Fluid JOURNAL
Official Journal of the Fluid Fertilizer Foundation
Early Spring 2010
Vol. 18 No. 3, Issue #69

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Are Current Fertilizer Recommendations Adequate?

Corn being a primary responder, yield goals in the next 20 years are targeted at 250 to 300 bu/A by some in the seed industry.

Summary: *Challenges undoubtedly face the fertilizer and nutrient management industry as crop yields and potential demand escalate. Are today's nutrient recommendations appropriate for the future? Will they enable these ever-increasing yields to be realized or will they become yield-limiting? Do we have the research in place to develop nutrient best management guidelines for these very high yields? If not, where do we start and what are the nutrient/crop priorities? What are the economic and environmental consequences of this extraordinary high-yield production system? Will time of application and placement method guidelines need to be reevaluated? How will the logistics and capabilities of the farmer and the dealer fit into these "new" nutrient management guidelines?*

Current status

Aging recommendations. Many of the current recommendations are based on research conducted in the '70s and '80s, and even earlier. Back then U.S. average yields ranged from 80 to 120 bu/A, and it is likely that yield in many of the calibration research trials seldom exceeded 175 bu/A. Yield response probabilities and critical levels are currently based on these calibration studies. In some states, little phosphorus (P) and potassium (K) calibration research has been conducted since. In other states, notably Iowa, some perceptive scientists began long-term P and K response trials that have been most helpful for updating nutrient rate recommendations. Recently, the University of Nebraska changed its longtime soil test P (STP) critical level from 15 ppm to 25 ppm for corn after corn, based on current high-yield data.

Logistical concerns. Soil testing is critical to the implementation of sound nutrient rate recommendations. But, soil testing has its share of uncertainties and a vigorous research and extension effort is needed to complement new fertilizer recommendations.

Variable rate application has come a long way since its inception. With improved technology and information, it will be desirable to apply variable rates of P and K to the soil to obtain very high and profitable yields with reduced risk of insufficient P or K.

Time and labor are substantial issues facing farmers and fertilizer suppliers, especially as farm operations get larger and the territory served by fertilizer dealers expands. Fertilizer applications that require more time, management and specific placement equipment often are passed over in favor of broadcast application as a farmer's acreage grows. With increased emphasis on early and timely planting, larger farm operations often pass on application methods that slow or delay planting. Storage space also becomes an issue for the dealer if non-traditional nitrogen (N) and P products are desired. Some of these products may have increased efficiency attributes desired by the grower, but extra storage needs for these products can be a negative issue for the dealer. Regardless, timing and fertilizer placement choices are influenced by the dealer's and grower's needs, and they require consideration by the nutrient research community as research is developed and prioritized.

Risk of yield loss is a concern that faces both dealers and farmers. The possibility that yield is left in the field due to inadequate nutrient availability or supply is unthinkable for growers attempting to maximize return on their fertilizer dollar. As farmers work with their dealers and/or agricultural advisors to arrive at a nutrient application game plan, risk plays a key role in arriving at the final decision. Researchers, working to provide adequate nutrient supply for high and very high yield conditions, need to keep economic and environmental risks in mind.

Table 1. Three-yr average corn grain yield, moisture, P concentration, and P uptake as affected by placement and rate of P in a strip-till system on HIGH and VERY HIGH P-testing soils at Waseca, 2005-2007.						
P Treatments			Grain	Grain	Grain	Grain
No.	Placement	Rate	Yield	H_2O	[P]	P Uptake
		lb P_2O_5/A	bu/A	%	%	lb/A
Stats for RCB Design analyzed across years (Split-plot, year is main plot)						
Treatment						
1	None	0	193	19.0	0.296	26.9
2	Pop-up starter	20	192	18.6	0.307	27.7
3	Deep band	20	196	18.7	0.313	28.9
4	Broadcast	20	196	18.9	0.314	29.0
5	Deep band + pop-up	20 + 20	189	19.2	0.313	27.8
6	Pop-up starter	40	194	18.4	0.305	27.9
7	Deep band	40	186	18.7	0.309	27.2
8	Broadcast	40	190	18.8	0.315	28.1
P > F:			0.392	0.086	0.850	0.718
LSD (0.05):			NS	NS	NS	NS
Interaction (Year*Treatment)						
P > F:			0.994	0.486	0.413	0.519
CV (%):			6.1	3.2	10.1	11.4
Stats for RCB Design with 2-Factor Factorial Arrangement (treatments 2-4 and 6-8)						
P Placement						
Pop-up			193	18.5	0.306	27.8
Deep band			191	18.7	0.311	28.0
Broadcast			193	18.9	0.314	28.5
P > F:			0.826	0.137	0.660	0.720
LSD (0.05):			NS	NS	NS	NS
P Rate (lb P_2O_5/A						
20			195	18.8	0.311	28.5
40			190	18.6	0.309	27.7
P > F:			0.102	0.382	0.828	0.313
Interactions (P > F)						
P Placement x rate			0.133	0.843	0.968	0.614
P place x year			0.971	0.628	0.249	0.331

Table 2. Three-yr average corn grain yield, moisture, P concentration, and P uptake as affected by placement and rate of P in a strip-till system on a LOW P-testing soil at Waseca, 2005-2007.						
P Treatments			Grain	Grain	Grain	Grain
No.	Placement	Rate	Yield	H_2O	[P]	P Uptake
		lb P_2O_5/A	bu/A	%	%	lb/A
Stats for RCB Design analyzed across years						
Treatment						
1	None	0	148	19.4	0.199	14.2
2	Pop-up starter	25	158	18.4	0.215	16.2
3	Deep band	25	158	18.9	0.200	15.1
4	Broadcast	25	166	18.7	0.212	16.7
5	Deep band + pop-up	25 + 25	172	18.8	0.229	18.6
6	Pop-up starter	50	166	18.4	0.218	17.2
7	Deep band	50	166	18.9	0.207	16.5
8	Broadcast	50	167	18.9	0.220	17.4
P > F:			<0.001	<0.001	0.031	<0.001
LSD (0.05):			10.5	0.5	0.019	1.9
Interaction (Year*Treatment)						
P > F:			0.032	0.519	0.144	0.013
CV (%):			7.9	3.0	11.0	14.0
Stats for RCB Design with 2-Factor Factorial Arrangement (treatments 2-4 and 6-8)						
P Placement						
Pop-up			162	18.4	0.216	16.7
Deep band			162	18.9	0.203	15.8
Broadcast			167	18.8	0.216	17.0
P > F:			0.256	<0.001	0.051	0.120
LSD (0.05):			NS	0.3	NS	NS
P Rate (lb P_2O_5/A						
25			161	18.7	0.209	16.0
50			166	18.7	0.215	17.0
P > F:			0.049	0.477	0.222	0.049
Interactions (P > F)						
P Placement x rate			0.447	0.705	0.901	0.793
P placement x year			0.044	0.268	0.005	0.001

Land tenure. Whether the land to be fertilized is owned or is rented can and perhaps should play an important role in decisions on fertilizer rate and placement. To date, this factor has not been included in fertilizer guidelines provided by most universities. Kansas State University has led the way in developing P recommendations based in part on land tenure. Farmers who own land to be fertilized generally have a long-term vision for that land that involves keeping the soil test values at somewhat higher levels to minimize risk of yield loss and to enhance the value of their enterprise. On the other hand, when land is rented and the tenure is not secure for more than 2 or 3 years, farmers often choose a short-term plan of using lower rates of fertilizer to maximize economic return for the current year or two. This approach annually requires a different nutrient rate recommendation than does the long-term approach suitable for land owners.

Financial position. Similar to land tenure, those farmers who are in a strong financial position can afford and do value keeping their soil tests at higher levels. Also, this is often true for those farmers who have purchased low-testing land and now want to build up the soil test to a higher level where they will maintain it at that level in the future. On the other hand, farmers with limited cash resources will lean toward applying just enough fertilizer to optimize profit for the present year.

Environmental concerns will continue to escalate as public perceptions mount relating decreased water quality to agriculture in general and fertilizer in particular. Nutrient regulations will likely become more prevalent and enforcement more strict. Thus, in addition to agronomic and economic factors, environmental concerns must be a part of the planning process when developing a nutrient game plan.

Uptake amounts. Based on uptake shown for P treatments in Tables 1 and 2 for corn and Tables 3 and 4 for soybeans, uptake was 70 percent greater for the 192 bu/A corn grown in a high STP environment compared to 164 bu/A corn with P fertilizer in a low STP environment. Furthermore, based on these high STP soils, it is estimated that P uptake will be increased 56 percent (13.2 lbs/A) by 250 bu/A corn, compared to 160 bu/A corn, and by 66 percent (9 lbs P/A) when increasing soybean yields

Table 3. Three-yr average soybean seed yield, P concentration, and P uptake as affected by placement and rate of P applied for corn in the previous year in a strip-till system on HIGH and VERY HIGH P-testing soils at Waseca, 2006-2008.

P Treatments			Seed	Seed	Seed
No.	Placement	Rate	Yield	[P]	P Uptake
		lb P_2O_5/A	bu/A	%	lb/A
Stats for RCB Design analyzed across years					
Treatment					
1	None	0	49.1	0.583	15.0
2	Pop-up starter	20	49.1	0.579	14.9
3	Deep band	20	48.8	0.579	14.8
4	Broadcast	20	50.3	0.576	15.1
5	Deep band + pop-up	20 + 20	49.3	0.577	15.0
6	Pop-up starter	40	48.9	0.578	14.8
7	Deep band	40	49.1	0.563	14.5
8	Broadcast	40	48.4	0.587	14.8
P > F:			0.842	0.677	0.962
LSD (0.05):			NS	NS	NS
Interaction (Year*Treatment)					
P > F:			0.982	0.671	0.976
CV (%):			5.6	5.0	7.7
Stats for RCB Design with 2-Factor Factorial Arrangement (treatments 2-4 and 6-8)					
P Placement					
Pop-up			49.0	0.579	14.8
Deep band			48.9	0.571	14.6
Broadcast			49.4	0.581	15.0
P > F:			0.827	0.396	0.605
LSD (0.05):			NS	NS	NS
P Rate (lb P_2O_5/A					
20			49.4	0.578	14.9
40			48.8	0.576	14.7
P > F:			0.331	0.732	0.423
Interactions (P > F)					
P Placement x rate			0.314	0.229	0.969
P placement x year			0.471	0.510	0.752

Table 4. Three-yr average soybean seed yield, P concentration, and P uptake as affected by placement and rate of P applied for corn in the previous year in a strip-till system on a LOW P-testing soil at Waseca, 2006-2008.

P Treatments			Seed	Seed	Seed
No.	Placement	Rate	Yield	[P]	P Uptake
		lb P_2O_5/A	bu/A	%	lb/A
Stats for RCB Design analyzed across years					
Treatment					
1	None	0	34.5	0.385	7.1
2	Pop-up starter	25	36.4	0.393	7.6
3	Deep band	25	34.7	0.379	7.0
4	Broadcast	25	36.7	0.399	7.8
5	Deep band + pop-up	25 + 25	40.8	0.444	9.5
6	Pop-up starter	50	38.2	0.419	8.4
7	Deep band	50	38.5	0.406	8.2
8	Broadcast	50	37.1	0.423	8.2
P > F:			0.013	0.001	0.001
LSD (0.05):			3.5	0.025	1.1
Interaction (Year*Treatment)					
P > F:			0.167	0.119	0.227
CV (%):			11.5	7.5	16.8
Stats for RCB Design with 2-Factor Factorial Arrangement (treatments 2-4 and 6-8)					
P Placement					
Pop-up			37.3	0.406	8.0
Deep band			36.6	0.393	7.6
Broadcast			36.9	0.411	8.0
P > F:			0.788	0.084	0.386
LSD (0.05):			NS	NS	NS
P Rate (lb P_2O_5/A					
25			35.9	0.391	7.4
50			37.9	0.416	8.3
P > F:			0.015	0.001	0.003
Interactions (P > F)					
P Placement x rate			0.228	0.988	0.521
P placement x year			0.226	0.053	0.120

from 45 to 75 bu/A. Over a two-year C-S rotation, this is a P increase of more that 22 lbs/A taken up from the soil by these higher yields.

STP decline rate will be greater with increasing amounts of P taken up annually by higher yield corn and soybeans. Research conducted on a Webster soil in southern Minnesota from 1974 to 1993 showed annual STP decline rates of 2 ppm Bray P/year when initial Bray P was about 20 ppm (until STP declined to 10 ppm) and 2.5 ppm Bray P/yr when the initial test was about 40 ppm when no fertilizer P was added. Corn and soybean yields averaged 150 and 49 bu/A, respectively, in this study. The University of Minnesota has no STP decline rate data for higher yielding situations, but it is fair to assume that STP decline rates will be much greater as P uptake is increased 50 percent per year.

Meeting Future Needs

Presently, there appears to be very little P and K management research to develop critical levels and calibration data, plus application rate, timing, and placement guidelines to meet the needs of exceptionally high-yield corn production. Three factors contribute to this situation:

- N has been a priority because of heightened water and air quality concerns
- Funding to support P, K, sulfur (S) and micronutrient research has been limited, especially with respect to high-yield conditions
- Due to funding issues and shifts in research priorities within universities, the number of applied scientists within soils and agronomy departments, who are available to conduct this research, is limited.

It appears that the following are needed if the scientific community is going to meet the needs of exceptionally high-yield corn production.

Calibration research. Present-day critical levels, yield response probabilities, and relative soil test interpretation ranges (L, M, Opt. H, and VH) will need to be reexamined under very high-yield levels. To minimize the effect of other non-controllable yield limiting factors (i.e., water), more of this research will need to be conducted under irrigated conditions or at least where supplemental water can be added at critical growth stages or during extensive dry periods. A combination of small and large-scale research (small plots and field-size plots) would be beneficial for obtaining this new calibration information.

Multiple recommendations. Rather than the single prescriptive nutrient rate recommendations that are often given now (tending toward one size fits all), we need to provide a set of recommendations that meets the needs of our customers. Land tenure, financial position, and fertilization philosophies differ among the clientele using nutrient guidelines. We must provide nutrient management options if we are going to meet their “tailor-made” needs. By doing so, these nutrient guidelines will facilitate communication between the growers and their fertilizer suppliers, ag advisors, and/or lenders. Fertilizer response-based recommendations should be available for short-term land rental and financially limited positions, whereas build-maintenance recommendations should be available for land owners with a long-term nutrient management vision.

Sulfur/micronutrients. Traditionally, S and micronutrients have received little attention on most highly productive Corn Belt soils. Corn yield responses to these nutrients were almost non-existent in the 20th century on higher organic matter and medium and fine-textured soils. This is changing as many responses to S and some to zinc (Zn) have been reported in the last few years. This trend is expected to continue, especially as a greater nutrient demand exists with very high-yield production.

Priorities with respect to crop and nutrient studied will need to be made for each state. Bringing the highest priorities to potential funding sources (fertilizer industry, commodity groups, biofuel industry, and other agencies) should produce the kind of research that will lead to improved nutrient recommendations for all growers--not just those capable of very high yields. From my perspective, a well coordinated Midwest regional approach to new P recommendations would be a very good place to start.

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