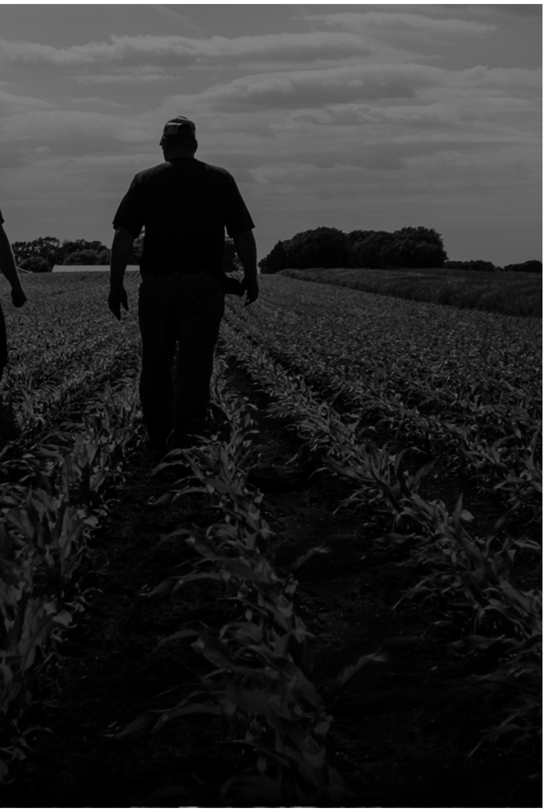

FOUR FACTORS TO CONSIDER BEFORE REDUCING FERTILIZER RATES

Growers may consider reducing fertilizer rates for various reasons such as lower crop prices, higher input costs, lower than expected yields, or uncertainty of profitable yield responses. The following four considerations should be accounted for to help determine fertilizer needs throughout a growing season.

1 UNDERSTAND CROP NUTRIENT DEMAND AND REMOVAL

Today's modern crop hybrids and varieties uptake and remove greater quantities of nutrients, which need to be resupplied annually to sustain soil nutrient levels. Yield trends continue to increase for major crops such as corn, wheat and soybeans by 1.9 (1.4%), 0.4 (0.9%), and 0.5 (1.4%) bu/ac/year respectively (Figure 1).

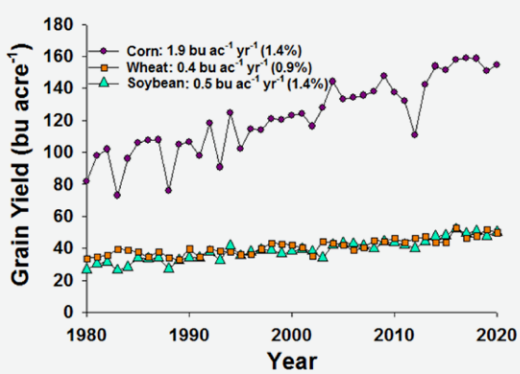

Figure 1: U.S. Average Grain Yields and Average Annual Yield Change. Source: USDA NASS, 2021.

As yields increase, total nutrient requirements also increase and must be supplied for optimal yields. While we often focus on nutrient removal with the grain at harvest, it is important to remember that crops require and uptake additional nutrients to support root and biomass growth (Table 1). Nutrient depletion can occur quickly for nutrients where the majority is partitioned into grain. For example, approximately 80% of the P_2O_5 corn and soybeans accumulate is stored in the grain. As the grain is

Crop	Nutrient Uptake (Removal)					Fertilizer Replacement (lb/ac)*	
	------lb/A ------			----oz/A ----		------lb/A------	
Yield (bu/ac)	P_2O_5	K_2O	S	Zn	B	MicroEssentials S10/SZ (P Source)	Aspire (K Source)
Corn							
150	66 (53)	117 (39)	15 (9)	4.6 (2.9)	0.8 (0.2)	133	67
200	88 (71)	156 (52)	20 (12)	6.1 (3.9)	1.0 (0.3)	178	90
250	110 (88)	195 (65)	25 (15)	7.7 (4.8)	1.3 (0.3)	220	112
Soybean							
40	29 (23)	113 (47)	11 (7)	3.2 (1.3)	3.1 (1.1)	58	81
60	43 (35)	170 (70)	17 (10)	4.8 (2.0)	4.6 (1.6)	88	121
80	57 (47)	227 (93)	23 (13)	6.4 (2.7)	6.1 (2.1)	118	160
Wheat (Winter)							
50	32 (24)	75 (15)	12 (5)	2.9 (2.1)	0.8 (0.6)	60	26
75	48 (36)	112 (22)	18 (8)	4.4 (3.2)	1.2 (0.9)	90	38
100	64 (48)	149 (29)	24 (10)	5.8 (4.2)	1.6 (1.3)	120	50

Table 1. Crop nutrient removal rates and fertilizer replacement. Source: Adapted from Alabama Extension 1999, Bender et al. 2013, Bender et al. 2015, IPNI 2014.
*Fertilizer requirement for crop removal of primary immobile nutrients.

harvested, soil test values can drawdown and become depleted. Additionally, when crop residues are removed from the field, soil test levels for nutrients such as potassium can be impacted much more quickly.

Essential nutrients are supplied by the soil and often require supplemental mineral fertilizers to fulfill crop requirements. In some instances, environmental conditions such as drought may lead to yields that are lower than originally anticipated, and therefore may not remove as many nutrients from the soil. Abnormally dry conditions can reduce nutrient availability to crops by limiting plant uptake, mineralization, and nutrient leaching from plant residues. Following these conditions, it is best to take soil samples and build a crop nutrition program that supports optimal yields.

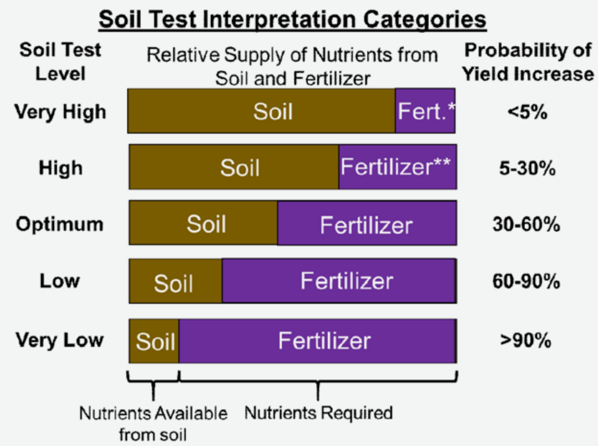

Figure 2. Probability of yield response from fertilizer by soil test level. Adapted from Havlin et al., 1999.
* Fertilizers used at very high soil test levels are for starter and high demand crops
** Fertilizers used at high soil test levels are starter, maintenance, or for anticipated environmentally driven shortages (i.e. limited soil moisture)

2 KNOW YOUR SOIL TEST LEVELS

Soil tests are used as a guide to help determine likelihood of response to fertilizer. While yield gains can occur at any soil test value, the probability of yield response to fertilizer increases as soil test levels decrease (Figure 2). A summary of soil tests taken throughout North America in 2020 showed that 46% of P and 44% of K soil samples were below the critical level of which soil test levels should be "built to" and "maintained at" to minimize yield loss (Figures 3 & 4).

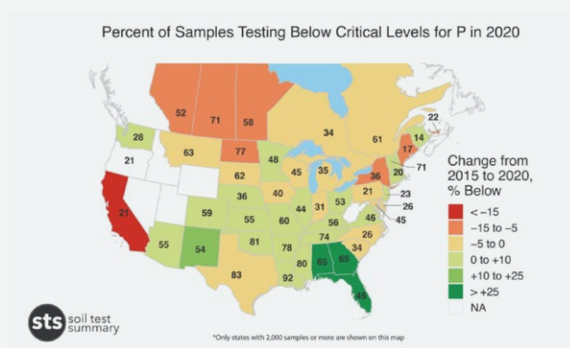

Figure 3. Percent of soil samples testing below University established critical levels for P in 2020. Source: STS, 2020.

Reducing or eliminating fertilizers in a crop nutrition program may result in yield loss or a decline in soil nutrient levels and reduced profitability in the future. Studies in Iowa assessed corn yield and corresponding soil test Bray-1 P concentrations in a long-term corn-soybean rotation when no fertilizer was applied. Between the 1970s and 2002, corn yield decreased an average of 1.08% per year and soil-P declined 1.09 ppm per year (Figure 5). Additionally, while Mallarino (2010) found that low rates of fertilizer

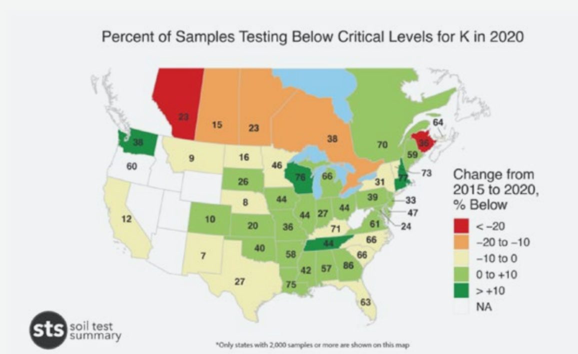

Figure 4. Percent of soil samples testing below University established critical levels for K in 2020. Source: STS, 2020.

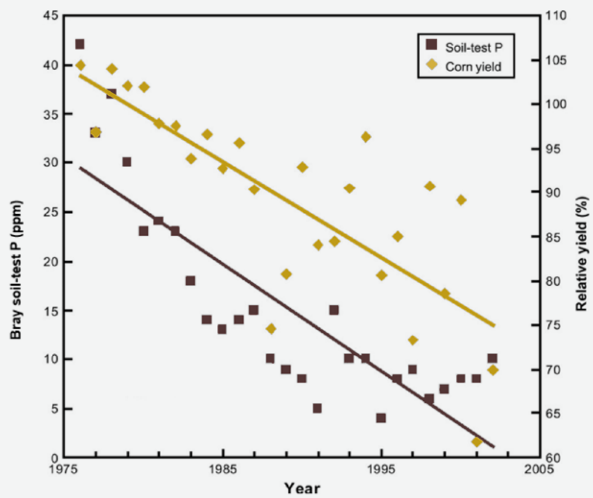

Figure 5. Decline in corn yield and soil-test phosphorus with no phosphorus fertilization in a corn-soybean rotation between the 1970s and 2002. Source: Nelson and Janke, 2007 (data from Dodd and Mallarino, 2005).

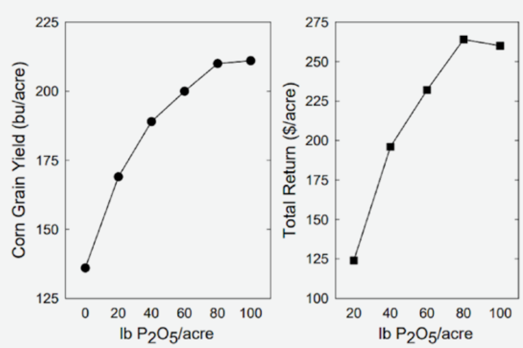

Figure 6. Agronomic and economic return to phosphorus fertilization in phosphorus-responsive soils. Data assumed a corn price of $4.00/bu and fertilizer price of $0.40/lb P2O5. Source: adapted from Mallarino, 2010.

had greater yield responses to the first increments of fertilizer, total corn yield and ROI were lower when P_2O_5 application rates were reduced below crop removal rates in phosphorus-responsive soils. (Figure 6). These data highlight the importance of replenishing crop nutrient removal in order to maintain and optimize both soil nutrient levels and crop yields.

When deliberating between fertilizer rates, it is best to gather soil test and yield data and follow the 4R's (i.e., right source, rate, time, and place) that will give guidance on maintaining soil nutrient levels and creating sustainable, more productive cropping systems that increase long-term profitability. Unfortunately, soils testing below critical levels have become more frequent, indicating that growers are leaving yield on the table by not fertilizing adequately. While several soils may be low in nutrients in an area, taking multiple soil samples in a field can help determine spatial variability of nutrients. Understanding a field's spatial variability can allow a grower to have prescriptive rates of fertilizer variable rate applied to maximize profitability by applying more nutrients to the lowest testing parts of fields and less to higher testing soils. Certain environmental conditions can decrease the availability of nutrients such as potassium that require moisture for plant uptake and it may be desirable for soil tests to be built into the high range if dry conditions are expected. For greatest probability of yield gains to fertilizer and maintenance of soil test levels, the following generalized rules should be applied.

A SUMMARY OF SOIL TESTS TAKEN THROUGHOUT NORTH AMERICA IN 2020 SHOWED THAT 46% OF P AND 44% OF K SOIL SAMPLES WERE BELOW THE CRITICAL LEVEL OF WHICH SOIL TEST LEVELS SHOULD BE BUILT TO MINIMIZE YIELD LOSS.

- Soils testing low in nutrients, apply maintenance + build up application rates
- Optimum-high soil tests, apply maintenance fertilizer rates
- Very high soil tests, fertilizer rates can be eliminated in the short term or reduced to starter fertilizer rates

Reducing or eliminating fertilizer applications below crop removal rates is not advised unless soils are in the very high range, or if yield loss and a reduction in soil test levels that would need to be replenished would be anticipated regardless of economics.

3 CONSIDER FERTILIZER ROI RELATIVE TO OTHER CROP INPUTS AND PRICES

Crop nutrition accounts for up to 60% of crop yield but only ~20% of the total cost of production. Extrapolating from the University of Illinois "farmdoc" website, the overall cost of production has increased approximately 15% between 2021 and the forecasted budget for 2022. Farmers in Illinois are projected to allocate approximately 29% of corn production costs (not including the cost of land) to fertilizer in 2022 and were estimated to allocate 23% of corn production costs to fertilizer in 2021 (Figure 7). Despite these

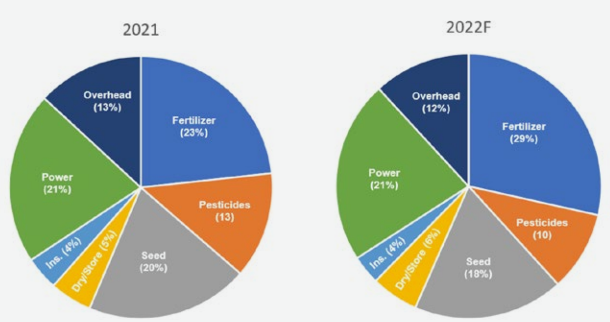

Figure 7. Total non-land costs estimated for corn after soybeans on high productivity farmland in Central Illinois. Source: Schnitkey, 2021, University of Illinois (www.farmdoc.illinois.edu).nutrients.

price increases, gross revenue is expected to increase 17% in 2022 due largely to higher crop prices, which is expected to result in greater operator and land return revenue compared to 2021 and offset any increase in production costs.

Projected crop prices are anticipated to remain higher than average, suggesting crop nutrients will remain affordable in the coming growing season. Table 2 shows how total net return on investment per ton of fertilizer a grower purchases is affected by a positive change in fertilizer or crop price. For example, if fertilizer prices have increased $300 per ton but corn price increased $2.00 per bushel during the same time, a grower would receive an additional $370 net

Positive change in crop price Farmer receives ($/bu)	Change in Fertilizer Price ($/ton)					
	$0.00	$50.00	$100.00	$200.00	$300.00	$400.00
	Total Net Increase In Return On Investment for Farmer per ton of fertilizer purchased*					
$0.00	$0.00	-$5.00	-$10.00	-$20.00	-$30.00	-$40.00
$0.50	$100.00	$95.00	$90.00	$80.00	$70.00	$60.00
$1.00	$200.00	$195.00	$190.00	$180.00	$170.00	$160.00
$1.50	$300.00	$295.00	$290.00	$280.00	$270.00	$260.00
$2.00	$400.00	$395.00	$390.00	$380.00	$370.00	$360.00

Table 2. Total net increase in fertilizer return on investment for a farmer per ton of fertilizer purchased as affected by a change in crop price ($/bu) and/or a change in fertilizer price ($/ton). Data are based on an application rate of 80 lbs of P_2O_5 per acre using MicroEssentials.

return on investment per ton of fertilizer. Increases in fertilizer prices are relatively small compared to the return value with high crop yields and an increase in the crop price farmers receive. Now is the time to optimize crop performance and profitability by considering various fertilizer technologies and the agronomic and economic benefits they provide.

4 OPTIMIZE SOIL AND CROP PERFORMANCE

Altogether, the agronomic and economic data do not support reduced or eliminated fertilizer applications in order to optimize yield or ROI, especially when soil test levels are at or below optimum. Trendline record yields often equate to above average nutrient removal, and those nutrients need to be replenished to ensure sustainable and productive cropping systems. Additionally, any potential profit increase from reduced fertilizer rates would be offset due to cumulative nutrient removal and the need for higher application rates in the future. Implementation of each of the 4Rs can result in increased fertilizer efficiency in a given year; however, reduced fertilizer rates will deplete soil and plant accessibility for future years. MicroEssentials® is a phosphate-based fertilizer with two forms of sulfur (sulfate and elemental) that provides uniform nutrient distribution, season-long sulfur availability, and increased nutrient uptake that leads to higher yields and ROI. Aspire® combines potassium with two forms of boron that provides uniform nutrient distribution, season-long B availability, and a flexible application window for higher yields and profitability. Applying advanced crop nutrition with technologies like MicroEssentials and Aspire, implementing soil health practices to ensure long-term productivity of the soil, and following the 4Rs of crop nutrition will lead to sustainable cropping systems that optimize soil and crop performance. To learn how MicroEssentials and Aspire can provide higher yields and profitability on your operation, please visit CropNutrition.com.

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