PROVIDING FLEXIBILITY IN P AND K RECOMMENDATIONS

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Introduction

Historically, land grant Universities have generally provided a single rate recommendation for nutrients such as phosphorus (P) and potassium (K). Depending on the particular University in question, these nutrient rate recommendations are generally based on two widely recognized approaches to managing soil and fertilizer P and K – the nutrient sufficiency approach and the build-maintenance approach.

The goal of a nutrient sufficiency based soil fertility program is to apply just enough P and/or K to maximize profitability in the year of application, but minimize nutrient applications and fertilizer costs, each year. While inherent variability in nutrient response, both field-to-field and year-to-year, may result in more or less nutrient actually being required for maximum profitability in a given year than is recommended, near optimum rates will be recommended over the longer term. Unless initial soil test levels are high and the soil can supply all the nutrient needs of the crop when this approach is adopted, little year-to-year flexibility in nutrient application exists and nutrient application is required every year in order to eliminate profit robbing nutrient shortages. Specific nutrient application methods, such as the use of band application, may also be needed for maximum nutrient response.

Nutrient sufficiency recommendations are based on long-term soil test calibration field data. In an attempt to address the complicated, constantly changing issue of marginal return on fertilizer investment in the year of application, these recommendations are typically developed to provide 90 to 95% of maximum yield. Crop response and recommended nutrient application rates are highest at very low soil test levels, while recommended nutrient application rates decrease to zero as the soil test level increases to a 'critical' soil test value. The critical level is the soil test value at which the soil is normally capable of supplying sufficient amounts of P and/or K to achieve 90-95% of maximum yield. For nutrient sufficiency recommendations, soil test values are not viewed as a managed variable and there is little or no consideration of future soil test values. When this system is followed for long periods of time, soil test values eventually stabilize at 'low', crop responsive levels, with recommended application rates being approximately equal to crop removal.

The objective of build-maintenance fertility programs is to manage a controllable variable, P and/or K soil test levels. At low soil test values, build-maintenance recommendations are intended to apply enough P and/or K to meet both the nutrient needs of the immediate crop and to build soil test levels to a non-limiting value, above the critical level. This build-up of soil test values occurs over a planned period of time (typically 4 to 8 years). Once the soil test value exceeds the critical value, nutrient recommendations are then made to maintain the soil test levels in a target, or management range. The soil test target range is typically at and slightly above the critical soil test value, where the soil can generally provide adequate nutrients to meet the nutritional needs of growing crops ('medium' to 'high' levels) without additional fertilizer.

While nutrient applications are required for optimum yields below the critical level, farmers have great flexibility as to when fertilizer is applied once soil tests are in the target range. Above the critical level the soil is largely capable of supplying the nutrients needed in a given year. Farmers can thus choose to apply fertilizer annually, or to combine applications and only apply the fertilizer every two or three years. This provides flexibility to manage both time and cash flow. It also allows more efficient utilization of the nitrogen in common P fertilizer products (ammonium phosphates; DAP, MAP, APP) by directing the applications to crops normally requiring additional nitrogen, such as corn or grain sorghum.

In recent years agronomists have become increasingly concerned over the environmental impact of nutrient programs, particularly P fertilization. So, the upper end of the target or management zone is commonly determined by a combination of agronomic, economic and environmental factors. When soil test values exceed the target range, the probability of crop response is relatively low while the potential for environmental concerns begins to increase. No P and/or K is normally recommended beyond the target range with the exception of small amounts of starter fertilizers. Build-maintenance fertility programs are not intended to provide optimum economic returns in any given year, but rather attempt to minimize the possibility of P and/or K limiting crop growth while providing near maximum yield, high levels of grower flexibility and good economic returns over the long-run. The disadvantage of soil build-maintenance programs when soil test levels are below the critical soil test level (the crop responsive range), is that required application rates are normally higher than those recommended for nutrient sufficiency programs.

KSU Approach To P and K Recommendations

So which is better, a nutrient sufficiency or a build-maintenance P and K program? Or is an approach somewhere in-between optimal? In the past there have been many lively and spirited discussions about the superiority of one or the other approaches by people with tightly held beliefs. And sound, well-reasoned arguments supporting both approaches to managing nutrients have been made by knowledgeable people. Some farmers, agronomists and agricultural economists staunchly support nutrient sufficiency based programs while distancing themselves from build-up and maintenance programs. Other farmers, agronomists and agricultural economists insist that build-maintenance programs are better suited for managing complex and somewhat unpredictable crop production systems.

At low soil test levels there is a greater possibility that the crop will respond to fertilizer, and that the fertilizer application will be profitable in the year of application. However, the probability that P and/or K nutrition may limit yield and profitability in any given year is also higher. At higher soil test levels there is less chance that P and/or K nutrition will limit crop yield in a given year, but the probability that a fertilizer application will be profitable in the year of application will also be lower. It should be an individual producer's decision on how to weigh and manage these various risks/uncertainties.

Higher soil test values provide for greater flexibility in future P and K management plans (e.g. application rate, method and frequency) and a greater cushion in the event of adverse environmental conditions (e.g. very wet, very dry, etc.) or financial conditions (e.g. unfavorable crop/fertilizer prices, cash flow, etc.). All things being equal, most producers would prefer to

have soil P and K tests above the critical level (but not excessively high) as opposed to in the low, crop responsive soil test range, because of greater flexibility in nutrient management options. There is, however, a cost associated with building or maintaining soil test levels in the medium-high range. Again, it should be the individual producer's decision on how much to value this flexibility.

Over an extended period of time, the two systems (sufficiency and build-maintenance) provide a grower the choice between a system which recommends lower nutrient application rates at low soil test levels, but requires annual fertilizer application (nutrient sufficiency programs), versus investing in higher rates for 4 to 8 years in order to gain the flexibility and potential cost savings of making multi-year applications when it is most convenient and economical (build-maintenance programs). While the short-term difference in cost between the between the two programs may be sizeable, the benefits from flexibility in the overall fertility program, reduced application costs, improved timeliness, and cash management can make the investment in build-maintenance programs worthwhile. Once a grower understands the two approaches, he/she can decide if that cost is a reasonable investment.

In the past, KSU phosphorus and potassium recommendations have been largely based on the nutrient sufficiency approach. As we evaluated and discussed revisions to our fertilizer recommendations, it became apparent that we needed to also provide growers the guidelines for the build-maintenance approach. It is often stated that the nutrient sufficiency approach is most appropriate for the Great Plains and western states since yields are more often limited by available moisture than areas farther east, where the build-maintenance approach has been widely used. But these overly broad assumptions do not always fit individual growers, fields, and other situations.

Over the years, farm operators and their advisors often request modified recommendations that will maintain soil test levels and prevent 'mining' P and K over time. Sometimes, landlords want to make certain that tenants leave the nutrient status of their fields in the same shape as it was prior to their lease. Other farmers have asked for guidelines for building soil test levels since the program they have used has resulted in soil test levels that remain in the low-medium range after a decade of fertilizer application. At the same time, growers have also inquired as to what recommendation would be appropriate if they only anticipate controlling the land for the current year. For others, cash flow challenges have resulted in farmers desiring fertility recommendations that minimize cash requirements for a particular year.

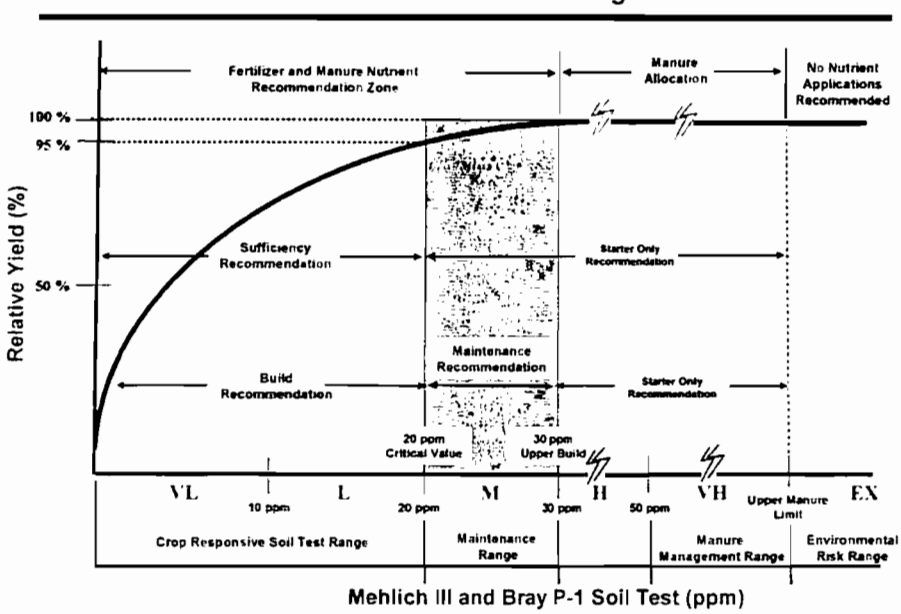
These and other issues come up every year, regardless if the farmer is in western or eastern Kansas, the Great Plains or the Corn Belt, if it is in a corn-soybean or winter wheat production area or if the field is dryland or irrigated. While some argue that economics, pure and simple, drive farmer's decisions relative to inputs such as fertilizer - others maintain that there are other valid, though somewhat subjective, reasons why some farmers make the decisions they do.

Another factor which has become more important in recent years is the possible requirement of Nutrient Management Planning for some targeted USDA farm programs. Typically, these plans require land grant University based crop nutrient recommendations. Previous KSU recommendations would have provided only a single rate recommendation that would effectively

eliminate flexibility for producers developing individualized nutrient management plans. In essence, a key management decision would be taken out of producers hands. This is undesirable from KSU's and the individual farmer's perspective.

Figure 1 presents the general P management model adopted for Kansas crop production and manure management. The general concept for K management is similar. Research data from Kansas and many other states generally supports a P soil test critical value of about 20 ppm Bray P1. Thus, we now provide both nutrient sufficiency recommendations and build-up recommendations at Bray P1 soil test values of 20 ppm and below, and soil test maintenance recommendations at soil test values of 20 to 30 ppm. No fertilizer P is recommended for soils testing 30 ppm Bray P1 or greater, except for starter applications at rates less than maintenance.

Figure 1. Phosphorus Management Model For Kansas Crop Production and Manure Management.



KSU faculty and Kansas NRCS personnel are in agreement that there is only minor environmental concern at soil test levels of 50 ppm Bray P1 or less. Thus by providing fertilizer recommendations that will maintain soil test levels below 30 ppm P, phosphorus concerns will be minimal as long as soil erosion and runoff are controlled.

With the revised recommendation system, farmers are able to maintain flexibility in developing individual nutrient management plans while providing for environmental protection and maintaining compliance with NRCS farm program provisions. Table 1 provides an example summary of the KSU phosphorus recommendations for corn. Other crops and potassium recommendations are handled similarly. Both nutrient sufficiency and build-maintenance guidelines are provided, allowing individual producers to choose the recommendations they feel are most appropriate for specific field conditions. Estimated crop removal values are provided for informational purposes with nutrient sufficiency recommendations, starter fertilizer applications may be suggested regardless of P and/or K soil test (if starter attachments available)

and including some portion of the overall fertility program as a band application for fields with low soil test values are a part of the recommendations.

Table 1. Kansas State University Corn Phosphorus Recommendations

Crop Sufficiency P Recommendations For Corn [1]

Bray P1 Soil Test (ppm)	Yield Goal (Bu/A) 60	100	140	180	220
	Lb P_2O_5/A				
0-5	55	60	70	75	80
5-10	40	45	50	55	60
10-15	25	25	30	30	35
15-20	15	15	15	15	15
20+	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]
Crop Removal [3]	20	33	46	59	73

Corn Sufficiency P Rec = [50 + (Yield Goal x 0.2) - (Bray P x 2.5) - (Yield Goal x Bray P x 0.01)]

If Bray P is greater than 20 ppm, then only a NP, NPK or NPKS starter fertilizer is suggested
If Bray P is less than 20 ppm, then the minimum P Recommendation = 15 Lbs P_2O_5/A

Build-Maintenance P Recommendations For Corn [5]

Bray P1 Soil Test (ppm)	4 Year Build Timeframe Yield (Bu/A) 60	140	220	6 Year Build Timeframe Yield (Bu/A) 60	140	220	8 Year Build Timeframe Yield (Bu/A) 60	140	220
	Lbs P2O5/A			Lbs P2O5/A			Lbs P2O5/A		
0-5	99	125	151	72	99	125	59	86	112
5-10	76	102	129	57	84	110	48	74	101
10-15	54	80	106	42	69	95	37	63	89
15-20	31	57	84	27	54	80	25	52	78
20-30 [4]	20	46	73	20	46	73	20	46	73
30+	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]	0 [2]

Corn Build-Maintenance P Rec = $\frac{\{(20 - \text{Current P Soil Test}) \times 18\}}{\text{Years To Build}}$ + P_2O_5 Removal In Crop

[1] Crop P & K recommendations are for the total amount of broadcast and banded nutrients to be applied. At low to very low soil test levels applying at least 25 to 50% of total as a band is recommended.

[2] Application of a NP, NPK or NPKS starter fertilizer may be beneficial regardless of P or K soil test level, especially for cold/wet soil conditions and/or high surface crop residues. Do not exceed N + K_2O guidelines for fertilizer placed in direct seed contact.

[3] Crop removal numbers provided for comparitive purpose only - 0.33 lb P_2O_5 and 0.26 lb K_2O per bushel of harvested corn. If crop removal exceeds nutrient applications, soil test levels are expected to decline over time.

[4] Recommended ammounts of P_2O_5 and K_2O are based on crop nutrient removal at the indicated yields (0.33 lb P_2O_5 / bu and 0.26 lb K_2O / bu).

[5] Four, six and eight year timeframes are examples only. Build programs can be over longer timeframe, however, build-maintenance recommendations should not be less than crop sufficiency based fertility programs.

Nutrient Management Scenarios

Following are examples of situations commonly facing producers in Kansas and other areas, and reasons why both the crop sufficiency and build-maintenance approach to nutrient management may be appropriate. Meet the operators of this farm, Gary, his wife Linda, and his dad. Much of Gary and Linda's operation involves taking over his fathers operation, who is now semi-retired. They also rent a substantial number of acres. The operation has generally been financially stable in the past and they always have some cattle around (cow/calf) and frequently feed out several hundred head of feeder calves, depending on the market. Crops include corn, soybeans, grain sorghum and wheat. In the past Gary's dad has typically applied '100 pounds of diammonium

phosphate (DAP. 18-46-0)' per acre per year prior to planting. They started soil testing all his dryland acres over the past year. Their local coop has sampled the irrigated corn land each year for them. They are considering purchasing a no-till planter during the next few years.

Field 1. This dryland field is representative of most of the acres they are taking over from their dad. Most of these fields have P soil test levels of about 25-30 ppm Bray P1. More and more acres are moving to no-till in this area, and Gary has started to move to less tillage as well. When he asks what KSU would recommend for P fertilizer application, he discovers that at these soil test values the crop sufficiency based recommendation would be zero. In further visits with his crop advisor, he indicates that he is not comfortable with skipping P fertilizer application since it will eventually result in depleting soil test values that his Dad had built up over the years.

Field 2. They just recently purchased this dryland field that lies just across the road from their farmyard. The soils and previous cropping history are similar to most of their acres. This field has a soil test level of about 12 ppm Bray P1 and the past fertility program is unknown.

Field 3. They have rented this dryland field, and several others, for many years from a family friend on a 1/3, 2/3 crop share basis – fertilizer costs are similarly shared. This field has a soil test of 20-22 ppm Bray P1. The past fertility program has been '100 pounds of DAP' per acre per year. There is no reason to suspect that the rental agreement will change in the near future.

Field 4. This irrigated field was purchased by Gary's dad 8 years ago and is in continuous corn. Soil texture is a sandy loam with a 1.5% soil organic matter content. Yields over the past five years have been 202, 172, 228, 232 and 238 bu/A. The P fertility program has consisted of '100 pounds of DAP' per acre and 5 gallons (~50 pounds) per acre of a liquid 8-20-5-5S-0.5Zn applied in a 2X2 starter band each year. His N program has consisted of 80 lb N/A as preplant ammonia, 50 lb N/A as UAN in a pre-emerge weed-feed application, and three UAN applications of 50 lb N/A through the pivot. Soil test values initially increased to about 18 ppm Bray P1 over the first five years that they controlled this land, but seems to be declining over the past three years (about 13 ppm in most recent sampling).

Field 5. This field and two others are located adjacent to the farmyard. The soils and previous cropping history are similar to most of the other dryland acres they have managed. These fields have soil test levels of about 48 to 64 ppm Bray P1. After visiting with Gary, it became apparent that these are the fields that most all of the manure has been hauled to in the past. Manure is only applied every two or three years when the pens are scraped and cleaned. Past fertility program has been '100 pounds of DAP' per acre per year, except those years when manure was applied.

Field 6. This field is similar to another one that has been in the family for many years. It is bottom ground that is also relatively close the farmyard. For most of the past 20 years, these fields have generally been planted to corn or sorghum silage for the livestock operation. His father has typically applied '100 pounds of DAP' per acre per year. While the field has historically been highly productive, yields have been disappointing over the past several years. Soil tests from this field indicate about 7-9 ppm Bray P1.

Field 7. This is the first year they have operated this field on a year-to-year cash lease from a farm management firm located in Indianapolis, IN. It is a somewhat eroded upland soil and the limited information available indicates a lower yield history than similar acres that Gary and/or his dad own. It has had three tenants over the past five years. Soil sampling indicates that it has a Bray P1 soil test of about 8 ppm Bray P1. The past P fertility program is unknown.

How might Gary and Linda decide to manage these fields? Would the same approach be appropriate for each individual field? Following is a short description of how and what they decided on fertility programs for each of the fields.

Management of Field 1. While crop sufficiency recommendations would suggest that no fertilizer P be applied to these fields, Gary did not want to deplete soil test levels that his dad had built up over the years. Since these fields have adequate soil test levels and he was wanting to move more to a no-tillage system, he decided to spend a little more on his no-till planter by equipping it with starter attachments. Gary and his crop advisors decided to apply 10 gallons (~100 pounds) per acre of 8-20-5-5S-0.5Zn starter for row crops in the rotation and to apply estimated crop removal rates of broadcast/incorporated DAP to winter wheat in the rotation. Since the overall goal is to maintain the P soil tests on these fields, they will monitor levels with a soil sampling program in the future. Since crop removals in the row crop portion of the rotation will exceed P application to those crops, shortfalls in nutrient replacement will be corrected by inclusion in the wheat broadcast/incorporated part of the nutrient management plan. Since soil test levels are adequate, routine soil sampling every 3-4 years should be adequate for monitoring the P status of these fields.

The overall goal for these fields is to maintain P soil test levels in the 25-30 ppm range. It needs to be pointed out that for a specific crop in the rotation, application rates may be greater or less than crop removal. This is a sound agronomic, economic and environmental P nutrient management plan that provides for future flexibility. Maintaining soil test levels over the long-term in the 25-30 ppm Bray P1 range allows Gary to skip fertilizer P application in any particular year with minimal risk of P limiting crop yields. Nutrient management plans should not simply be evaluated/scored on a single year basis.

Management of Field 2. While their ultimate goal is to build the soil P level of this field to those found on most of the remaining dryland fields they operate, they have decided for now to adopt a crop sufficiency approach to nutrient management for this field. With a soil test of 12 ppm Bray P1, KSU sufficiency recommendations will generally approximate crop removal and soil test levels should change very little. Since soil P levels are relatively low, soil sampling every year or two will be needed to closely monitor soil test levels on this field in order to minimize the potential for soil and fertilizer P limiting crop yields.

Management of Field 3. Just because a field is rented rather than owned, doesn't mean that inputs should be cut or that longer-term management is not appropriate. This field has been rented from a family friend for many years and Gary's dad has managed it like he owned it in the past. Based on conversations with the owner, Gary decided to manage the ground similarly to what his dad did since it is unlikely that he will lose this ground in the near future. They decided to maintain soil test levels in the 20-25 ppm Bray P1 range.

Management of Field 4. After examining the yield history and P application records, it is likely that soil test levels might be slowly declining. With an average corn yield of slightly more than 230 bu/A over the past three years, about 75 lb P_2O_5/A per year are removed in the grain. A total of about 55 lb P_2O_5/A are being applied annually. Since crop removal is substantially greater than P additions, soil tests would be expected to decline. Because of the overall investment in this field, variable and fixed costs associated with irrigation, their overall goal is to build soil test values to 20-25 ppm Bray P1 in 4-6 years and then maintain them in that range. They will use a combination of fertilizer and manure for the build program. The starter application will continue at 10 gallons (~100 pounds) of NPKS starter fertilizer in order to be consistent with dryland acres program. Their N management program seems to be on target, but will be more closely examined by collecting two 24" profile samples for nitrate-N analysis from each quarter of the pivot. Also, the N program will be adjusted in years of manure application.

Management of Field 5. These three fields have relatively high P soil tests as a result of historical manure applications. Gary will not make any more fertilizer P or manure additions to these fields – with the exception of starter P applications. The manure will be diverted mainly to Field 6 and to a smaller degree to Field 4.

Management of Field 6. While the same management approach was used on this field(s) in the past as for others (100 pounds of DAP per acre), crop removal has been much higher since it was frequently in a silage crop. With the resulting low P soil test levels, crop production has likely declined over the past decade. With expected silage yields of 20-25 tons/A, 65-75 lb P_2O_5/A per year are needed just to replace what is removed in the harvested crop. By utilizing manure when the pens are cleaned, and redirecting some fertilizer P dollars from other fields in their operation, Gary and Linda intend to build soil test levels to 20-25 ppm Bray P1 over the next 4-6 years.

Management of Field 7. Based on the limited history and soil test results, this field has not had much 'TLC' over the past several years. It is likely that he may only farm this field for a single year. Gary is hesitant to put anymore inputs (e.g. fertilizer) into this field than absolutely necessary. Based on a grain sorghum yield goal of 100-120 bu/A (yield potential of similar ground in the area), KSU sufficiency recommendations suggest 40-45 lb P_2O_5/A with soil tests of about 8 ppm Bray P1. Gary decides to apply about 10 gallons (~100 pounds) of 8-20-5-5S-0.5Zn starter to the field and no broadcast DAP fertilizer. This is about 50% of the rate suggested by KSU.

Summary

We believe nutrient management programs must be tailored to fit the specific conditions affecting each field of individual growers. The nutrient recommendation system employed by Kansas State University is intended to provide the flexibility needed to develop these individualized nutrient management programs while providing for environmental stewardship. While there are persuasive arguments supporting both general approaches to P and K nutrient management (sufficiency and build-maintenance), in actuality there are a continuum of valid approaches to nutrient management that provide for environmental stewardship/protection as well as meeting varying goals and objectives of individual producers. With the complexity of

many farm operations today, it is likely that many growers will choose to use multiple approaches. It is also likely that individual producers may adopt different management systems, even if they are facing the same crop/field situation. It is up to individual farmers to decide what management program best fits each field and/or situation.

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