MANAGEMENT OF ENHANCED EFFICIENCY FERTILIZERS

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Abstract

Phosphorus generally occurs in soils as the anions $H_2PO_4^-$ or HPO_4^{-2}, depending on the soil pH. These anions readily react with soil cations such as calcium, magnesium, iron, and aluminum to produce various phosphate compounds of limited water solubility. Crop recovery of applied P fertilizer can be quite low during the season of application. Specialty Fertilizer Products[1] has developed and patented a family of dicarboxylic co-polymers that can be used as a coating on granular or mixed into liquid phosphate fertilizers. The registered trade name for the new product is AVAIL®[1] The polymer is reported to sequester antagonistic cations out of the soil solution thus keeping P fertilizer in a more available form for plant uptake. To evaluate the effectiveness of the AVAIL product, experiments were conducted at the North Central Kansas Experiment Field during the period 2001-2004 using mono-ammonium phosphate (MAP, 11-52-0) coated with AVAIL on both corn and soybeans. In 2003-2005 AVAIL also was evaluated in liquid ammonium polyphosphate fertilizer (10-34-0) applied as a starter for corn production. Treatments in the corn experiment consisted of applying MAP at rates to give 20, 40 or 60 lb/A P_2O_5, either treated with AVAIL or untreated. A no P check plot was also included. The soybean experiment consisted of applying either treated or untreated MAP at rates to give 30 or 60 lb/A P_2O_5. A no P check was again included. The phosphate fertilizer was banded beside the row in both the corn and soybean experiments. The liquid starter experiment conducted from 2003-2005 consisted of a no starter check and a 30-30-5 treatment applied alone or with AVAIL at various concentrations. Fertilizer was placed two inches to the seed and 2 inches below the seed at planting. Soil test P values were in the "medium" category in all experiments. When averaged over years and P rates, the Avail treated MAP increased corn grain yield by 18 bu/A over the untreated MAP. Tissue P concentration was greater in the AVAIL treated plots than in untreated plots at both the 6 leaf stage and at mid-silk. When averaged over years and P rates, soybean yield was improved by 9 bu/A by the use of AVAIL treated P fertilizer. In 2003-2005, liquid starter fertilizer mixed with AVAIL increased corn grain yield by 9 bu/A over the untreated starter treatment. In 2005 and 2006 fall applications of AVAIL treated MAP were investigated for irrigated corn production. The experiment consisted of untreated MAP applied at the rates of 30, 60 and 90 lb P_2O_5/A and AVAIL treated MAP applied in either the fall of the spring. Fall and spring applications of P fertilizer were equally effective. Fall applied AVAIL treated MAP preformed as well as spring applied and yielded 13 bu/A greater than untreated MAP. Influencing reactions in the micro-environment around the fertilizer granule or droplet has proven to have a significant benefit to the availability of applied P fertilizer. The use of AVAIL increased P uptake and yield of corn and soybeans.

[1] Mention of a commercial company or a trade name does not imply endorsement by the author or his institution.

Introduction

Phosphorus occurs in soils mainly as inorganic P compounds but also as low concentrations of P in the soil solution. Most soils contain relatively small amounts of total P, and only a small fraction of the total P is available to plants. Most inorganic P compounds in soils have a very low solubility. Phosphorus generally occurs in soils as the anions $H_2PO_4^-$ or HPO_4^{-2}, depending on the soil pH. These anions readily react with soil cations such as calcium, magnesium, iron, and aluminum to produce various phosphate compounds of very limited water solubility. Crop recovery of applied P fertilizer can be quite low during the season of application. Specialty Fertilizer Products has developed and patented a family of dicarboxylic co-polymers that can be used as a coating on granular or mixed into liquid phosphate fertilizers. The registered trade name of the new product is AVAIL®. The polymer is a high-charge density polymer (cation exchange capacity of approximately 1,800 meq/100 grams) that is reported to sequester multivalent cations that would normally form insoluble precipitates with P fertilizer. The polymer does not react with the P but does react with antagonistic positively charged multivalent cations. The process is supposed to create a zone of access and higher P availability, allowing more P to be taken up and used by plants. The objective of this research was to evaluate the use of AVAIL with phosphorus fertilizer for corn and soybean production.

Materials and Methods

Experiments were conducted during the period 2001-2004 at the North Central Kansas Experiment Field on a Crete silt loam soil in order to evaluate the effectiveness of the dicarboxylic polymer, AVAIL®, in increasing P availability and yield of corn and soybeans. The corn experiment consisted of applying granular MAP (11-52-0) at rates to give 20, 40 or 60 lb P_2O_5/A either treated with 0.25% AVAIL or untreated. A no P check plot also was included. The MAP fertilizer was sub-surface banded at planting. Soil test values at the experimental site were: organic matter, 2.8%; pH, 6.2; and Bray-1 P, 22 ppm. A liquid fertilizer starter test was conducted with corn in 2004-2006. Treatments consisted of liquid starter (30-30-5) applied with or without various concentrations of AVAIL. A no starter check also was included. The fertilizer was placed two inches to the side and 2 inches below the seed at planting. The soybean experiment consisted of applying granular MAP at rates to give 30 or 60 lb P_2O_5/A either with or without AVAIL, plus a no-P check. As in the corn experiment the MAP was applied in a sub-surface band at planting. Soil test values were: organic matter, 2.5%; pH, 6.7; and Bray-1 P, 23 ppm. Because MAP contains nitrogen and rates were calculated on the basis of P content, N in the form of ammonium nitrate was added so that all treatments received the same amount of N. In 2005 and 2006 fall applications of AVAIL treated MAP were compared with spring applied in order to determine if the polymer retained its effectiveness over the winter period. Treatments consisted of MAP applied at 30, 60, and 90 lbs P_2O_5/A, AVAIL treated MAP applied at the same rates in either the fall or spring. A no P check also was included. Fall applications were made in mid-November and spring applications were made in early April. All experiments were irrigated.

Results

When averaged over years and P rates, the AVAIL treated MAP increased corn grain yield by 18 bu/A over the untreated MAP (Table 1). The AVAIL treated MAP gave greater grain yield at all rates of applied P. Ear leaf P concentration at silking was greater in the AVAIL treated plots than in the untreated plots. The use of AVAIL with P fertilizer did result in improved plant P uptake (Table 2). When averaged over years and P rates, MAP plus AVAIL treated plots increased soybean yield by 9 bu/A over the untreated MAP plots (Table 3). Phosphorus uptake at the full bloom stage was increased by the use of AVAIL applied with MAP (Table 4). When AVAIL was applied with liquid starter fertilizer yields were increased by 9 bu/A over the untreated starter (Table 5). Phosphorus uptake in the AVAIL treated plots was greater than the untreated plots at both the 6-leaf stage and at silking. Studies with AVAIL in liquid starter fertilizers indicate that polymer concentrations in high volume fluid starters need to be in the 1.5% by volume range to produce the desired effects. This percentage is of the entire fluid mix, not just the P component. Further studies have shown that a lower 2.0 pH polymer formulation is more effective than a higher 5.5 pH formulation and allows for side band placement concentration to be reduced to 0.5% by volume. In 2005 and 2006 fall applications of AVAIL treated MAP were investigated for irrigated corn production (Table 6). Fall and spring applications of P fertilizer were equally effective. Fall applied AVAIL treated MAP preformed as well as spring applied and yielded 13 bu/A greater than untreated MAP.

Influencing reactions in the micro-environment around the fertilizer granule or droplet has proven to have a significant benefit to the availability of applied P fertilizer. The use of AVAIL with P fertilizer increased plant P uptake and yield of corn and soybeans

Table 1. Corn yield response to phosphorus and AVAIL.

Treatment	2001	2002	2003	Average
lb/A P_2O_5			bu/A	
20 untreated	188 B*	142 D	182 D	171 D
40 untreated	191 B	169 C	188 C	182 CD
60 untreated	190 B	173 BC	195 BC	186 BC
20 + AVAIL	194 B	173 BC	210 B	192ABC
40 + AVAIL	195 B	190 AB	210 A	198AB
60 + AVAIL	209 A	194 A	210A	204A
Check	174 C	120 E	169A	154 E
LSD (0.05)	9	17	10	12

* Means separated using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different

Table 2. Applied phosphorus and AVAIL effects on corn earleaf P concentration.

Treatment	2001	2002	2003	Average
lb/A P2O5		%P		
20 untreated	0.229 D*	0.229 E	0.238 D	0.232 D
40 untreated	0.239 C	0.247 CD	0.248 C	0.245 C
60 untreated	0.251 B	0.257 B	0.255 B	0.254 B
20 + AVAIL	0.236 C	0.240 D	0.244C	0.240 C
40 + AVAIL	0.257 A	0.253 BC	0.258 B	0.256 B
60 +AVAIL	0.261 A	0.274 A	0.265 A	0.267 A
Check	0.199 E	0.212 F	0.204 E	0.205 E
LSD (0.05)	0.005	0.007	0.006	0.006

* Means separated using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 3. Soybean yield response to phosphorus and AVAIL.

Treatment	2002	2003	2004	Average
lb/A P_2O_5		bu/A		
30 untreated	62 C*	41 C	69 C	58 C
60 untreated	62 C	48 B	74 B	61 B
30 + AVAIL	70 B	57 A	78 A	68 A
60 +AVAIL	73 A	58 A	79 A	70 A
Check	52 D	32 D	60 D	48 D
LSD (0.5)	2	3	1	2

*Means were separated using Duncan's Multiple Range Test. Means followed by the same letter are not significantly different.

Table 4. Applied phosphorus and AVAIL effects on whole plant P uptake at full bloom.

Treatment	2002	2003	2004	Average
lb/A P_2O_5		lb/A		
30 untreated	6.51 C	7.37 D	9.64 C	7.84 B
60 untreated	6.86 BC	8.02 C	10.84 B	8.57 B
30 + AVAIL	8.56 AB	9.16 B	13.13 A	10.28 A
60 + AVAIL	10.20 A	10.18 A	12.91 A	11.09 A
Check	4.17 D	4.67 E	5.37 D	4.64 C
LSD (0.05)	1.15	0.91	0.45	0.83

Table 5. AVAIL in liquid starter fertilizer, 2003-2005.

Treatment	Yield	V6 P uptake	Ear Leaf P
	bu/A	lb/A	%
No starter	195	1.42	0.212
Starter	214	1.96	0.257
Starter + AVAIL	223	2.30	0.300
LSD (0.05)	5	0.20	0.011

Table 6. Timing of P application effects on yield of corn (average over P rates), 2005-2006.

Material	Timing	Yield, bu/A
Check		178
MAP	Fall	202
	Spring	204
MAP+AVAIL	Fall	216
	Spring	217
LSD(0.05)		8

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