CORN PRODUCTION AS AFFECTED BY PHOSPHORUS ENHANCERS, PHOSPHORUS SOURCE AND LIME

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Prompted by high cost of fertilizer, farmers are investigating ways to enhance the efficiency of their P fertilizers. 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). 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).

Little published research has investigated plant growth and yields in the presence of Avail®. A study conducted in 2008 and 2009 at five locations throughout Kansas evaluated its effectiveness under corn and wheat cropping systems (Ward, 2010). Avail® had no significant effect on plant biomass, P uptake, or grain yields for corn and wheat. In Canada, two trials evaluated a nonfertilized control and three rates of seed-placed MAP at 6, 12, and 17 lbs P/acre with and without Avail® (Karamanos and Puurveen, 2011). The results showed neither a significant effect of treating MAP with Avail®, nor a significant interaction between Avail® treatment and rate of P on wheat yield and P uptake. The objective of this study was to evaluate the effect of liming, P source, and P enhancer products on corn production and P uptake.

This study set out to determine the effects of P source (non-treated control and a broadcast application of DAP or TSP), presence or absence of the phosphorus efficiency products [non-treated control, Avail® at 0.5 gal/ton, and P2O5-Max® at 1.0 gal/ton], and broadcast surface application of agriculture calcitic limestone [0 and recommended rate (3.6 ton/acre at Novelty in 2010, 1.5 ton/acre at Novelty in 2011, and 2.0 ton/acre at Portageville in 2010)] on corn (*Zea mays* L.) production. The study was conducted at Novelty in northeastern Missouri and Portageville in southeastern Missouri. The Novelty site was no-till and rain fed, while the Portageville site was conventional tillage with furrow irrigation and application of irrigation water (1 in) when no rainfall

events occurred. Soil test P (Bray-1 P) was 26.7 $\pm$ 9 lbs/acre at Novelty in 2010, 11 $\pm$ 2 lbs/acre at Novelty in 2011, and 132 $\pm$ 34 lbs/acre at Portageville in 2010. 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, protein, oil, or starch concentrations at either location (data not presented). Phosphorus enhancers did affect plant P (Table 1 and 3), K uptake (data not presented), and APRE at Novelty, but not at Portageville (Table 3). In the absence of the P enhancer, DAP increased plant P uptake 7.4 to 8.0 lbs/acre greater than the non-treated control and TSP (Table 1). At Novelty, neither P enhancer paired with DAP increased P uptake over the non-treated control. Triple superphosphate treated with Avail® increased P uptake 7.7 lbs/acre compared to the non-treated control and 6.4 lbs/acre compared to P_2O_5-Max®. In 2010 at Novelty, TSP treated with Avail® increased K uptake 134 lbs/acre compared to the non-treated TSP and 89 lbs/acre compared to P_2O_5-Max®.

Nitrogen uptake, K uptake, grain moisture, oil, protein, and starch concentrations were not affected by the lime treatment at either location (data not presented). At Novelty, plant population was 1,000 plants/acre greater in the non-limed control compared to the recommended rate in 2011, though at Portageville plant population was not affected (Table 2). At Portageville, the recommended amount of lime increased grain yields 12 bu/acre, but at Novelty, there was no effect. At Novelty, plant P uptake increased 3.4 kg $ha^{-1}$with the application of lime, but at Portageville there was no effect (Table 3). The lime application in this research decreased APRE 13.4%. Silage dry weights increased 1.0 ton/acre with an application of lime in the non-treated control, but no dry weight differences between lime treatments were observed in the presence of DAP or TSP (Table 4). Triple superphosphate increased silage dry weights 0.9 ton/acre over the non-treated control when no lime was applied. With application of TSP or DAP, grain moisture was 0.9 to 1.3% lower than the non-treated control. Grain yield increased 5 bu/acre with TSP compared to the non-treated control.

In this study, the two P enhanced efficiency products did not consistently increase agronomic performance, including apparent P recover efficiency, at the sites and environmental conditions or in interaction with several P fertilizers and liming practices evaluated in this research. Enhanced efficiency P products did not affect plant population, silage dry weight, grain moisture, yield, oil, protein, starch, or N uptake compared to the non-treated control. Since in this trial the soils tested were acidic, additional research on the P enhancers should be performed on alkaline soils. The application of lime resulted in mixed production results for the first year corn production after application, at the sites and environmental conditions in this research. This study showed no significant production differences between TSP and DAP at either location. The application of TSP increased grain yield compared to the non-treated control, while no differences were observed between DAP and the non-treated control.

Table 1. Phosphorus uptake as affected by P enhancers.

	P uptake			
	Novelty[‡]			
	P source			
P enhancer	Non-treated	DAP[†]	TSP[†]	Portageville
	----------lbs/acre----------			
Non-treated	28.6	36.0	28.0	47.4
Avail®	26.0	32.8	35.7	42.0
P_2O_5-Max®	31.5	29.0	29.3	44.1
LSD (*P*=0.1)	----------6.0----------			NS[§]
P-value	----------0.033----------			0.365

[†] DAP and TSP was applied at a 105 lbs P_2O_5/acre at Novelty in 2010, 100 lbs P_2O_5/acre at Novelty in 2011, and 50 lbs P_2O_5/acre at Portageville in 2010.
[‡]Data were combined over years (2010 and 2011).
[§]NS = Not significant

Table 2. Plant population and yield as affected by recommended lime rate.

	Plant population			Yield	
	Novelty				
Liming Rate	2010	2011	Portageville	Novelty[‡]	Portageville
	----------plants/acre----------			-----bu/acre-----	
None	24,200	23,500	15,200	151	105
Recommended[†]	26,100	22,500	14,300	146	117
LSD (*P*=0.1)	NS[§]	1,000	NS	NS	4

[†]The recommended liming rate was 3.6 ton/acre at Novelty in 2010, 1.5 ton/acre at Novelty in 2011, and 2.0 ton/acre at Portageville in 2010.
[‡]Data were combined over years (2010 and 2011).
[§]NS = Not significant

Table 3. Phosphorus uptake and apparent P recovery efficiency (APRE) as affected by recommended lime rate.

	P uptake		
Liming Rate	Novelty[‡]	Portageville	APRE
	----------lbs/acre----------		%
None	29.3	45.0	7.2
Recommended[†]	32.3	43.9	-6.2
LSD (*P*=0.1)	2.8	NS[§]	13.0

[†] The recommended liming rate was 3.6 ton/acre at Novelty in 2010, 1.5 ton/acre at Novelty in 2011, and 2.0 ton/acre at Portageville in 2010.
[‡]Data were combined over years (2010 and 2011).
[§]NS = Not significant

Table 4. Phosphorus source effects on silage dry weights, grain moisture, and yield.

	Silage dry weights			
	Liming rate		Grain	
P source[†]	None	Recommended[‡]	moisture[§]	Yield
	----------ton/acre----------		%	bu/acre
Non-treated	6.5	7.5	26.2	132
DAP	6.8	7.2	25.3	135
TSP	7.4	7.1	24.9	137
LSD (*P*=0.1)	----------0.6----------		0.7	4

[†] DAP and TSP was applied at a 105 lbs P_2O_5/acre at Novelty in 2010, 100 lbs P_2O_5/acre at Novelty in 2011, and 50 lbs P_2O_5/acre at Portageville in 2010.
[‡]The recommended liming rate was 3.6 ton/acre at Novelty in 2010, 1.5 ton/acre at Novelty in 2011, and 2.0 ton/acre at Portageville in 2010.
[§]Data were combined over years (2010 and 2011).

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