Purdue University Department of Agronomy
Soil Fertility Update

October 29, 2021

Thoughts on Profitable Fertilizer Rates

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Should the price of fertilizer be considered when determining the rate of fertilizer applied?

This approach is common with nitrogen (N) on corn where we recommend the Economic Optimum N Rate (EONR) to produce the highest profit rather than the Agronomic Optimum N Rate to produce the highest yield[1]. In other words, why fertilize to produce bushels that cost more than they are worth?

When implementing the EONR approach with corn, we assume that other nutrients are adequate, either as a result of a high enough soil test or because they are also applied as fertilizer. It makes sense that N is the nutrient that is fine-tuned to produce the most profit growing corn - of the nutrients usually applied to corn, N is the costliest, almost always inadequate without fertilization, does not carryover substantially from season to season, and has the greatest impact on yield.

Should we use a similar approach to fertilizing soybean and adjust the application rate of one nutrient to produce the most profit, rather than the highest yield?

Phosphorus (P) and potassium (K) are the most commonly added nutrients to soybean fields. The standard recommendation is to maintain soil test at an optimal level where fertilization is unlikely to impact yield, but not at excessive soil test levels[2] (Figure 1). To maintain soil test levels in the maintenance range, we recommend applying P_2O_5 equivalent to crop removal, but for K we suggest replacing crop removal plus 20 lb K_2O/A. Sixty-bushel soybeans remove 48 pounds of P_2O_5 per acre and 69 pounds of K_2O per acre (lb K_2O/A).

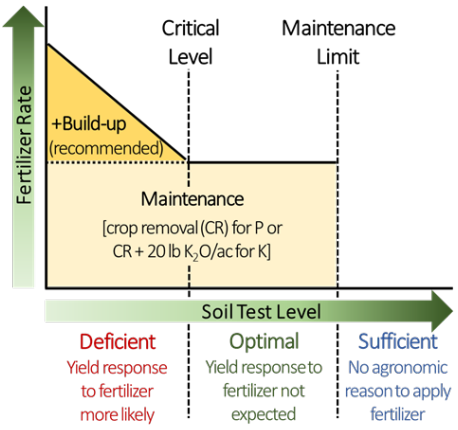

Figure 1. *Fertilizer recommendations for P and K based on soil test levels and likelihood of response to applied*

Maintaining optimal soil test levels of P and K allows farmers the flexibility in years of high fertilizer prices, low commodity prices, and/or unsuitable soil conditions for fertilization during fall and spring, to defer a maintenance application of P and K to the next season[3]. When soil test is optimal, the highest dollar return to fertilizer is produced at a zero-application rate, not by following the maintenance recommendation. Since soil test P and K levels decrease gradually if crop removal is not replaced, it may be possible to skip several years of P and K application if soil test levels are near the top of the maintenance range or beyond[2].

This work partially supported by Purdue Pesticide Programs, Nutrien Ag Solutions, Corteva Agriscience, A&L Great Lakes Laboratory, and SureTech Laboratory. Thanks also to the Purdue staff at the Ag Centers and Professor Antonio Mallarino at Iowa State University.

What if soil test P or K levels are deficient and a response to application of P or K is expected to increase yield and perhaps profit?

Fortunately, we have three on-going K response trials with soybean that we can utilize to illustrate the effects of potash fertilizer prices on the economic optimal potash fertilizer rate (EOKR). Soil test levels were very low to low at the three Purdue Ag Centers – SEPAC, DPAC, and NEPAC – ranging from 24 to 69 parts per million (ppm). All three soils had cation exchange capacities greater than 5 milliequivalents per 100 grams of soil (meq/100 g), therefore the critical soil test level was 120 ppm Mehlich-3 K.

Grain yield responses to K fertilization were 48, 9, and 13 bushels per acre (bu/A) at the three locations, respectively (Figure 2).

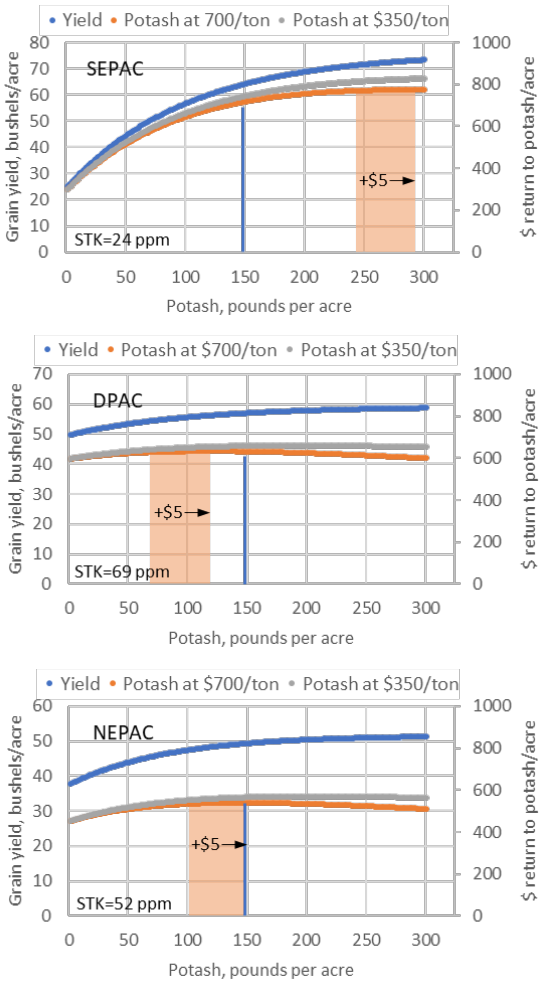

Figure 2. *Soybean grain yield and dollar return to potash at $700 and $350 per ton potash and $12 per bushel soybean at three Purdue Ag Centers (noted in the upper left of each graph) in 2020 in response to rates of potash fertilizer (0-0-60) on soils testing below the critical level of 120 parts per million (ppm). Soil test K (STK) by the Mehlich-3 method is shown in each figure. The right edge of the shaded rectangle indicates the economical optimum potash rate (EOKR) at $700/T potash while the left edge indicates the minimum potash rate within $5 of the EOKR. The blue line indicates the maintenance potash recommendation.*

Economic Optimum Potash Rates

Economic optimal potash rates (0-0-60), the rates needed to maximize profit from the application of potash, ranged from 119 to 292 lb potash/A at $700/T potash and $12/bu soybeans (Table 1). Applying about 50 lb potash/A less at each of the locations resulted in about a $5/A loss in dollar return to potash (Figure 2; Table 1).

Economic optimal potash rates did not change substantially if last year's potash price ($350/T) was considered at SEPAC (Table 1), which had the lowest soil test K level and the greatest response to K fertilization. At the other locations the lower potash price increased the optimal rate 58 to 70 lb potash/A.

Comparing the Economic Optimal Potash Rate to the Build-up and Maintenance Recommendations

The build-up recommendation differed for each location based on the initial soil test K level and the cation exchange capacity which are both used to determine the build-up recommendation, but not the chosen yield level - 60 bu/A for all locations. The build-up recommendation ranged from 292 to 364 lb potash/A for the three locations (Table 1). These values were 72 to 173 lb potash/A more than the EOKR (at $700/T) and would not be advisable to follow when potash prices are high, unless you predict higher prices for potash in future years.

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The maintenance recommendation for all locations was calculated based on 60 bu/A and a grain removal rate of 1.15 lb K_2O/bu plus 20 lb K_2O/A acre equaling 89 lb K_2O/A or 148 lb potash/A. The maintenance recommendation, in comparison to the EOKR, was 145 lb potash/A less at SEPAC, 30 lb potash/A higher at DPAC, and essentially equivalent at NEPAC. If the crop removal rate of potash was applied at SEPAC the loss to underapplication would have been $60 per acre. The cost of overapplication at DPAC was negligible.

Table 1. Comparison of the 'Build-up' potash recommendation for three locations in 2020 with low Mehlich-3 soil test K levels to economic optimal potash rates considering a current potash price of $700 per ton, last year's price of $350 per ton, and a soybean price of $12 per bushel. Also shown is the minimum potash rate within $5/acre of the optimal rate.

			Potash at $700/T		Potash at $350/T	
Location	Soil test[1]	'Build-up' recommend-ation[2]	Economic optimal rate	Minimum rate within $5/acre of optimal	Economic optimal rate	Minimum rate within $5 of optimal
	ppm	---------- Potash, pounds per acre ----------				
SEPAC	24	364	292	243	301	275
DPAC	69	292	119	69	189	122
NEPAC	52	318	146	102	204	143

[1] Mehlich-3 soil test in parts per million (ppm).

[2]Based on Mehlich-3 soil test and cation exchange capacity specific to each location, target soil test K level of 120 parts per million, an expected soybean yield of 60 bushels per acre, and removal of 1.15 pounds of K_2O per bushel of soybean.

Summary

Nitrogen fertilizer recommendations for corn are routinely adjusted based on prices of fertilizer and grain. **For more details see reference 1.**

When soil test P and K are optimal or above the highest return to fertilizer P and K is at the zero rate of application in that season. Across multiple seasons the zero rate remains best as long as soil test levels remain in the optimal range and fertilizer prices remain the same or decrease in cost. **For more details see reference 3.**

Fertilizer rate decisions have more potential impact on profits when soil test levels of a nutrient are deficient, because yield can be decreased by nutrient deficiency to an extent that offsets the savings of reduced fertilizer rates. This approach to fertilization is often called the "Sufficiency Approach", where the rate applied is targeted to produce the highest return to fertilization in that season without regard to the impact on future seasons. This has not been the philosophy recommended by Purdue for at least the last 40 years. The approach we have recommended is the "Build-up and Maintenance" approach (or "Build-up, Maintenance, and Draw-down" approach in the original Tri-State recommendations. This approach was used because it minimized the potential for yield loss due to nutrient deficiency and gave farmers the flexibility to skip a fertilization when fertilizer prices were high, commodity prices were low,

fertilizer was unavailable, field conditions were unsuitable for application, etc. This conservative approach to fertilization was well-suited to farmers who owned the land they farmed or had stable leases on the land they rented because the additional P and K they had added over several years remained in the soil and could be taken advantage of in later years if maintenance rates of fertilizer could not be applied. Unfortunately, this is not the most profitable approach in times of high fertilizer prices (if expected to fall in future years) or when farmers are cash renting on a yearly basis.

We began to conduct experiments to gather the data necessary to make "Sufficiency" recommendations for K in 2019 at the Southeast Purdue Ag Center (SEPAC) and in 2020 at the Northeast and Davis Purdue Ag Centers. These experiments continue, but have not been harvested in 2021. At this point we have four sites years of data for soybeans and one for corn. This is not enough data to make recommendations, but the early results support what most researchers suspect – the amount of fertilizer needed at deficient soil test levels to maximize dollar return to fertilizer is less than the "Build-up recommendation". We illustrated this with the soybean data from 2020 – the SEPAC data from 2019 told the same story.

The standard build-up recommendation was 72 to 173 lb potash/A more than the EOKR (at $700/T) at the three locations with very low to low soil test K levels as tested in 2020. Applying the build-up recommendation would have resulted in significantly lower dollar returns to potash fertilizer and would be unadvisable with current potash prices, if prices are expected to be lower in future years.

At the location with the lowest soil test K level, SEPAC, applying the maintenance recommendation (148 lb potash/A) would have reduced return to potash fertilizer $60/A, while negligible decreases in dollar return to potash fertilizer would have occurred at the other two locations. At the DPAC location, the value of small increases in yield with increased potash application rate nearly compensated for the additional cost of potash fertilizer, whereas at the NEPAC location the maintenance recommendation and the EOKR were nearly identical.

Although these results are only from one season at three locations and only represent a narrow range of Mehlich-3 soil test K values (24 to 69 ppm) we expect more research will show that when soil test is near the critical level the rate of fertilizer needed to maximize dollar return to fertilizer will be something less than crop removal and at very low soil test values the rate of fertilizer needed will be more than crop removal, but less than the standard build-up recommendation (Figure 3). Unfortunately, we do not have enough data to be specific about what those rates are at this point in time and we do not have any recent data related to P response on low P soils. We hope to provide this information with additional research in the years to come.

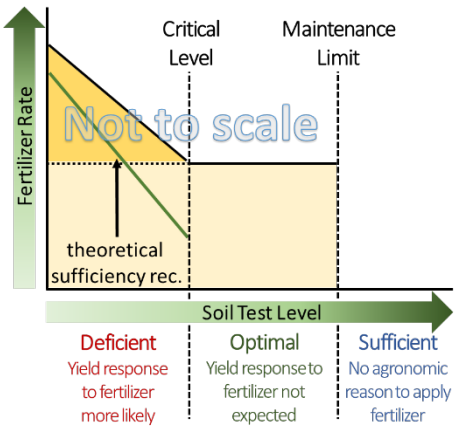

Figure 3. Depiction of what a sufficiency recommendation for K fertilization of soybean at deficient soil test levels will look like after enough data is collected to make a quantitative recommendation.

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References

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