ENHANCED EFFICIENCY PHOSPHORUS APPLICATION FOR A CORN-SOYBEAN ROTATION

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Abstract

Phosphorus (P) is an essential plant nutrient that is taken up by plants as inorganic ions ($H_2PO_4^-$ and HPO_4^{-2}) found in soil solution. With higher fertilizer costs, farmers are evaluating application rates and considering enhanced efficiency phosphorus applications or treatments. AVAIL®(Specialty Fertilizer Products, Leawood, KS), NutriLife Max® (Advanced Microbial Solutions, Pilot Point, TX), and P_2O_5 Max (Rosen's Inc., Fairmont, MN) are three products that are intended to enhance the efficiency of P-based fertilizers. The first objective of this research is to evaluate the effect of P placement (surface broadcast or strip-till), rate, and P enhanced efficiency products on grain yield and P uptake in a corn-soybean rotation. The second objective was to determine the effect of P source, P enhancer, and ag lime (0 or recommended rate) on grain yield and P uptake in a corn-soybean rotation. The research was conducted at three locations in Missouri; the Greenley Memorial Research Center near Novelty, Delta Center near Portageville, and Hundley-Whaley Center near Albany. Preliminary results indicate that AVAIL increased corn grain yield 8 bu/acre when applied with P in a strip-till band. There was no effect of P enhancer on grain yield when broadcast applied in a non-till system or when applied with the recommended ag lime rate. Strip-till increased plant population 9,400 plants/acre and test weight 0.3 lbs/bu compared to no-till at Novelty. Lime increased silage yields 1.1 tons/acre when compared to the non-treated control at Novelty, but grain yields were similar among lime treatments. However, lime had no effect on silage yields at Portageville, but grain yields increased 11 bu/acre. The corn plots will rotate into soybean and another location will repeat this research in 2011.

Background

Phosphorus (P) is an essential mineral plant nutrient that is taken up by plants as inorganic ions ($H_2PO_4^-$ and HPO_4^{-2}) found in soil solution. Phosphorus in plants is an important structural element in nucleic acids (RNA and DNA), serves as an energy transfer element (ATP), and has a critical role in cellular regulation and carbon partitioning. Soluble forms of P or P bound to clay particles can be lost from agricultural land through runoff and surface erosion. Unless the soil is coarse-textured or artificial drainage is present, P leaching is generally considered very low. Precipitation reactions involving P affects the availability of P and are dependent on soil pH. At a low soil pH, the P will form precipitates with Fe and Al which makes the P less available for plant uptake (Kurtz, 1953). Precipitation of calcium phosphate compounds at high pH (>8) can also reduce P availability (Wild, 1950). Enhanced efficiency P products have been developed to reduce P fixation. Field research was needed to evaluate P uptake and yield response to these P enhancing products.

Introduction

With high fertilizer cost, farmers are evaluating application rates and considering enhanced efficiency P treatments. AVAIL®(Specialty Fertilizer Products, Leawood, KS), NutriLife Max® (Advanced Microbial Solutions, Pilot Point, TX), and P_2O_5 Max® (Rosen's Inc., Fairmont, MN) are three commercially-available products that are intended to enhance the efficiency of P containing fertilizers. AVAIL is a stabilizer product for granular phosphate fertilizers including DAP, MAP, and other phosphate fertilizers. It was designed to reduce the impact of metals in the soil around the fertilizer granule on plant uptake, P sorption, and allow P to be more available to the plant. This product primarily binds with calcium, iron, manganese, and aluminum to prevent precipitation of P. When applied to single crops, Blevins (2009) reported a 19 to 22 bu/acre increase in corn grain yields when AVAIL was added to MAP at 20 lbs P_2O_5/acre and applied as a broadcast or banded treatment. Dunn (2009) reported increased Bray-P1 soil test P availability and a 4 bu yield increase in soybean after applying 50 lbs P_2O_5/acre with AVAIL. Similarly, rice yields increased 8 bu/acre when reduced rates of triple super phosphate were applied (25 lbs P_2O_5/acre) with AVAIL (Dunn and Stevens, 2008). P_2O_5 Max is supposed to increase P uptake and improve root surface area resulting in better nutrient absorption and higher yields (Rosen's Diversified Inc, 2010), while NutriLife Max is supposed to improve fertilizer uptake, thus contributing to overall plant vigor and quality (Advanced Microbial Solutions, 2005).

Objective #1. Evaluate the effect of P placement, rate, and P enhanced efficiency products on grain yields and P uptake in a corn-soybean rotation.

Objective #2. Determine the effect of P source, P enhancer, and ag lime on grain yield and P uptake in a corn-soybean rotation.

Materials and Methods

Research was conducted at Novelty, Portageville, and Albany. The three different locations offered differences in soil and climate. These locations represented three major cropping areas in Missouri. Challenges and issues related to intensive agriculture at each location arises from the diversity of temperature, rainfall, humidity, and soils.

The Greenley Memorial Research Center is located near Novelty in Knox County. The soils in which this study was conducted on was a Putnam silt loam (fine, smectitic, mesis Vertic Albaqualfs) and Kilwinning silt loam (fine, smectitic, mesis, Vertic Epiaqualfs). The Hundley-Whaley Center near Albany is in Gentry County. A Grundy silt loam (fine, smectitic, mesis Aquertic Argiudolls) was the soil series on which this experiment was conducted on near Albany. The Delta Research Center is near Portageville in Pemiscot County. In Portageville, the Tiptonville silt loam (fine-silty, mixed, superactive, thermic Oxyaquic Argiudolls) was the soil series on which this experiment was conducted.

A two-year rotational crop study utilizing P fertilizer application for corn was initiated in 2010, and will evaluate the subsequent impact on soybean yield and/or P uptake. Each site was arranged as a randomized complete block design with four replications. Prior to application from each replication at each site, soil test P (Bray P1) concentrations were determined. Soil test P will

be determined following soybean harvest for each treatment. Plant populations, silage dry weights, P uptake, grain moisture, test weight, and yields were determined and evaluated at each location. Grain samples were evaluated for starch, protein, and oil concentrations.

Research for objective 1 was conducted at Novelty and Albany. Treatments include a factorial arrangement of application placement (i.e., surface broadcast or subsurface banding), MAP rate (0, half the recommended rate, and recommended rate), presence or absence of two enhanced phosphorus efficiency products [AVAIL® (Specialty Fertilizer Products, Leawood, KS) at 0.5 gal/ton and P_2O_5 Max® (P-Max, Rosen's Inc., Fairmont, MN) at 1 gal/ton]. Plots were 10 to 15 by 70 ft. Phosphorus treatments were deep banded using a Yetter® 2984 strip-till system equipped with high residue Maverick® units (Yetter Manufacturing, Inc., Colchester, IL) with a rolling basket and dry fertilizer application tubes a the Novelty site. Phosphorus treatments were deep banded using a Yetter® 2984 strip-till system equipped with residue manager wheels (Yetter Manufacturing, Inc., Colchester, IL), B-33 mole knife, and opposing closing wheel disks at the Albany site. A Gandy Orbit Air (Gandy Company, Owatonna, MN) fertilizer applicator was used to deliver fertilizer behind the applicator knife in the strip till system at both locations. Phosphorus was broadcast applied with a hand spreader in the no-till treatments. Ammonium nitrate fertilizer was broadcast applied for the appropriate treatments to balance the N contribution of MAP as the rate was reduced. The planter was equipped with Shark-tooth® (Yetter Manufacturing, Inc., Colchester, IL) residue cleaners used in tandem with a no-till coulter. Grain and tissue samples were collected and are currently being analyzed by the University of Missouri Soil and Plant Testing Laboratory to determine crop P uptake due to the effects of the treatments at both locations.

Research for objective 2 was conducted at Novelty and Portageville. Treatments included a factorial arrangement of the presence or absence of the phosphorus efficiency products [AVAIL®(Specialty Fertilizer Products, Leawood, KS) at 0.5 gal/ton, NutriLife MAX® at the Novelty location only (Advanced Microbial Solutions, Pilot Point, TX) at 1 gal/ton, and P_2O_5 Max® (P-Max, Rosen's Inc., Fairmont, MN) at 1 gal/ton], P source [non-treated control and a broadcast application of DAP (diammonium phosphate) or TSP (triple superphosphate)], and broadcast surface application of ag lime (0 and recommended rate). Plots were 10 by 40 ft. The Portageville site was conventional tillage with furrow irrigation and the Novelty site was no-till and rain fed. Tissue (Novelty and Portageville) samples were collected to determine crop P uptake and are currently being analyzed by the University of Missouri soil and Plant Testing Laboratory. Grain samples were collected and analyzed for protein, oil, and starch at Novelty in 2010.

Preliminary Results

Objective 1. Corn was planted early at Novelty and replanted due to a poor overall stand at Albany. Tillage system had no effect on silage dry weight. Harvested plant population was not different among tillage systems at Albany, while the plant population was 9,400 plants/acre greater with strip-till than no-till at Novelty (Table 1). Grain moisture was slightly greater (0.5%) with no-till corn at both locations, but test weight was 0.3 lbs/bu greater with strip-till at Novelty. There was no effect of P enhancer or fertilizer rate on silage dry weight, grain moisture, plant population, test weight at Novelty or grain yield (Table 2). However, there was an interaction between P placement and enhancer (Figure 1). AVAIL increased grain yield 8 bu/acre when

applied in a strip-tilled band compared to P without an enhancer, but there was no effect of P enhancer on grain yield when broadcast applied in a no-till system.

Objective 2. Phosphorus enhancer had no effect on plant population, test weight at Novelty, moisture at Novelty, or grain yield (Table 3). Silage yields were greater at Novelty than Portageville. At Novelty, AVAIL increased silage yield 1.2 tons/acre when compared to the absence of a P enhancer. Silage yields were ranked non-treatment control = AVAIL > P-Max at Portageville. NutriLife MAX was added at the Novelty location, but there was no significant difference (P=0.91) between P enhancer treatments and the non-treated control (Figure 2).

Lime was applied at 2 and 3.6 ton/acre at Portageville and Novelty, respectively. The harvested plant population at both locations was approximately 20,000 plants/acre (Table 4). Plant populations were similar among P sources in the absence of lime, but were 2,600 and 3,200 plants/acre lower where TSP and DAP were applied, respectively. There was no effect of P source or lime on test weight or moisture at Novelty, and there was no effect of P source and lime application on silage yield at Novelty and Portageville. Grain yields were 7 bu/acre greater with TSP compared to DAP. Ammonium nitrate was added to TSP to balance the N present in DAP. This ready available N source with TSP may have contributed to the yield differences between the P sources. The recommended lime rate increased silage yields 1.1 tons/acre at Novelty, but grain yields were similar between lime treatments. However, recommended lime had no effect on silage yields at Portageville, but grain yields increased 11 bu/acre compared to the non-treated control (Table 5).

References

Advanced Microbial Solutions. 2005. NutriLife. http://superbio.com/product.asp?cod=3. Accessed July 16, 2010.

Blevins, D. 2009. Missouri Corn. Online at http://www.chooseavail.com/research.aspx?region=midwest. Accessed July 16, 2010.

Dunn, D.J., and G. Stevens. 2008. Response of rice yields to phosphorus fertilizer Rates and polymer coating. Online. Crop Management doi:10.1094/CM-2008-0610-01-RS.

Dunn, D. 2009. Missouri Soybean. Online at http://www.chooseavail.com/research.aspx?region=midwest. Accessed July 16, 2010.

Kurtz, L.T. 1953. Inorganic phosphorus in acid and neutral soils. Soil and Fertilizer Phosphorus in Crop Nutrition. W. H. Pierre and A. G. Norman, eds. Agronomy 4:59-88.

Rosen's Diversified Inc. 2010. Rosen's Inc. - Serving Agribusiness. http://rosensdiversifiedinc.com/contentpage.asp?contentid=10. Accessed July 16, 2010.

Wild, A. 1950. The retention of phosphorus by soils, a review. Journal of Soil Science 1:221-238.

Table 1. The effect of P placement on harvested corn population, silage dry weight, grain moisture, and test weight at Novelty and Albany in 2010. Data were combined over P enhancer, rate, and location unless otherwise denoted below.

P placement	Population		Silage dry weight	Grain moisture	Test weight†
	Novelty	Albany			
	----- no./acre -----		lbs/acre	%	lbs/bu
No-till broadcasted	18,000	19,000	12,100	16.8	55.1
Strip-till banded	27,400	21,900	11,700	16.3	55.4
LSD‡ (P = 0.05)	----- 2,400 -----		-- NS --	0.3	0.1

†Novelty location only.
‡Abbreviations: LSD, least significant difference; NS, non-significant

Table 2. The effect of P rate and enhancer on harvested corn population, silage dry weight, grain moisture, test weight, and yield at Novelty and Albany in 2010. Data were combined over P placement and location.

P enhancer	Rate	Population	Silage dry weight	Grain moisture	Test weight†	Yield
	lbs P_2O_5/acre	no./acre	lbs/acre	%	lbs/bu	bu/acre
None	0	21,700	12,200	16.6	55.3	100
	50	23,200	11,800	16.9	55.3	94
	100	21,800	12,200	16.7	55.3	98
AVAIL	0	21,200	12,900	16.5	55.3	100
	50	20,400	10,900	16.7	55.3	98
	100	20,900	11,600	16.7	55.3	98
P-Max	0	21,400	12,800	16.6	55.3	103
	50	21,200	11,600	16.3	55.3	94
	100	21,400	11,400	16.3	55.4	96
LSD (P = 0.1)		-- NS --	-- NS --	-- NS --	-- NS --	-- NS --

†Novelty location only.

Table 3. The effect of P enhancer on harvested population, silage dry weight, test weight, moisture, and grain yield at Novelty and Portageville in 2010. Data were combined over lime treatment and location when appropriate.

P enhancer	Population	Silage dry weight		Test weight†	Moisture†	Yield
		Novelty	Portageville			
	no./acre	---------- lbs/acre ---------		lbs/bu	%	bu/acre
Non-treated	19,600	15,100	14,000	51.1	26.4	135
AVAIL	20,400	17,500	13,000	51.2	25.8	135
P-Max	19,100	15,400	12,700	51.2	25.7	136
LSD (P = 0.1)	-- NS --	---------- 1,100 ----------		-- NS --	-- NS --	-- NS --

†Novelty location only.

Table 4. The effect of P source and lime application on harvested plant population, silage dry weight, and grain yield at Novelty and Portageville in 2010. Data were combined over P enhancer, location, and lime treatment when appropriate.

P source†	Harvested population		Silage dry weight		Test weight‡	Moisture‡	Yield
	-------- Lime --------		-------- Lime --------				
	None	Recommended	None	Recommended			
	-------- no./acre --------		-------- lbs/acre --------		lbs/bu	%	bu/acre
Non-treated	19,600	21,900	13,400	15,700	51.1	26.2	132
TSP	20,400	19,300	15,200	14,800	51.2	25.8	139
DAP	19,400	18,700	13,500	15,000	51.1	26.0	135
LSD (P = 0.1)	---------- 1,300 ----------		---------- NS ----------		-- NS --	-- NS --	6

†Abbreviations: DAP, diammonium phosphate; LSD = least significant difference; NS = non-significant; TSP, triple super phosphate.
‡Novelty location only.

Table 5. The effect of lime on silage and grain yields at Novelty and Portageville in 2010. Data were combined over P source and enhancer.

Lime application	Silage yield		Grain yield	
	Novelty	Portageville	Novelty	Portageville
	------- lbs/acre -------		------- bu/acre -------	
Non-treated	14,900	13,100	160	105
Recommended	17,100	13,200	159	116
LSD (P = 0.1)	---------- 900 ----------		---------- 5 ----------	

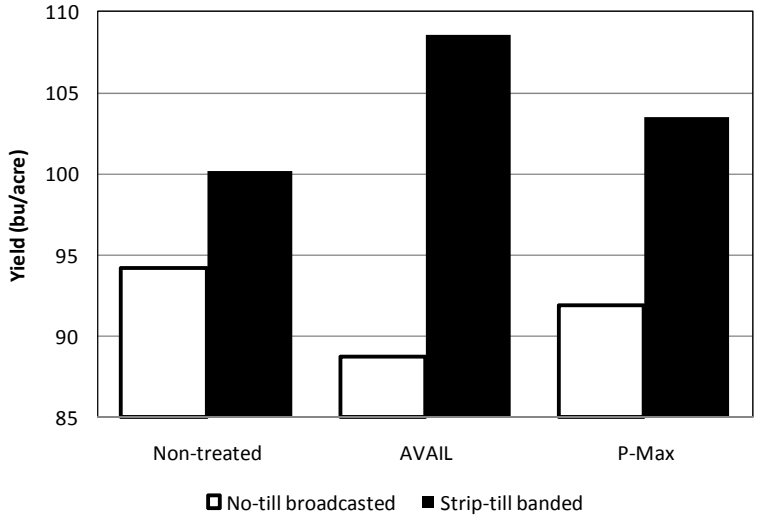

Figure 1. The effect of P placement (no-till surface broadcasted and strip-till banded) and enhancer (non-treated control, AVAIL, and P-Max) on grain yield at Novelty and Albany in 2010. LSD (P = 0.1) was 8 bu/acre.

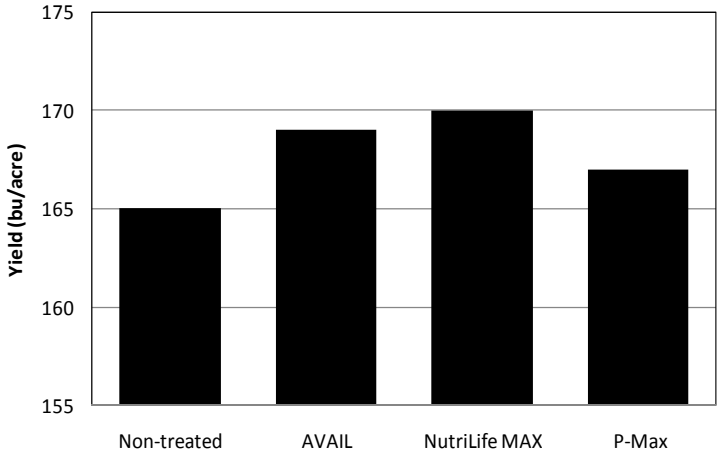

Figure 2. Corn grain yield response to P enhancers at Novelty in 2010. There was no significant (P = 0.91) yield difference among treatments. Data were averaged over lime treatments and P sources.

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