficiency Vs. Soil Cation Balance (SCB) + Maintenance + Soil Test Micro-nutrients Fertilizer Recommendations in 4 Counties in Western Kentucky. Average of 12 Trial Years.[1]

	Sufficiency	**SCB + Maint. + Micro**
Recommendations (lb/ac)[2,4]		
Corn	164-14-6	189 - 87 - 120 + 8 Mg + 6 S + 1 B + 5 Zn
Soybean	0-30-30	10 - 93 - 107 + 26 Mg + 15 S + 1 B + 10 Zn
Wheat	90-0-0	90 - 117 - 96 + 27 Mg + 1 B
Costs ($/ac)[1]	$31.59	$72.80
Yield (bu/ac)[1,3]	112	106

[1] Trial Years = Corn (10), Soybeans (1), Wheat (1). All crops averaged over all years for costs and yield data.
[2] Recommendation = N - P_2O_5 - K_2O + Mg (magnesium) + S (sulfur) + B (boron) + Zn (zinc)
[3] Yields were not significantly different at 0.1 level in 11 trial years and sufficiency was significantly higher 1 year.
[4] Soil Test Levels = 4 locations medium and 8 high in P and K.

Effect of 5 Different Fertilizer Recommendation Philosophies on Amount of Fertilizer Recommended, Costs, and Crop Yield



**The amount of fertilizer recommended, costs, and yield for the sufficiency philosophy was placed at 100% as a comparison for other treatments.*

Effect on Soil Tests

The philosophy used to make fertilizer recommendations had an effect on long-term soil tests. Since several of the trials were conducted for only one year, it was not possible to evaluate the effect of the recommendation philosophy on the soil test at harvest. However, at the locations where the trials were conducted for 3 to 4 years, comparison could be made. When the maintenance or soil cation balance philosophy was used, the soil test for P and K continued to increase with time. This happened for both medium and high testing soils and indicates that some of the surplus fertilizer added to the plots was being stored for future use. The percentage of the surplus fertilizer which would actually be used by the following crops could not be determined by this study.

Summary

Five different philosophies or combinations of philosophies used in Kentucky to make fertilizer recommendations were evaluated and the results are summarized in Figure 1. All recommendations resulted in excellent crop yields when the weather conditions were good. In almost all cases, there was no real difference in yields. However, there were always fairly large differences in the amount and kinds of fertilizer recommended. This resulted in large differences in the costs, with very high fertilizer costs giving no yield advantage. Soil tests taken a few years following use of the various recommendations indicated that surplus fertilizer was being stored in the soil. Fertilizer rates based on the crop sufficiency philosophy cost the least and produced equivalent yields compared to the more costly recommendations based on the other philosophies tested.

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