PHOSPHORUS ENHANCERS AND STRIP-TILLAGE AFFECTS CORN PRODUCTION IN UPSTATE MISSOURI

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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 is 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.

Prompted by high fertilizer costs, farmers are seeking ways to reduce phosphorus (P) fertilizer application rates and use of enhanced efficiency P fertilizer applications or treatments. The manufacturers of Avail® (Specialty Fertilizer Products, Leawood, KS) and P_2O_5-Max®(P-Max, Rosen's Inc., Fairmont, MN) have promoted these products as enhancing the efficiency of P-based fertilizers on several soil types. Avail® is a P enhancer for granular phosphate fertilizers, including DAP and MAP and other liquid P fertilizers. Avail® was designed to reduce the impact of cations (i.e., Ca, Fe, Mn, and Al) around fertilizer granules on soil P sorption and plant P uptake. This product binds with Ca, Fe, Mn, and Al in soil to prevent precipitation of P (SFP, 2009). P_2O_5-Max® increases P uptake and improves root surface area resulting in better nutrient absorption and higher yields (Rosen's Inc, 2012). The objective of this study was to evaluate the effect of tillage/fertilizer placement, P rate, and two P enhancer products on corn production, grain quality, P uptake, and apparent P recovery efficiency.

This two year study sought to determine the effects of tillage/fertilizer placement [no-till (NT)/surface broadcast or strip-till (ST)/deep banding], monoammonium phosphate (MAP) rate [0 lbs/acre, half the recommended rate (50 lbs/acre), and the recommended rate (100 lbs/acre)], and the presence or absence of two enhanced phosphorus efficiency products [non-treated control, Avail® at 0.5 gal/ton, and P_2O_5 Max® at 1.0 gal/ton] on corn (Zea mays L.) production. The study was conducted in 2010 and 2011 at Novelty and Albany, Mo. At Novelty, P treatments were deep banded using a Yetter® 2984 strip-till system equipped with high residue Maverick® units (Yetter Manufacturing, Inc., Colchester, IL), a rolling basket, and dry fertilizer application tubes. At Albany, phosphorus treatments also were deep banded using a Yetter® 2984 strip-till system equipped with residue manager wheels, B-33 mole knife, and opposing closing wheel disks. A

Gandy Orbit Air® (Gandy Company, Owatonna, MN) dry fertilizer applicator metered and delivered fertilizer behind the applicator knife in the strip till system. Phosphorus was applied with a hand spreader in the NT surface broadcast treatment. Ammonium nitrate fertilizer was broadcast-applied for the appropriate treatments to balance the N contribution of MAP as the rate was reduced. Plant N, P, and K uptake were calculated by multiplying silage dry matter yield by tissue nutrient concentration. Apparent phosphorus recovery efficiency (APRE) was calculated as [((P uptaketreated-P uptakecontrol)/(P fertilizer applied))*100]. All data were subjected to analysis of variance and means separated using Fisher's Protected LSD ($P = 0.1$). Data were combined over factors and locations when appropriate as indicated by the analysis of variance (data not presented).

The P enhancers did not affect plant population, silage dry weights, grain moisture, yield, grain protein, grain starch, plant nitrogen (N), potassium (K) uptake, or apparent P recovery efficiency (APRE) at either location (data not presented). At Albany, the non-treated control oil concentration was 0.13% greater than P_2O_5-Max® (Table 1). In the NT/broadcast and ST/deep banding treatments, the addition of Avail® or P_2O_5-Max® did not increase P uptake over the non-treated controls. Avail® increased P uptake 5.1 lbs/acre over P_2O_5-Max® with ST/deep banding, and no differences were observed between products with NT/broadcast. Phosphorus uptake increased 5.3 lbs/acre when P fertilizer was applied with P_2O_5-Max® and NT/broadcast instead of ST/deep banding.

Strip-till/deep banding increased plant populations 1,400 to 6,200 plants/acre compared to NT/broadcast (Table 2). Fertilizer placement showed no effect on silage dry weights, N, or K uptake (data not presented). However, grain moisture was 0.4% greater in NT/broadcast compared to ST/deep banding (Table 2). At Novelty, yields increased 24 bu/acre with use of strip-till/deep banding over NT/broadcast, but at Albany yields were affected by placement and MAP rate. When no MAP was added at Albany, NT/broadcast increased grain yields 9 bu/acre over ST/deep banding. However, no difference was observed between NT/broadcast and ST/deep banding with MAP at 50 or 100 lbs P_2O_5/acre. MAP at 0 kg P_2O_5/acre yielded 11 bu/acre more than MAP at 50 lbs P_2O_5/acre under NT/broadcast, but no difference was observed with MAP at 100 lbs P_2O_5/acre. No-till/broadcast increased APRE 20.7% over ST/deep banding.

Grain protein and starch concentrations had an interaction between year and placement at Novelty, but not Albany. NT/broadcast had 1.4% higher protein concentration in 2010 than ST/deep banding and 0.6% higher protein concentration in 2011 (Table 3). In 2010, ST/deep banding increased starch by 0.8%, while in 2011 starch increased 0.3% with ST/deep banding. Grain oil concentration was affected by location, placement, and MAP rate (Table 4). At Novelty, NT/broadcast with MAP at 0 lbs P_2O_5/acre had 0.17% lower oil concentration than the other placement-MAP rate combinations. At Albany, ST/deep banding with MAP at 0 lbs P_2O_5/acre had a lower oil concentration than any other placement-MAP rate combination except for NT/broadcast MAP at 100 lbs P_2O_5/acre. The effect of tillage on plant stand was less pronounced at Albany than at Novelty which may have affected grain quality.

Monammonium phosphate fertilizer rate did not affect plant population, silage dry weights, and grain moisture during all four site-years (data not presented). Monammonium phosphate fertilizer rate had a significant effect on yields with P_2O_5 at 0 lbs P_2O_5/acre yielding 4 to 6 bu/acre more than MAP at 50 or 100 lbs P_2O_5/acre (Table 5). At Novelty in 2011, grain protein

concentration increased 0.3% with MAP at 50 and 100 lbs P_2O_5/acre compared to the non-treated control, but at Novelty in 2010 or Albany no differences were observed. MAP at 0 and 100 lbs P_2O_5/acre increased starch concentration 0.2% over MAP at 50 lbs P_2O_5/acre at Novelty, but not Albany. Plant N, P, K uptake, or APRE were not affected by MAP rate during all four site-years evaluated in this research (data not presented).

The two P enhanced efficiency products this study evaluated did not consistently increase agronomic performance, including apparent P recovery efficiency, at the sites and environmental conditions in interaction with several fertilization rates and tillage practices evaluated in this research. Additionally, the P enhancers did not affect plant population, silage dry weights, grain moisture, yield, grain protein, grain starch, N, K uptake, or apparent P recovery efficiency. In the NT/broadcast and ST/deep banding treatments, the addition of Avail® or P_2O_5-Max® did not increase P uptake over non-treated controls. Since soils in this study were acidic, more research should be performed evaluating Avail® or P_2O_5-Max® use on alkaline soils. Strip-till/deep banding increased plant populations compared to NT/broadcast. An improved seedbed environment with lower soil moisture and higher soil temperatures likely caused the greater plant populations with ST. At Novelty, greater plant populations associated with ST increased grain yields compared to NT. Poorly drained claypan soils in Northeast Missouri responded more to ST than silty clay soils in Northwest Missouri.

Table 1. The effect of P enhancer on grain oil and P uptake.

	Oil		P uptake	
			Placement	
P enhancer	Novelty†	Albany†	NT/broadcast	ST/deep banding
	----------%----------		----------lbs/acre----------	
Non-treated	3.68	3.77	35.3	34.0
Avail®	3.64	3.69	33.9	35.5
P_2O_5-Max®	3.69	3.64	35.7	30.4
LSD (*P*=0.1)	NS‡	0.07	----------3.7----------	
P-value	0.74	0.01	----------0.09----------	

† Data were combined over years (2010 and 2011).
‡NS = Not significant

Table 2. Phosphorus placement effect on plant population, grain moisture, yield, and apparent P recovery efficiency (APRE).

	Plant population			Yield				
					Albany†			
					MAP rate (lbs P_2O_5 acre)			
Placement	Novelty†	Albany†	Grain moisture	Novelty†	0	50	100	APRE
	----plants/acre-----		%	----------bu/acre----------				%
NT/broadcast	20,500	23,300	17.2	100	139	128	133	21.4
ST/deep banding	26,700	24,700	16.8	124	130	132	135	0.7
LSD (*P*=0.1)	1,300	1,200	0.2	5	----------7----------			11.5

† Data were combined over years (2010 and 2011).
‡NS = Not significant

Table 3. Placement effect on grain protein and starch. Data were combined over MAP rate and P stabilizer.

	Protein			Starch		
	Novelty			Novelty		
Placement	2010	2011	Albany†	2010	2011	Albany†
	----------%----------			----------%----------		
NT/broadcast	8.4	9.3	8.4	73.9	72.9	72.3
ST/deep banding	7.0	8.7	8.5	74.7	73.2	72.2
LSD (*P*=0.1)	0.2	0.2	NS‡	0.2	0.2	NS

† Data were combined over years (2010 and 2011).
‡NS = Not significant

Table 4. Placement effect on grain oil. Data were combined over site-year and P stabilizer.

	Oil					
	Novelty†			Albany†		
	MAP rate(lbs P_2O_5/acre)			MAP rate(lbs P_2O_5/acre)		
Placement	0	50	100	0	50	100
	----------%----------			----------%----------		
NT/broadcast	3.48	3.73	3.65	3.74	3.73	3.68
ST/deep banding	3.75	3.75	3.67	3.60	3.76	3.70
LSD (*P*=0.1)	----------0.14----------			----------0.1----------		

†Data were combined over years (2010 and 2011).

Table 5. Yield, protein, and starch concentration as affected by MAP rate.

		Protein			Starch	
		Novelty				
MAP Rate	Yield	2010	2011	Albany†	Novelty†	Albany†
lbs P_2O_5 acre	bu/acre	----------%----------			-------%-------	
0	126	7.7	8.8	8.5	73.7	72.3
50	120	7.7	9.1	8.4	73.5	72.2
100	122	7.6	9.1	8.4	73.7	72.3
LSD (*P*=0.1)	4	NS	0.2	NS	0.2	NS

† Data were combined over years (2010 and 2011).
‡NS = Not significant

References

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