IMPROVING NUTRITION WITH ENHANCED EFFICIENCY FERTILIZERS AND SEED TREATMENTS

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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 (now Verdesian Life Sciences, Cary, NC) 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. Nutrisphere, a product also marketed at present by Verdesian Life Sciences, is reported to function both as a urease inhibitor and a nitrification inhibitor. To evaluate the effectiveness of AVAIL and Nutrisphere for cotton production, experiments were conducted at two locations in southwestern Tennessee (Grand Junction and the Ames Plantation) both on a Loring silt loam soil (Fine-silty, mixed, thermic Oxyaquic Fragiudalf) during the period 2010-2013. Initial soil test results at Grand Junction were: P =30 ppm (Mehlich 1) and pH=6.5 and the soil test at the Ames Plantation was P=25 ppm and pH=6.9. Treatments in the AVAIL study 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. 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 locations, years and P rates AVAIL treated MAP increases cotton lint yield by 110 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_20_5 treated with AVAIL than with 60 lb/acre P_2O_5 untreated. The Nutrisphere experiment was conducted at the Grand Junction site and consisted of three rates of nitrogen (N) (40, 80 and 120 lbs/acre) as urea with and without Nutrisphere. A no N check was also include. The urea was broadcast on the soil surface at planting time in residue from the previous year's cotton crop. When averaged over years and N-rates, urea treated with Nutrisphere yielded 133 lbs/acre lint cotton more than the untreated urea. With the untreated urea, yields increase with increasing N rate up to the 120 lb/acre rate whereas with the Nutrisphere treated urea, maximum yield was achieved with 80 lb/acre N. Tuxedo is another long-chain polymer product developed by Verdesian Life Sciences that contains 5% zinc, 2.5% manganese, and 500 ppm copper. The material is applied directly to the seed at the rate of 2.4 oz/100 lbs of seed. In tests conducted at the Memphis Ari-Center on a Falaya silt loam soil the use of the seed treatment tuxedo increased cotton yields by 217 lbs of lint/acre. The use of enhanced fertilized products consistently increased yield and nutrient content of cotton in west Tennessee.

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 $H_2PO_4^{-1}$ 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 (now Verdesian Life Sciences) 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 milliequilents/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, bids 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.

For maximum yield, it is critical to supply a consistent supply of nitrogen to cotton. Nitrogen can be lost by several different means. Fertilizer containing urea can be subject to volatilization losses, especially when broadcast on the soil surface in no-tillage production systems. When nitrogen is converted from the ammonium form to the nitrate form, it can also be lost through leaching and denitrification. The product Nutrisphere is classified as a partial calcium salt of maleic-itaconic copolymer (CAS# 877469-38-0). Nutrisphere is reported to act both as a nitrification inbiitor and as a nitrification inbititor. The objective of this research was to evaluate the effectiveness of Nutrisphere in a no-till production when urea is used as the nitrogen source.

Cotton is very sensitive to cold air and soil temperatures. Root growth and nutrient uptake can be adversely affected when early season growing conditions are poor. Tuxedo is a new material that has not yet been released commercially. It too is a long-chain polymer material that contains 5% zinc, 2.5% manganese and 500 ppm copper. The material was applied to cotton seed at the rate of 2.4 oz/100 lbs of seed. The use of a nutrient coated seed treatment may overcome some of the early season growth problems that cotton suffers when temperatures are less than optimum.

Methods

The phosphorus experiments 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 and at the Ames Plantation in the years 2011-2013. The soil at both sites was classified as a Loring silt loam with a pH of 6.5 and a Mehlich I P value of 30 ppm at the Grand Junction site and a pH of 6.9 and a Mehlich I P value of 25 ppm at the Ames Plantation. 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. 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 in the first week of May in all years and at both locations. Harvest occurred in early October each year. All treatments received a total of 100 lb/acre N as urea and 50 lb/acre K_2O 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 at the Grand Junction site and in 2012 and 2013 at the Ames Plantation 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.

The Nutrisphere experiment was conducted in adjacent areas to the phosphorus experiments at both the Grand Junction and Ames Plantation locations. Soil test values, general cultural practices, plot size and harvest procedures were all the same as with the phosphorus studies. Urea was used as the N-source and treatments consisted of 40, 80 and 120 lbs N/acre applied as urea. A no N check was also included. The urea was broadcast on the soil surface just prior to planting.

The seed treatment study using the new Tuxedo product was conducted at the Memphis-Agi-Center on a Falaya silt loam soil in 2014. The Mehlich I P value was 30 ppm and the pH was 6.8. Three cotton varieties (ST4946GLB2, ST5289GLT and PHY339WRF) were planted with and without Tuxedo.

Results and Discussion

In spite of the site having what is considered adequate Soil Test P, a good response to applied P was seen at both sites (Table 1). When averaged over sites and years, the no-P check averaged 740 lb lint/acre verses 930 lb lint/acre for all applied P treatments (Table 1). When averaged over location, years and P rates, The AVAIL treated MAP increased cotton lint yield by 110 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.

Table 1. Lint cotton yields as affected by P-Rate and AVAIL

N-P-K	AVAIL	3-YEAR AVG GRAND JUNCTION	3-YEAR AVG AMES PLANTATION	AVERAGE
LB/ACRE		lb lint/acre		
100-0-50	No	720	760	740
100-30-50	No	813	889	851
100-60-30	No	833	962	898
100-30-50	Yes	895	1065	980
100-60-50	Yes	904	1076	989
LSD (0.05)		47	51	56
CV %		3.3	3.8	5.2

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 P_2O_5 with AVAIL giving greater P concentration than 60 lb/acre P_2O_5 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.

Table 2. Cotton leaf tissue (uppermost fully expanded leave at full bloom) P concentration (%) as affected by P-Rate and AVAIL,

N-P-K	AVAIL	3-YEAR AVG GRAND JUNCTION	3-YEAR AVG AMES PLANTATION	AVERAGE
LB/ACRE				
100-0-50	No	0.320	0.312	0.316
100-30-50	No	0.383	0.388	0.386
100-60-30	No	0.477	0.457	0.467
100-30-50	Yes	0.539	0.559	0.549
100-60-50	Yes	0.540	0.555	0.548
LSD (0.05)		0.031	0.036	0.037
CV %		4.2	4.5	4.8

Cotton yield continued to increase with increasing N-rate up to the 120 lb/acre N-rate when untreated urea was applied (Figure 1). When the urea was applied treated with Nutrisphere maximum yield was achieved with 80 lbs N/acre. When averaged over N-rates, yield was 133 lb/ace lint greater with urea treated with Nutrisphere than with urea alone.

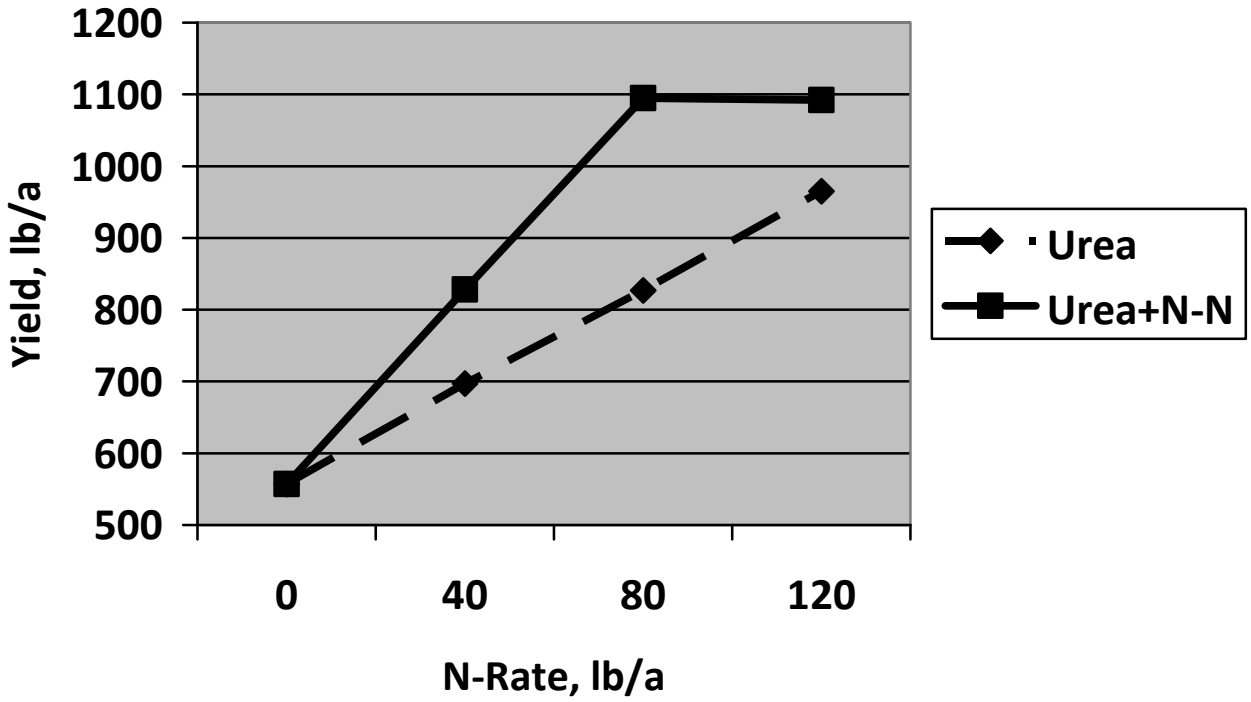

Figure 1. Cotton yield as affected and N-Rate and Nutrisphere (N-N) 3-year average, Grand Junction.

The use of the seed treatment Tuxedo increased cotton yield by 217 lbs of lint/acre (Table 3). Tuxedo increase yield regardless of variety.

Table 3. The seed treatment Tuxedo effect on yield (lb. lint/acre) of three cotton varieties, Memphis Agri-Center, 2014.

VARIETY	NO TUXEDO	TUXEDO	AVERAGE
ST4946GLB2	1106.7	1254.4	1180.5
ST5289GLT	866.9	972.0	919.4
PHY339 WRF	996.2	1155.9	1076.1
AVERAGE	889.2	1207.0	1058.7

Variety LSD (0.05)=82.2
Seed Treatment LSD (0.05)=67.1
Variety x Seed Treatment=Not Significant

Nutrient management is a key element in successful cotton production. 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 soil not low in available P. Significant N losses can occur with surface applied nitrogen fertilizers containing urea. Additional losses can occur through leaching and denitrification when nitrogen is converted from the ammonium to nitrate form. The use of Nutrisphere with granular urea improved yields and reduced the amount of nitrogen need to reach maximum yield. The new nutrient containing seed treatment Tuxedo greatly improved the yields of three different cotton yields and may prove to be a useful tool in overcoming some of the early nutrient stress problems cotton encounters when growing conditions are poor and temperatures are cooler than normal.