

IMPROVING PHOSPHORUS NUTRITION OF COTTON

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Abstract

Phosphorus generally occurs in soil 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 phosphorus fertilizer can be quite low during the season of application. In addition low soil temperature can decrease crop root growth and nutrient uptake especially early in the growing season. In crops like cotton whose roots are very susceptible to chilling, phosphorus deficiency can occur even on soils not low in available P. Specialty Fertilizer Products of Leawood, KS 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 this product is AVAIL. The polymer has a very high negative charge and is reported to have the ability to attract and sequester antagonistic cations out of the soil solution thus keeping more of the applied P fertilizer in a plant available form. To evaluate the effectiveness of the AVAIL product for cotton production, experiments were conducted in West Tennessee near Grand Junction on a Loring silt loam soil (Fine-silty, mixed, thermic Oxyaquic Fragiudalf) during the period 2010-2012. Initial soil test P was 30 ppm (Mehlich 1) and pH was 6.5. Treatments consisted of applying mono-ammonium phosphate (MAP, 11-52-0) alone or coated with AVAIL at rates to give 30 or 60 lb/acre P_2O_5 . A no P check was also included. An additional treatment consisting of AVAIL treated P in combination with Nutrisphere, a nitrogen (N) stabilizer product offered by Specialty fertilizer Products, was also included. Fertilizer was broadcast on the soil surface 10-14 days prior to planting each year. Cotton was planted without tillage into the previous year's stubble. When averaged over P rates and years, AVAIL treated MAP increases cotton lint yield by 140 lb/acre over untreated MAP. Tissue P concentration was also significantly improved with the use of AVAIL. Consistently greater yields and higher tissue P concentrations were achieved with 30 lb/a P_2O_5 treated with AVAIL than with 60 lb/acre P_2O_5 untreated. The greatest yield in the experiment was achieved with the use of AVAIL and Nutrisphere in combination. Influencing reactions in the micro-environment around the fertilizer granule has proven to have a significant benefit on the yield and P uptake of cotton.

Introduction

Phosphorus occurs in soils mainly as inorganic P compounds but also as low concentrations of P in the soil solution. Compared to other macronutrients like calcium, the concentration of P in the soil solution is very low, ranging from 0.001 mg/L in very infertile soils to about 1 mg/l in heavily fertilized soils. Only a small fraction of the total P in soils is available for plant uptake. Most inorganic P compounds in soils have a very low solubility making them only slowly available for plant uptake. Phosphorus generally occurs in soils as the anions H_2PO_4^- or HPO_4^{2-} depending on soil pH. These anions react readily 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, Leawood, KS 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 this product is AVAIL and it is identified as a partial sodium salt of maleic-itaconic copolymer (CAS# 556055-76-6). The compound is a high-charge density polymer (cation exchange capacity of approximately 1,800 miliequivalents/100 grams) that is reported to sequester multivalent cations such as calcium and magnesium in high pH soils and iron and aluminum in low pH soils that normally form insoluble precipitants with applied P fertilizer. The AVAIL compounds attracts the positively charged cations in the soil solution, binds them, leaving the P in solution available for plant uptake. The objective of this research was to evaluate the use of AVAIL with phosphorus fertilizer in order to improve nutrient management in a no-tillage cotton production system.

Methods

The experiment was conducted during the period 2010-2012 on land owned by Tennessee Framers Cooperative but rented by a private farmer located near Grand Junction, TN. The soil was classified as a Loring silt loam with a pH of 6.5 and a Mehlich I P value of 30 ppm. Treatments consisted of applying phosphate fertilizer as MAP (11-52-0) at rates to give 30 or 60 lb P_2O_5 /acre either treated with 0.25% AVAIL or untreated. A no P check was also

included. An additional treatment include AVAIL treated P in combination with urea treated with Nutrisphere, another product offered by Specialty Fertilizer Products, that is classified as a nitrogen (N) stabilizer. The fertilizer was broadcast on the soil surface 7-10 days prior to planting each year. Cotton was planted without tillage in the previous year's stubble. Planting date was May 7, 12 and 10 in 2010, 2011, 2012, respectively. Harvest occurred in early October each year. All treatments received a total of 100 lb/acre N as urea and 50 lb/acre K₂O as muriate of potash regardless of P treatment. All additional fertilizer was applied just prior to planting. Plots consisted of four rows, thirty-eight inches in width by 30 feet long. Each treatment was replicated four times. Fertilizer was weighed out for each plot and applied by hand. Plant leaf samples were taken in 2011 and 2012 from the uppermost fully expanded leaf at full bloom (August 8, 2011 and Aug1, 2012) and analyzed by Kansas State University Soil Testing Lab, Manhattan, KS. The center two rows of each plot were harvested for yield and a hand sample ginned on a small table-top experimental gin in order to determine lint cotton turnout.

Results and Discussion

In spite of the site having what is considered adequate Soil Test P, a good response to applied P was seen. The no-P check averaged 721 lb lint/acre versus 958 lb lint/acre for all applied P treatments (Table 1). When averaged over years and P rates, The AVAIL treated MAP increased cotton lint yield by 140 lbs/acre. Consistently greater yields were achieved with 30 lb/acre AVAIL treated MAP than 60 lb/acre untreated. Yields continued to increase with increasing P rate in the untreated plots but no additional response was seen in increasing P from 30 to 60 lb/acre in the AVAIL treated plots. The greatest yields in the experiment were achieved with the application of AVAIL treated P in combination with Nutrisphere treated urea. Nutrisphere is a product offered by Specialty Fertilizer Products that is classified as a nitrogen stabilizer. It is reported to act as both a urease inhibitor and a nitrification inhibitor. In this experiment, treating both N and P resulted in a yield increase of 191 lb lint cotton/acre over the untreated plots and a 73 lb/acre increase over the AVAIL only treatment.

Table 1. Lint cotton yields as affected by P-Rate and AVAIL, Grand Junction, TN.

N-P-K	AVAIL	2010	2011	2012	AVG
LB/ACRE		lb/acre lint			
100-0-50	No	710	700	752	721
100-30-50	No	855	929	837	873
100-60-50	No	890	998	867	918
100-30-50	Yes	921	1269	912	1034
100-60-50	Yes	925	1270	914	1036
100-60-50	Nutrisphere+AVAIL	1021	1383	922	1109
LSD (0.05)		28	21	65	47
CV%		2.8	2.7	4.9	3.3

Tissue P concentrations followed the same trends as yield (Table 2.). P concentrations were greater for AVAIL treatments than for the untreated, with 30 lb P₂O₅ with AVAIL giving greater P concentration than 60 lb/acre P₂O₅ untreated. P concentrations were lowest for the No-P check. Results indicate that the use of AVAIL does result in better P uptake by cotton.

Phosphorus management is a key element in successful cotton production. Nutrient management can be difficult in no-tillage system that maintains significant amounts of residue on the soil surface. Soils can be cooler in the spring than conventionally-tilled soils. Cool soils can depresses plant root growth and P uptake even on soils not low in available P. In this experiment AVAIL consistently improved both leaf tissue P concentration and yield of cotton grown in the Mid-South on a soil not low in available P.

Table 2. Cotton leaf tissue* P concentration (%) as affected by P-Rate and AVAIL, Grand Junction, TN.

N-P-K	AVAIL	2011	2012	AVG
LB/ACRE				
100-0-50	No	0.296	0.344	0.320
100-30-50	No	0.368	0.398	0.383
100-60-50	No	0.492	0.462	0.477
100-30-50	Yes	0.526	0.551	0.539
100-60-50	Yes	0.531	0.547	0.540
100-60-50	Nutrisphere+AVAIL	0.542	0.544	0.543
LSD (0.05)		0.029	0.033	0.031
CV%		3.9	5.1	4.2

*Uppermost fully expanded leaf at full-bloom (Aug. 8, 2011, Aug 1, 2012).