FERTILIZER RECOMMENDATIONS IN THE EASTERN CORN BELT[1]

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The purpose of this paper is to discuss fertilizer recommendations for corn and soybeans made by three universities and by three private institutions in the Eastern Corn Belt. For lack of a better term, the six sources of recommendations will be referred as "labs", a commonly-used abbreviation for soil testing laboratories. This term does not accurately describe Countrymark which uses the results from other labs on which to base its recommendations.

ABSTRACT

Nitrogen (N), phosphorus (P) and potassium (K) recommendations for corn and soybeans were compared from six institutions (labs) active in the Eastern Corn Belt. The six labs base their N recommendations on one or more of the following factors: yield goal, previous crop, soil organic matter, manure applications and soil type. The recommended N rates are quite uniform for the 150 and 180 bu/A yield goals. Adjustments for N credits can have a large influence on the final N recommendation and each lab uses unique factors for these adjustments.

All six labs follow some form of a build-up/maintenance approach to making P and K recommendations. This approach strives to build the soil test to a desired level and then keep it there with maintenance applications of P and K. Differences in recommendations can be partly explained by how high and how quickly the lab recommends building the soil test. All labs recommend no P or K if soil tests are above ceilings established for each lab.

Farmers will end up using the same amount of P and K fertilizer on an annual basis regardless of which recommendations they follow once the soil test is increased to a certain level. Because all labs call for zero recommendations above soil test ceilings, differences in fertilizer costs are attributable to soil build-up. Long-term, the recommendations of all the labs will eventually match P and K crop removal.

NITROGEN RECOMMENDATIONS FOR CORN

Nitrogen (N) recommendations for corn are economically and environmentally the most meaningful for most Eastern Corn Belt farmers. Profits can easily be lost if too little N is applied while over-application is inefficient and raises the specter of water contamination.

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Corn requires large amounts of N and the pathways by which N can be lost are complex and hard to predict because they depend so heavily on weather. It is very difficult to say at the beginning of a growing season precisely how much N must be applied to achieve the optimum yield. Since a N soil test is not widely available in the Eastern Corn Belt, recommendations must be based on long-term research measuring yield responses over a range of growing seasons and on experience using diagnostic techniques.

Most labs base their N recommendations on one or more of the following factors: yield goal, previous crop, soil organic matter, manure applications and soil type. Table 1 compares N recommendations made by the six labs. The recommended rates are quite uniform for the 150 and 180 bu/A yield goals. There is somewhat more variation at the 120 bu/A yield goal.

Table 1. Nitrogen recommendations for corn made by six labs. Assumptions include corn as the previous crop and a soil with 3% organic matter.

Yield Goal	OSU[1]	Purdue	MSU	A&L	Agrico	Country-mark
bu/A	lb/A N					
120	115	140	135	150	170	130
150	200	170	180	195	210	180
180	200	230	220	240	250	230

[1] OSU recommends an additional 50 lb/A of N for light-colored or imperfectly drained soils with the total application not to exceed 200 lb/A on light-colored soils.

NITROGEN CREDITS AND DEBITS

Factors such as previous crop, soil organic matter and soil type affect how much fertilizer N is needed for corn. Often the N rate can be sharply reduced without harming crop yield when N credits are properly accounted for. Nitrogen recommendations can also be adjusted upward when accounting for N debits. The labs consider some or all of the following factors when making N recommendations.

Soil organic matter. Plant available N is released as organic matter (OM) decomposes in soils. Nitrogen credits are based on the assumption that a certain portion of the OM will decompose each year making the N credit proportional to the total soil OM. Nitrogen availability is thus enhanced and the need for fertilizer N reduced as soil organic matter increases. Labs that adjust N recommendations for OM normally subtract 10 to 20 lb/A for every one percent of soil OM.

Previous crop. The previous crop can strongly influence the need for applied N. Forage legumes receive the largest credits ranging from -50 to -100 lb/A N. Some labs adjust for the quality of the legume crop because a good stand of a legume will provide more residual N than will a legume/grass mixture. Credits for soybeans range from 0 to -40 lb/A N.

Manure. Credits for manure are in the -4 to -5 lb N/ton range. This credit is often overlooked by farmers when determining N rates. Manure varies widely in N content. For the most reliable results, the manure should be analyzed for its nutrient content.

Date of planting. Purdue University reduces the recommended N rate when planting is delayed past May 25 reflecting the likelihood of a lower yield with late planting.

Soil color and drainage. OSU recommends the N rate be adjusted upward (a N debit) by +50 lb/A on light-colored or imperfectly drained soils with the total application not to exceed 200 lb/A on light-colored soils.

The following is a summary of the techniques used by the six labs to determine N adjustments (lb/A N) for corn. A N credit is that amount of N which can be subtracted from the recommended application rate without loss of yield. Each lab uses a unique method to determine the final N recommendation so comparisons of N adjustments between labs are useful only in the context of the overall approach used.

OSU	Previous crop: Varies depending on yield goal. Credits for 150 bu/A corn yield goal: soybeans -10, forage legume -90, grass crop -30. Soil: +50 lb/A of N for light-colored or imperfectly drained soils with the total application not to exceed 200 lb/A on light-colored soils.
Purdue	Previous crop: soybeans -20, good legume -80, average legume -50. Date of planting: -20 to -40 if planted after May 25.
MSU	Previous crop: 100% alfalfa -100, 60% alfalfa -80. Manure: T/A X -4.
A&L	Previous crop: soybeans -20, alfalfa or clover -50 to -70. Organic matter: Credit varies depending on yield goal and %OM reference point. Generally -10 to -15 for each %OM.
Agrico	Previous crop (compared to previous crop of corn): soybeans -40, alfalfa -80, clover -70, small grain -10. Organic matter: -10 for each %OM. Manure: T/A solids X -5.
Countrymark	Previous crop: soybeans -20, alfalfa -60, legume/grass -40. Organic matter: -20 for each %OM.

THE BUILD-UP MAINTENANCE APPROACH

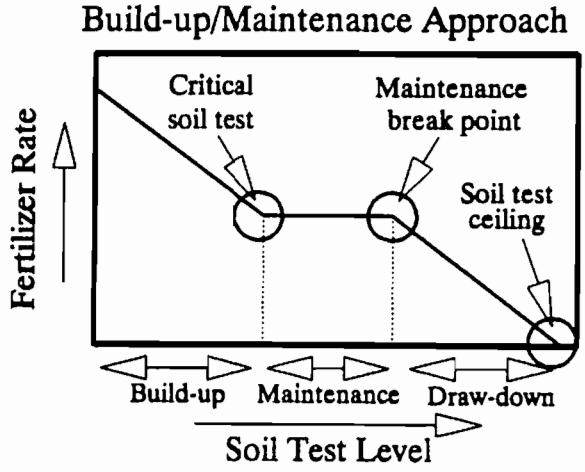
All six labs follow some form of a build-up/maintenance approach to making phosphorus (P) and potassium (K) recommendations. This approach strives to build the soil test to a desired level and then keep it there with maintenance applications of P and K. Maintenance applications are roughly equal to the amount of P and K removed by the harvested portion of the crop.

Differences in recommendations can be partly explained by how high and how quickly the lab recommends building the soil test. The three university labs generally do not build soil tests as high as the other three labs and cut off maintenance rates at lower levels. OSU's K recommendations are an exception.

Figure 1 is a simplified schematic showing the general approach to making P and K fertilizer recommendations in a build-up/maintenance program. Build-up rates are recommended until a critical soil test is reached. Research has shown increasing the soil test above the critical level will usually increase crop yields no more than 5% to 10%.

Maintenance rates are recommended for soils testing between the critical soil test and the maintenance break point. Above the maintenance break point, less than maintenance is recommended allowing the draw-down of soil fertility. Above the soil test ceiling no P or K is recommended except for small amounts of starter fertilizer in some situations.

Figure 1. The build-up/maintenance approach to making P and K recommendations.



OSU provides both annual recommendations and separate P and K build-up recommendations for soils testing less than the critical level. OSU's annual plus build-up recommendations are shown in a separate column in Tables 2 and 3.

The P and K recommendations provided by A&L, Agrico and Countrymark follow a more aggressive build-up/maintenance approach which makes their recommendations generally higher than those of the university labs except for OSU's K recommendations. All six labs, however, recommend that no fertilizer be applied if the soil test is above the soil test ceiling established by each lab. Several of the labs, however, suggest a small amount of starter fertilizer be applied even at very high soil test levels in situations, such as reduced tillage, where early season crop growth is often restricted by inadequate nutrition.

PHOSPHORUS RECOMMENDATIONS

There is reasonably good agreement among the labs in their P recommendations for corn and soybeans (Table 2). This especially true at the low and medium soil test levels. As soil tests increase, Purdue's and MSU's recommendations tend to drop more quickly than do the other labs. Phosphorus recommendations are generally lower for 50 bu soybeans than for 150 bu/A corn. This reflects the soybean's ability to produce adequate growth at lower soil P levels than corn.

POTASSIUM RECOMMENDATIONS

More variation exists among the K recommendations (Table 3). This is particularly evident when comparing the corn with the soybean recommendations. While OSU and Countrymark recommend more K for soybeans than for corn at the same soil test level, the other labs recommend less.

OPTIMUM SOIL TEST RANGES

All labs reduce the amount of P and K recommended as soil tests increase. At low soil test levels, all labs recommend more P and K than what is removed by the crop. Once the critical soil test level is reached, the P or K recommended is equal to what is removed by the crop. Above the maintenance break point, the amount of P or K recommended is less than what is removed by the crop.

The range between the critical soil test and the maintenance break point is the optimum soil test range. It is represented in Figure 1 as the "maintenance" zone.

The optimum soil test ranges for the six labs were estimated by comparing the recommended rates with crop removal (Table 4). The optimum ranges for K show greater variability among the labs than do the optimum ranges for P.

The optimum soil test ranges are useful when considering the long-term effects of following a lab's fertilizer recommendations. Soil tests should equilibrate somewhere within the optimum soil test range. For example, if a farmer followed OSU's P recommendations for many years his soil test would equilibrate between 30 and 60 lb/A P. His K soil test would equilibrate between 300 and 400 lb/A K.

Table 2. Phosphorus recommendations for 150 bu/A corn grain and 50 bu/A soybeans. The approximate maintenance rates are 65 lb/A P_2O_5 for 150 bu/A corn grain and 45 lb/A P_2O_5 for 50 bu/A soybeans.

Corn, 150 bu/A

Soil Test P lb/A	OSU	OSU +build-up	Purdue	MSU	A&L	Agrico	Country-mark
				lb/A P_2O_5			
20	80	100	90	90	115	130	130
40	60	60	40	65	85	100	75
80	20	20	0	10	45	50	45

Soybeans, 50 bu/A

Soil Test P lb/A	OSU	OSU +build-up	Purdue	MSU	A&L	Agrico	Country-mark
				lb/A P_2O_5			
20	55	100	70	60	90	100	120
40	45	45	30	40	70	70	85
80	25	25	0	0	35	40	70

Table 3. Potassium recommendations for 150 bu/A corn grain and for 50 bu/A soybeans grown on a soil with a CEC of 15 meq/100g. The approximate maintenance rates are 45 lb/A K_2O for 150 bu/A corn grain and 70 lb/A K_2O for 50 bu/A soybeans.

Corn, 150 bu/A

Soil Test K lb/A	OSU	OSU +build-up	Purdue	MSU	A&L	Agrico	Country-mark
				lb/A K_2O			
150	95	280	120	155	225	200	240
250	55	90	50	20	125	170	140
350	35	40	0	0	45	70	45

Soybeans, 50 bu/A

Soil Test K lb/A	OSU	OSU +build-up	Purdue	MSU	A&L	Agrico	Country-mark
				lb/A K_2O			
150	110	280	90	60	195	150	265
250	90	90	60	0	95	120	165
350	75	75	0	0	70	70	70

Table 4. Optimum soil test ranges for P and K estimated from the recommendations of six labs. Assumptions include a soil with a CEC of 15 meq/100g, a yield goal of 150 bu/A for corn and 50 bu/A for soybeans.

Optimum Soil Test Ranges for P

	OSU	Purdue	MSU	A&L	Agrico	Country-mark
	lb/A P					
Corn	30-60	30-50	40-50	50-70	60-100	45-95
Soybeans	30-60	30-50	30-40	50-70	60-100	45-95

Optimum Soil Test Ranges for K

	OSU	Purdue	MSU	A&L	Agrico	Country-mark
	lb/A K					
Corn	300-400	210-300	225-250	330-500	300-500	345-445
Soybeans	300-400	210-300	150-175	275-415	300-500	345-445

Table 5. P and K soil test ceilings above which six labs recommend no P or K. Assumptions include a soil with a CEC of 15 meq/100g, a yield goal of 150 bu/A for corn and 50 bu/A for soybeans.

P Soil Test Ceilings

	OSU	Purdue	MSU	A&L	Agrico	Country-mark
	lb/A P					
Corn	80	50	80	100	100	95
Soybeans	90	50	50	100	100	95

K Soil Test Ceilings

	OSU	Purdue	MSU	A&L	Agrico	Country-mark
	lb/A K					
Corn	450	300	250	500	500	450
Soybeans	550	300	200	415	500	450

SOIL TEST CEILINGS

All of the labs recommend no P or K when soil tests are above certain levels. The soil test ceiling is the soil test above which no P or K is recommended. The soil test ceilings used by the six labs are shown in Table 5. As noted earlier, several of the labs suggest a small amount of starter fertilizer be applied even at very high soil test levels in some situations.

PHOSPHORUS AND POTASSIUM RECOMMENDATIONS COMPARED

Most farmers plan to be in business for many years and take a long-term view towards soil stewardship. Fertilizer recommendations should be evaluated on their long-term effects on fertilizer use decisions and on soil productivity.

From the standpoint of fertilizer use decisions, farmers will end up using the same amount of P and K fertilizer on an annual basis regardless of which recommendations they follow once the soil test is increased to a certain level. Because all labs call for zero recommendations above soil test ceilings, differences in fertilizer costs are attributable to soil build-up. When the farmer stops applying fertilizer, crop removal will lower the soil tests and recommendations will again call for P and K to be applied. Long-term, the recommendations of all six labs will eventually match the P and K removed by the crop.

A major difference among the recommendations is at what levels the soil tests will eventually stabilize. Farmers following recommendations of the three university labs will see their soil tests stabilize at generally lower levels than if they follow the recommendations of the other three labs. A exception is OSU's optimum soil test ranges for K which are among the highest of the six labs.

Proponents of a less aggressive build-up/maintenance approach will argue that there is no need to build to higher soil test levels. The annual recommendations are designed to produce the optimum yields each year regardless of the soil test and, long-term, less money will be spent on fertilizer while causing little, if any, loss in yield. The recommendations are based on replicated research performed at multiple locations and are actually adjusted upward from what the data suggest to provide a safeguard against losing yield from applying too little P or K.

Proponents of a more aggressive build-up/maintenance approach will argue that higher soil tests and maintenance applications provide insurance against nutrient shortages in years with weather extremes and in fields with non-uniform soil fertility. Small applications of P or K, often applied as a starter fertilizer, sometimes give yield responses even at high soil test levels. Higher soil tests also provide greater flexibility to a farmer when he cannot afford to buy fertilizer. And the soil fertility and productivity of a farm should be in the best possible shape when it is passed to the next generation.

Farmers should receive individual guidance from a qualified advisor when determining the best fertilizer program for each field. Advisors who know the management ability of the farmer and have had experience working with similar soils are in the best position to make personalized fertilizer recommendations tailored for a specific farmer and his soils.

SOURCES

The actual procedures used by the labs in making fertilizer recommendations are more complex than what is summarized in this paper. Additional information can be obtained from the following sources.

OSU
Dr. Jay Johnson
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Purdue
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