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Contents

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New Technology and Alternative Nitrogen Sources for Crops in the Southern U.S.

C.C. Mitchell and D. Osmond

Background

Minimizing nitrogen (N) fertilizer rates while maintaining crop yields is essential both for improving agricultural profitability and reducing environmental consequences of farming, such as leaching and runoff from agricultural crop fields, which can be major sources of N to streams, rivers, and estuaries in the Southeast.

Significant increases in N fertilizer costs during the last nine years have substantially increased crop production input costs forcing farmers to search for alternative N sources. For most farmers, the only potential N alternatives are planting legumes as winter cover crops (which can deplete soil moisture needed for the primary crop) or applying animal manures (which are not available in all production areas). Another option is applying slow release nitrogen fertilizers, which have the potential to improve nitrogen use efficiency of corn and other field crops and, thereby, enhance both production economics and environmental protection.

Several traditional N fertilizer sources are available to farmers. Ammonium nitrate (34-0-0) formerly was the standard, but has become difficult to find and transport. Solid urea-ammonium sulfate blend (33-0-0) is one substitute but is very acid-forming and also subject to ammonia volatilization. Solid urea (46-0-0) is another alternative but also has a high risk of volatilization losses during hot, dry summer months when surface applications are not incorporated. This is especially true when urea is applied on crop residue in a high pH soil. Reduced tillage and high-residue management in row crops often require surface application of some materials. Liquid urea-ammonium nitrate solutions (UAN) are currently the most popular N source for row crops.

A number of products have been developed to combat N losses from volatilization and leaching. Nitrification inhibitors (e.g., nitrapyrin) have been available for many years and used mainly in the Midwestern U.S. where fall-applied anhydrous ammonia is popular. Recently, urease inhibitors (e.g., Agrotain®) have been marketed to help manage urea-based N fertilizers. Many new polymer coated products are on the market to control the release of N from both liquid and dry urea-based materials. The technology to manufacture controlled release fertilizers or to include an additive to a traditional fertilizer material will, of course, result in a higher cost to the consumer. Are the benefits worth the extra cost? Do these materials work effectively and consistently under the heat and humidity of the Southern U.S. climate and for the major crops produced in the region?

The overall objective of this Southern Region Water Quality Program Special Project funded through USDA NIFA was to conduct field research to evaluate the effectiveness of several slow-release N fertilizers and N fertilizer stabilizer products as compared to standard N fertilizers for the production of selected major row crops in the cooperating southern region states: Arkansas, Alabama, Florida, New Mexico, North Carolina, Oklahoma, and Texas.

Procedures and Materials Evaluated

Each state conducted research with alternative and new technology N sources independently comparing products and using crops and management practices common in that state. These procedures are described under each state.

Each state compared various new technology N products along with one or more “traditional” N source. Rates, methods, and timing of application(s) depended on the objectives for each experiment. Where possible, materials were applied according to the manufacturers’ recommended rate and method. However, because of the difficulty of comparing commercial products, each state used products differently. The materials and products used are listed and briefly described below.

Ammonium nitrate (34-0-0) has been the most popular, dry form of N used on forages and some row crops in the South. However, as a powerful oxidizer, its use has come under close scrutiny by the U.S. Department of Homeland Security and the U.S. Department of Transportation. Federal regulations have made it difficult to purchase and expensive to transport so alternatives are being used by most producers.

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Ammonium nitrate is not subject to volatilization losses and was used as the standard for comparison in some tests.

Urea-ammonium sulfate blend (33-0-0) has become the most popular substitute for ammonium nitrate for home grounds use and for some farmers. It is more acid-forming than ammonium nitrate and the urea component may be subject to volatilization losses.

Liquid urea-ammonium nitrate (UAN solution) may be the most widely used N source for crops in the South. Sources range from a 28-0-0 with 5 percent S to a 32-0-0 UAN solution. Liquid N is usually applied by injection to prevent volatilization losses and may be dribbled or sprayed in a band on the surface as a sidedress N application.

Dry urea (46-0-0) is usually the least expensive dry material per pound of N and is the most concentrated dry source of N available. Widespread concerns about ammonia volatilization losses on hot, dry soils with a significant surface residue often discourage its use as a sidedress N source on no-till/conservation tilled crops. Dry urea was used as a standard for comparison in some studies.

Agrotain® has become the standard urease inhibitor product currently being used in the Southeastern U.S. (Agrotain International, LLC). Agrotain was mixed with dry urea or with liquid UAN solutions at the recommended rate. For example, in the Alabama studies it was applied at the highest recommended rate with urea (5 quarts per ton; 24 milliliters Agrotain per 10 pound urea) to give 14-day protection under adverse soil conditions. For 28 percent or 32 percent UAN solutions, the rate was 2.4 quarts per ton or about 11 milliliters per 10 pound UAN solution (~1 gallon). (www.agrotain.com)

Nutrisphere N® (SFP, Leawood, Kansas) is formulated to be used with both dry urea and UAN solutions. Both formulations were included at the manufacturer's recommended rate. Nutrisphere includes both a nitrification inhibitor and a urease inhibitor. (http://www.nutrisphere-n.com)

Nitamin Nfusion® is a slow release N product manufactured by Georgia-Pacific that can be blended with UAN solutions. Nfusion is 22 percent N with 20.7 percent (94 percent of total N) derived from triazone and methylene urea. (http://www.kochfertilizer.com/nitamin/)

Environmentally Smart Nitrogen (ESN®) (44-0-0) is a polymer-coated, controlled release urea product from Agrium Advanced Technologies (U.S.) Inc. (http://www.smartnitrogen.com/)

NDemand® 30L (30-0-0) is a slowly available, liquid N derived from triazone and methyl urea. It is marketed primarily as a foliar N source by Wilbur-Ellis Company. (http://ag.wilburellis.com/Products/Product%20Documents/PlantNutritionRACKCARDS/NDemand%2030L%20Rackcard%20K-0310-355_SP.pdf)

CoRoN® 25-0-0 is a controlled release liquid N derived from methylene diurea and methylene ureas and marketed by Helena Chemical Company, Collierville, Tennessee. It is promoted primarily for foliar fertilization. (http://www.helenachemical.com/specialty/Labels/Coron25-0-0Code25.pdf)

Poultry litter is abundant in many southern states, and since the fertilizer crisis of 2008 an increasing number of row crop farmers are using it as a main source of N, P, and K for their crops. An 11-year study in Alabama showed rather conclusively that it could be used on conservation tillage corn and cotton based on the total N in the litter. Most growers assume about 50 to 67 percent available N.

Calcium chloride. Some previous reports have suggested that calcium chloride reduces volatilization losses of urea-based N sources. Alabama included a liquid calcium chloride for two years with both urea and UAN solution, but eliminated the treatment when no differences were observed in yield or ammonia volatilization losses.

UCAN®-23 (YaraLiva®), marketed by Yara International ASA, Oslo, Norway, is a clear liquid N fertilizer plus calcium. UCAN contains 8 percent NO_3–N, 5 percent NH_4–N, 10 percent urea N (23 percent total N), and 4 percent calcium. Water-soluble calcium purportedly reduces ammonia volatilization of the urea. (http://www.yara.us/fertilizer/products/yaraliva/ucan_23.aspx)

Florida evaluated three products manufactured by Prathista International, India, with registered offices in Alabama and Kansas. These products are recommended, particularly for commercial crops, as slow release organic nutrient supplements and/or substitutes, readily absorbed through the leaf surfaces. They are formulated with patented gluconate-microbial technology (www.prathista.com) and provide more than just an N source.

New Suryamin® is sold both as a foliar spray and a granular formulation. The New Suryamin® liquid formulation label lists its ingredients as total N (3.50 to 4.00 percent), total hydrolyzed proteins (10 to 12 percent), total carbohydrates (3.00 to 4.00 percent), and bio-enzymes (0.50 percent).

Ingredients in the granular New Suryamin® product are protein hydrolysate (2.45 percent), organic N (0.40 percent), and carbohydrates (0.50 percent).

Megacal® is a liquid formulation label containing the following: organic Ca (6.50 to 7.00 percent), organic Mg (5.00 to 6.00 percent), organic potash (2.00 to 3.00 percent), organic Zn (5.00 to 6.00 percent), organic B (0.5 percent), organic ferrous Fe (0.50 percent), organic Cu (0.50 percent), organic P (0.50 percent), and organic Mn (0.50 percent.

BioPotash® is a spray product containing 50 to 52 percent potassium gluconate with 7 to 8 percent w/v bio-available potash as per the label.

Conclusions

- Nutrisphere®, Nitamin® and Agrotain® did not improve yields at any location for any crop where tested.
- Pre-plant incorporated ESN® (as compared to urea) improved the corn yield at one site in Arkansas. When tested at two sites in Arkansas, ESN® improved seed cotton yield at one site but produced yields equal to urea at the second site. However, surface applied ESN® performed similarly or worse than UAN solution or urea in Alabama (corn), North Carolina (corn and wheat), Oklahoma (wheat), and Texas (grain sorghum).
- Evaluation of three organic nutrient supplements on vegetables in Florida gave mixed results depending upon the rate and method used but generally required regular fertilizer applications to maintain optimum yields.

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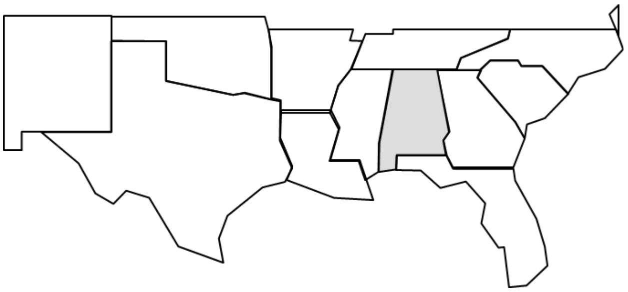
Alabama

Charles Mitchell, Dexter Watts, Don Moore



Years in study: 2007-2011

Soils: Lucedale s.c.l. (fine loamy, siliceous, thermic Rhodic Paleudults)

Crops: No-till, non-irrigated cotton and corn

Products evaluated: AN, urea, urea-AS blend, UAN solution, Agrotain®, Nutrisphere®, Nitamin Nfusion®, ESN®, poultry litter, calcium chloride

N rates: 120 pounds total N per acre on corn; 90 pounds total N per acre on cotton; 20 pounds N applied at planting; all fertilizer treatments applied as a sidedressing.

Data collected: Yield, leaf N, ammonia volatilization from selected treatments

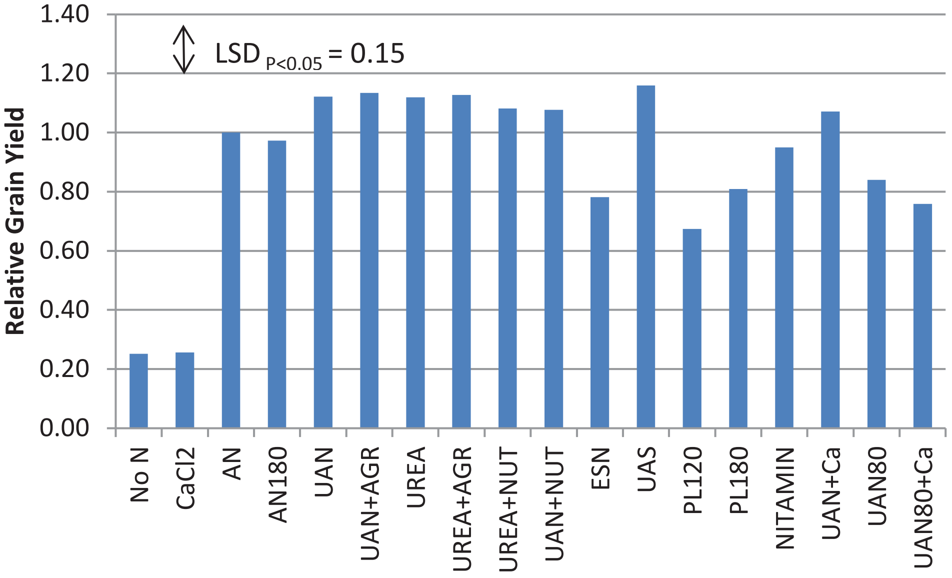
Objectives: The objectives of this study were to compare some of the alternative N fertilizer sources for non-irrigated cotton and corn in Central Alabama and estimate potential ammonia volatilization losses from these products under Alabama conditions. Similar research took place in Arkansas and was reported by Griggs et al. (2007), Slaton et al. (2011), and Franzen et al. (2011).

Results

When mean relative yields (relative to ammonium nitrate treatment) are presented for all the products, there were no differences when N was applied at the recommended rate of 120 pounds total N per acre for corn and 90 pounds N per acre for cotton (Figures AL1 and AL2). The most notable exception was poultry broiler litter for corn. Poultry broiler litter applied to corn as a side dressing at either 120 or 160 pounds total N per acre was not adequate for optimum grain yields compared to the other treatments (Figure AL1). Most producers apply poultry litter at planting, which gives the total N time to mineralize before peak N uptake. On the other hand, poultry litter applied to cotton at either 90 or 120 pounds total N per acre was adequate for optimum yields. Alternative N sources and N stabilizer products—including Agrotain®, Nutrisphere ®, and Nitamin®—did not increase yields or N concentration in leaves (Table AL1) compared to more conventional sources such as urea, ammonium nitrate, or UAN solution.

Ammonia volatilization losses: We attempted to measure ammonia losses in the field using static chambers installed immediately after the fertilizer materials were applied. Ammonia was measured for 60 minutes at the same time each day and estimated ammonia volatilization losses were calculated. There were statistical differences in the estimated ammonia loss each year (2007, 2008, and 2009). Patterns of ammonia loss varied with year as would be expected due to temperature, rainfall, and field conditions. Data shown are only for 2007 when comparisons were made between losses from bare soil and a heavy rye reside (Figure AL3).

Figure AL1. Mean relative corn grain yields (2008-2011) from different products when applied as a sidedress at the recommended rate of 120 pounds total N per acre. Some products were applied at a higher or lower rate as indicated.
AN=ammonium nitrate
UAN=urea-ammonium nitrate liquid
UAS=urea-ammonium sulfate blend
PL=poultry broiler litter
AGR=Agrotain®
NUT= Nutrisphere N®
ESN=ESN® nitrogen
Ca=calcium chloride



Because of the devastating drought in 2007, no sidedress N was applied to the crops and the ammonia measurements were made in August in a separate study using a bare soil and a heavy rye residue (Figure AL3). Soils were very dry when the test was initiated and daytime high temperatures were near or above 100 Fahrenheit each day during the study—conditions favorable for ammonia loss. Initial losses on the bare soil were highest with UAN solutions regardless of supplemental additives. Urea losses were also high on the high residue cover. Agrotain® appeared to reduce initial losses from both the UAN and urea only where there was a high residue cover. This may be explained by increased urease activity associated with the residue. A dramatic increase in ammonia loss on day 8 occurred from urea on the bare soil and from the UAN solution on the high residue cover. This was probably due to a 9.4 millimeters (0.37 inch) rain on August 18, which was the only significant rainfall on the site until near the end of the volatilization study in 2007.

Conclusions

Controlled release N and N stabilizer products did not show any yield advantage compared to more conventional N sources such as urea, ammonium nitrate, UAN solution, or the urea-ammonium sulfate blend, which is being sold as a substitute for ammonium nitrate. Agrotain® did not reduce ammonia losses in general but did reduce losses when both urea and UAN solutions were applied to a high residue cover. Poultry litter results in very high ammonia losses when applied as a sidedress to both cotton and corn. For the relatively low, non-irrigated yields represented by this study, the newer, controlled-release N products failed to produce a consistent yield advantage over traditional N materials such as urea, UAN solutions, or a urea-ammonium sulfate blend.

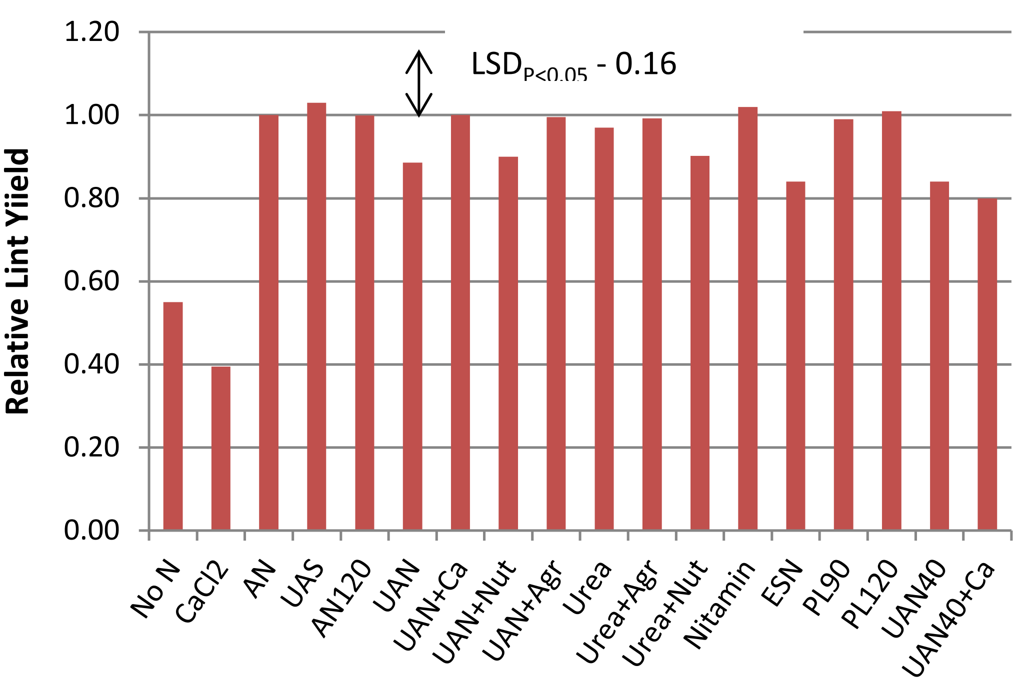


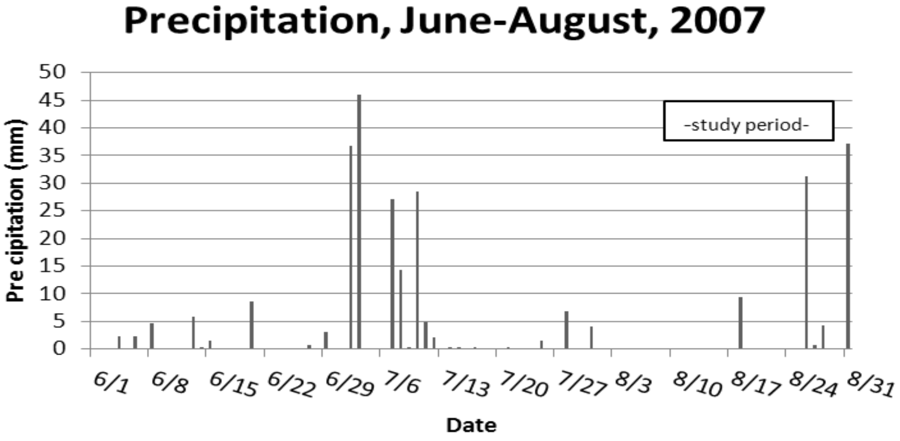
Figure AL2. Mean relative cotton lint yields (2008-2011) from different products when applied as a sidedress at the recommended rate of 90 pounds total N per acre. Some products were applied at a higher or lower rate as indicated.
AN=ammonium nitrate
UAN=urea-ammonium nitrate liquid
UAS=urea-ammonium sulfate blend
PL=poultry broiler litter
AGR=Agrotain®
NUT= Nutrisphere N®
ESN=ESN® nitrogen
Ca=calcium chloride

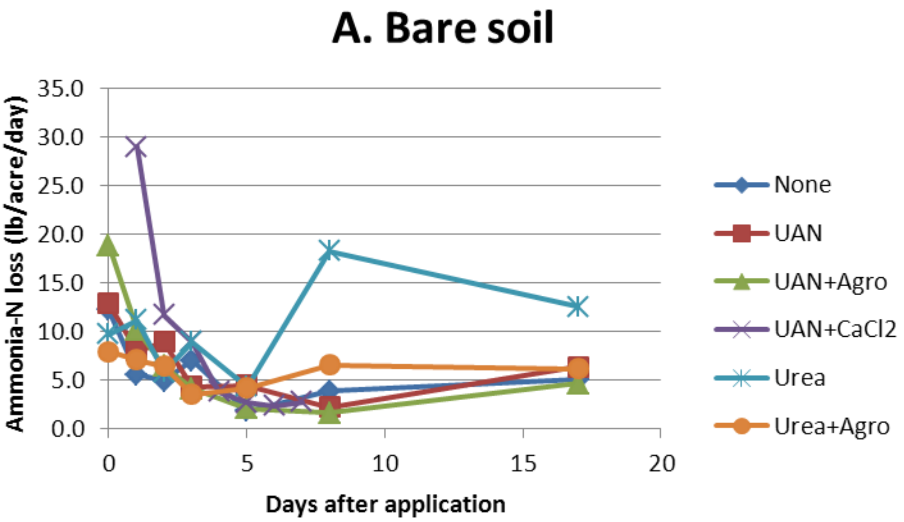
Table AL1. Total N in corn ear leaves at silking and cotton leaf blades at early bloom, 2010

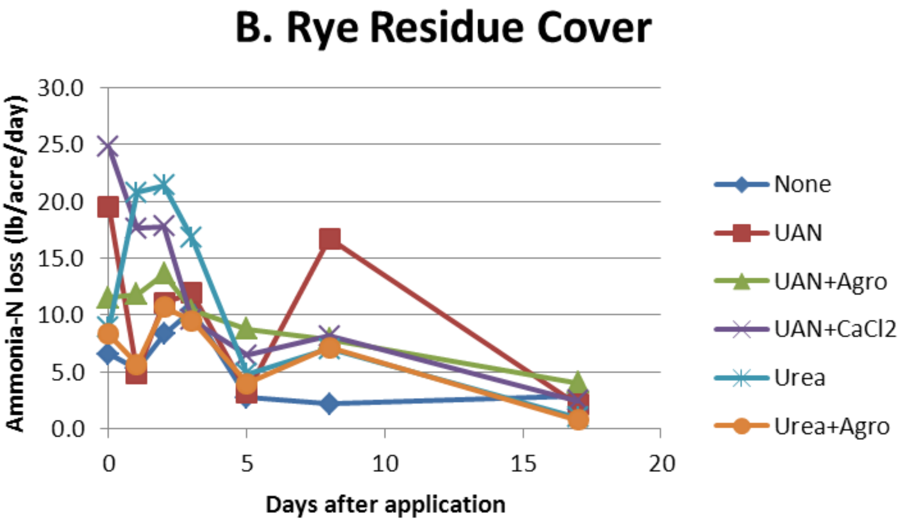
No	Source	Corn ear leaves %	Cotton leaf blades %	No	Source	Corn ear leaves %	Cotton leaf blades %
1	None	3.20 d	1.36 c	8	Urea + Nutrisphere N®	3.91 abc	2.18 a
2	Am. Nitrate	4.25 a	2.09 ab	9	UAN + Nutrisphere N®	4.19 a	2.23 a
3	Am. nitrate at 4/3 rate	4.24 a	2.13 a	10	Nitamin Nfusion 22-0-0®	3.83 bc	1.90 b
4	UAN solution†	3.96 abc	2.10 ab	11	Urea-am. sulfate blend	3.97 abc	2.08 ab
5	UAN + Agrotain®	4.04 ab	2.17 a	12	Poul. litter at 120/90# N/a	3.33 d	1.54 c
6	Urea	4.19 a	2.06 ab	13	Poul. litter at 160/120# N/a	3.65 c	1.56 c
7	Urea + Agrotain®	4.06 ab	2.03 ab	Published sufficiency range		2.80-3.20	3.50-4.50

† 28-0-0-5S

Figure AL3. Ammonia volatilization in 2007 from several N sources after application on August 10 to (a) bare soil and (b) rye residue cover.

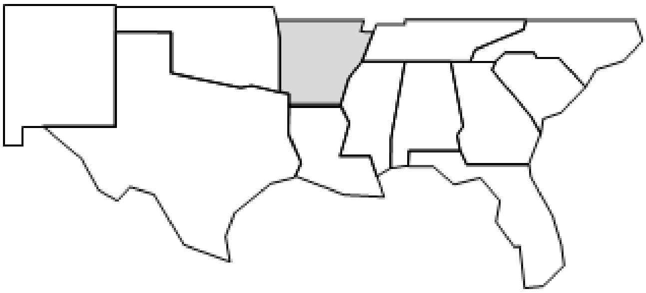






Arkansas

Morteza Mozaffari



Years in study: 2010

Soils and locations: Cotton and corn on a Loring silt loam (fine silty, mixed, thermic Typic Fragiudalfs), Cotton on a Dundee loam (fine silty, mixed, thermic Aeric Ochraqualfs)

Crops: Conventional tilled, non-irrigated corn, cotton

Products evaluated: Preplant incorporated urea and ESN®

N rates: Five N rates plus no-N control

Data collected: Yield, leaf N

Results

Corn ear leaf N concentration and grain yield were both affected by the main effects of N rate (P≤ 0.001) and N source (P≤0.05) but not by their interaction (Table AR1). Corn that received no N had an average ear leaf N concentration of 1.13 percent and yielded 13 bushels per acre, both of which were substantially lower than the lowest values of corn receiving N. Averaged across N rates, corn receiving ESN® had higher N concentration (2.20 percent) than corn fertilized with urea (2.11 percent N) LSD 0.10 =0.09). Ear leaf N concentration, averaged across N sources, increased with each increase in N rate, except between 180 and 240 pound N per acre, which had similar N concentrations. Corn yield response to N rate was similar to that of ear leaf N concentration. Grain yield averaged across N rates of the ESN®-treated corn was 116 bushels per acre, and yield of the urea-treated corn was 104 bushels per acre (LSD 0.10 = 7).

Seed cotton yield at the Lon Mann Cotton Research Station was affected only by N source (P=0.0466). Yield means for each N source and rate combination are listed in Table AR2. Averaged across N rates, the LSMEAN for ESN®- and urea-treated cotton were 2041 and 1885 pounds per acre, respectively, but both yielded greater than cotton receiving no N (1264 pounds per acre).

At Judd Hill, seed cotton yields were not affected by N source, N rate, or their interaction (Table AR2). The data for the 0 N plot were not included in the above analysis. Application of 30 pounds N per acre, the lowest N rate, maximized cotton yield, producing an increase of 675 pounds of seed cotton per acre compared to the no N control. The mean seed cotton yields produced with ESN® and urea, averaged across N rates (P-value for N source = 0.6758), differed by only 26 pounds per acre. The results suggest that ESN® provided equal N availability for cotton at Judd Hill or slightly better N availability than urea for cotton and corn at Lon Mann Cotton Research Station.

Table AR1. Corn ear leaf N concentration at silking and grain yield as affected by the non-significant (NS, P>0.10) N rate × N source interaction and significant N rate, averaged across N sources †

N rate	Ear leaf N			Grain yield		
	Urea	ESN®‡	Source mean	Urea	ESN®	Source mean
lb N/acre	% N			bu/A		
0	1.13 ††		1.13	13 ††		13
60	1.34	1.46	1.39	28	36	32
120	1.98	1.85	1.92	86	86	86
180	2.33	2.44	2.39	131	152	143
240	2.38	2.45	2.41	129	141	134
300	2.50	2.68	2.59	154	147	150
LSD $_{0.10}$	NS‡‡		0.15	NS‡‡		12
p-value	0.4226		<0.0001	0.4500		<0.0001

† Trial located at the Lon Mann Cotton Research Station.
‡ ESN®, Environmentally Smart N, polymer coated urea.
†† data for the 0 N plots were not used in the statistical analysis and are presented as a reference only.

Analysis of soil samples collected after corn and cotton harvest at LMCRS did not indicate any effect of N source or N rate or their interaction on soil NO_3-N.

Conclusions

In corn and cotton fields, early season soil moisture conditions, which directly influence N losses that occur following fertilizer application, are known to vary among years due to annual fluctuations in rainfall and temperature. The 2010 summer was drier than normal, making fertilizer N losses from denitrification less likely than in wet years. Corn yields, averaged across all N rates, were numerically greater by 10 percent when ESN® was applied pre-plant compared to urea applied pre-plant. Yields of cotton treated with urea and ESN® were not significantly different at one site, but were significantly different at another site. These results indicate that ESN® is a suitable, alternative N fertilizer (to urea) for both crops. Use of ESN® as the pre-plant N source does not necessarily guarantee greater corn and cotton yields than urea under all conditions but likely helps reduce the risk of losing greater amounts of N in wet years. Thus, ESN® should be considered a tool that can enhance N management and crop uptake. Additional research, encompassing several years and various field and weather conditions common to Arkansas, is needed to determine the frequency and magnitude of yield increases and whether other crop management benefits may be realized when ESN® is used in place of urea for pre-plant N applications.

Table AR2. Seed cotton yield as affected by the non-significant (NS, P>0.10) N rate and source interaction and N rate, averaged across N sources

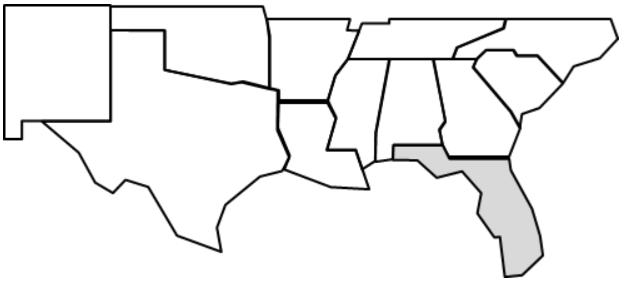
N rate	——Judd Hill Research Farm——			—Lon Mann Cotton Research Station—		
	Urea	ESN®†	Source mean	Urea	ESN®	Source mean
lb N/acre	——————lb/A——————			——————lb/A——————		
0	——— 1795‡ ———		1795	——— 1264 ‡ ———		1264
30	2501	2438	2470	1804	1968	1895
60	2319	2548	2434	1807	2006	1893
90	2542	2510	2528	2036	2046	2041
120	2277	2387	2338	1929	2212	2071
150	2468	2388	2423	2055	2081	2067
LSD $_{0.10}$	——— NS———		NS	——— NS———		NS
p-value	——— 0.4669 ———		0.4958	——— 0.6005 ———		0.4609

† ESN®, Environmentally Smart N, polymer coated urea.

‡ The seed cotton yield data for the 0 N plots were not used in the statistical analysis and are presented as a reference only.

Florida

Rao Mylavarapu



Years/Seasons of study: Spring of 2009 and 2011

Soil type: Lakeland sand and Gainesville loamy sand (Thermic/Hyperthermic, coated Typic Quartzipsamments)

Crops: Tomatoes and green bell pepper, irrigated, under plastic mulch.

Products evaluated and N rates: Three products manufactured by Prathista Intgernational, India, were evaluated: (1) liquid and granular formulations of New Suryamin®, (2) Megacal®, and (3) BioPotash®.

The various treatment combinations for these studies included the use of products both as nitrogen and other nutrient supplements as well as substitutes to the standard recommended nutrients doses for these crops. The University of Florida-recommended N rates are 200 pounds N per acre each for both tomatoes and green bell peppers. In 2009, 70 pounds N were soil applied through ammonium nitrate at planting and the remaining N amounts were supplied through fertigation using 7-0-7 once a week until harvest. In 2011, 70 pounds per acre of the total recommended N was applied as one of the treatments through 10-10-10, except for absolute control plots where no fertilizer was applied. For all other treatments, granular and foliar spray products were applied in multiple combinations every two weeks starting about two weeks after planting. A 100 percent product spray as per label recommendation was 4 milliliters New New Suryamin® in 1.0 liter of water and a 100 percent granular product as per label recommendation was 55 pounds New New Suryamin® per A.

Data collected: Crop yields, total N in the tissue, and total nitrogen in the soil along with several other nutrients

Results (2009)

Green bell pepper: Leaf tissue concentrations at harvest are given in Table FL1. The mean total N concentrations were similar in all treatments and ranged from 4.04 percent in control to 4.18 percent in treatment that received highest concentrations of New New Suryamin® and Megacal® foliar sprays. Leaf tissue concentrations were optimized for plant production as per the standard requirements. Similarly, the mean P, K, Ca, and Mg leaf tissue concentrations were optimum for economic yield production. While all micronutrient concentrations were optimum in the leaf tissue in all treatments, Zn concentrations were found to be significantly highest in plants that received any combination of nutrient sprays compared to plots that did not receive any foliar treatments, which had the lowest Zn leaf tissue concentrations. Total and marketable yields were highest when the green bell pepper plants were foliar sprayed with 3 milliliters of Megacal®, 5 milliliters of New Suryamin®, and 5 milliliters each of Megacal® and New Suryamin® per liter of water (Table FL2). However, control plots also produced similar yields. The other two treatments produced lower but similar grades of fruit and total yields.

Tomatoes: The nutrient concentrations in the tomato leaf tissue for all treatments are given in Table FL3. The data indicate that the uptake efficiency of tomato plants was high, resulting in optimized tissue levels of all nutrients in all treatments and indicating that soil-applied nutrients were adequate for plant growth requirements. No differences were observed among the treatments.

The yield data for tomatoes in Table FL4 complement the tissue nutrient concentrations, where no significant differences in graded or total yields were recorded. As all the standard nutrient applications were made to the soil and also since a high dose of supplemental N was applied through fertigation further increasing the N uptake efficiency, any effect of foliar spray was probably minimized resulting in similar tissue nutrient concentrations and yields.

Results (2011)

Green bell peppers: The nutrient analysis in green bell pepper tissue sample showed that application of 100 percent Standard Recommended Practices for Florida (SRP) and product spray resulted in relatively higher nitrogen concentration in all samplings, closely followed by 75 percent SRP+25 percent product spray and 100 percent SRP (Figure FL1). With regards to P, a higher concentration was observed in 100 percent SRP and product spray and was followed closely by the soil application of product granules and spray but these higher concentrations in this treatment were not reflected in higher yields. The potassium concentrations were higher in 100 percent SRP and product spray and were followed by 100 percent SRP.

In bell peppers, applications of 100 percent SRP along with or without product spray resulted in similar yields (Table FL5). However, yields were significantly higher in 100 percent SRP treatment compared to 50 percent SRP + 50 percent product spray but were similar to 75 percent SRP + 25 percent product spray. This showed that 25 percent savings on fertilizer could be realized, if the product was sprayed on pepper plants at 1 milliliter L^{-1}. Also, the treatment with

50 percent product granules and 50 percent product spray produced significantly higher yields than 100 percent SRP, showing that both granular and foliar spray were effective in increasing the yields significantly.

Tomatoes: The tomato tissue data showed that the N concentrations (percent) across the sampling stages gradually decreased as the crop growth progressed, indicating the normal growth and nutrient requirement pattern (Figure FL2). The statistical analyses of tissue nutrient concentration data did not show any consistent trend, and the data were not varied across the treatments in spite of random significant differences.

Tomatoes were harvested in two pickings, graded according to the USDA sizes, and weighed (Table FL6). Application of product spray alone increased yields significantly over absolute control. Yields with 50 percent product spray in combination with 50 percent SRP were similar to yields with 100 percent product spray alone. This indicated that addition of 50 percent SRP was not adequate to compensate for 50 percent reduction in product spray. Obviously, application of foliar product spray in smaller installments over the crop growth period was significantly more effective in supplying N and K requirements of tomato plants and, therefore, resulted in similar yields. Application of 100 percent fertilizers as per the SRP produced significantly higher yields than 50 percent SRP + 50 percent product spray. Highest yields were found in treatments where 100 percent product sprays were applied along with 100 percent SRP and where 75 percent of the SRP was applied along with 25 percent of the product spray. Yields obtained with 100 percent SRP (Treatment 3) were similar to yields in plants that received 75 percent SRP and 25 percent product spray (Treatment 5), which suggested a savings of 25 percent SRP could be realized when using product spray without reducing the yields.

Conclusions

The products did not show any effective yield or quality advantages in 2009 as nutrient requirements of both green bell peppers and tomatoes were more than adequately met through both pre-plant soil application and supplemental N fertigation. However, in 2011 as the treatment combinations were changed appropriately to document the effects, yields and performance in both crops were significantly lower in absolute control and with product sprays alone indicating the need for regular fertilizer applications. In tomatoes, application of the product spray resulted in significant yield increases both over absolute control and the standard recommendations, indicating that under intensive nutrient management practices foliar spray may help tide over nutrient stresses, particularly with regard to highly leachable and mobile nutrients such as N and K. A 25 percent savings in fertilizers was realized without yield reductions, when fertilizer was applied as per standard recommendations in combination with the product spray. In green bell peppers, a 25 percent savings in fertilizers was possibly derived by the 75 percent SRP and 25 percent product spray combinations. Also, the granular and foliar spray combination at 50 percent dosages produced significantly higher yields, suggesting that if the dosages of the product combinations of soil and foliar applications were increased to 100 percent, the potential is to increase yields or to achieve the highest yields. Foliar applications of N and K products at 100 percent labeled dosages could possibly sustain the supply to meet all the crop nutrient requirements.

Table FL1. Tissue nutrient concentrations in green bell pepper at harvest

Treatments	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	percent					mg kg-1				
3cc/L ea. Megacal + Suryamin	4.07	0.26	3.57	1.31	0.38	81.6	262.2	93.33 ab	155.88	29.03
5cc/L Megacal + 3cc/L Suryamin	4.06	0.27	3.71	1.5	0.42	74.85	288.51	102.86 a	173.75	28.88
3cc/L Megacal + 5cc/L Suryamin	4.08	0.27	3.63	1.36	0.38	78.61	253.99	93.40 ab	155.67	29.24
5cc/L ea. Suryamin + Megacal	4.18	0.26	3.7	1.38	0.4	82.95	258.88	95.62 ab	160.82	29.34
Control (Water)	4.04	0.26	3.67	1.39	0.4	76.92	269.7	85.47 b	172.74	28.95

Table FL2. Total and graded yields of green bell pepper

Treatments	Total wt	Market wt	Fancy wt	No.1 wt	No.2 wt	Cull wt
	kg/ha					
3cc/L ea. Megacal + Suryamin	7632.9 b	4946.7	2317.3	1816.0	813.4	2686.27
5cc/L Megacal + 3cc/L Suryamin	7968.8 b	5012.9	2572.7	1541.7	898.5	2955.9
3cc/L Megacal + 5cc/L Suryamin	9406.5 a	6658.7	3627.5	2038.5	993.1	2747.8
5cc/L ea. Suryamin + Megacal	8016.1 ab	5831.0	2955.9	1925.0	950.6	2184.9
Control (Water)	9368.6 ab	6715.0	3164.0	2274.9	1276.9	2653.5

Table FL3. Tissue Nutrient Concentrations in Tomatoes at Harvest

Treatments	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	percent					mg kg-1				
3cc/L ea. Megacal + Suryamin	3.86	0.31	1.98	1.8	0.38	94.29	272	45.92	178.59	26.12
5cc/L Megacal + 3cc/L Suryamin	3.89	0.31	1.94	1.82	0.39	87.55	264.28	45.36	162.48	25.26
3cc/L Megacal + 5cc/L Suryamin	4.01	0.33	2.03	1.79	0.39	84.39	277.22	46.3	181.92	25.89
5cc/L ea. Suryamin + Megacal	3.98	0.31	2.02	1.85	0.41	72.35	273.24	46.42	169.08	25.82
Control (Water)	3.83	0.31	1.99	1.89	0.4	101.2	290.38	43.31	184.4	25.8

Table FL4. Total and graded yields of tomato

Treatments	Total wt	Market wt	Fancy wt	No.1 wt	No.2 wt	Cull wt
	kg/ha					
3cc/L ea. Megacal + Suryamin	9579	7869	2263	2665	2941	1710
5cc/L Megacal + 3cc/L Suryamin	9160	7437	1833	2849	2755	1724
3cc/L Megacal + 5cc/L Suryamin	8635	7396	2324	2752	2320	1239
5cc/L ea. Suryamin + Megacal	8896	7080	2083	2365	2632	1816
Control (Water)	8936	7382	2372	2514	2497	1554

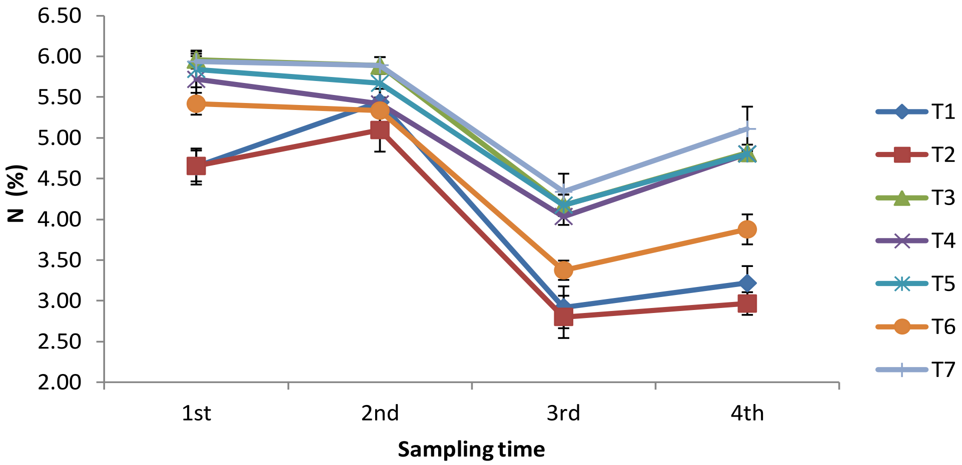


Figure FL1. Nitrogen concentration (percent) in green bell pepper plant tissue samples. The bars indicate the standard errors. T1-T7 refers to treatment numbers in Table FL5.

Table FL5. Green bell pepper yield as influenced by various treatments

No	Treatment	Yield (tons/A)
1	Absolute Control	8.64
2	Absolute Control + One spray of product at 2 week interval	9.95
3	100 percent SRP*	16.13
4	50 percent SRP* + 50 percent product spray	14.49
5	75 percent SRP* + 25 percent product spray	14.98
6	50 percent product granules as basal (25 kg/A New Suryamin®) + 50 percent product spray	14.55
7	100 percent SRP* + product spray	16.79
	ANOVA	
	Treatments	***
	CD at (p=0.05)	1.63

*SRP= Standard Recommended Practices for Florida

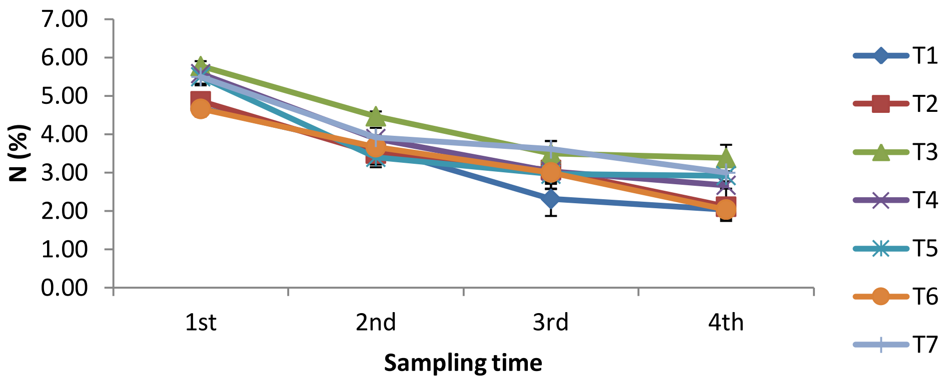


Figure FL2. Nitrogen concentration (percent) in tomato plant tissue samples. The bars indicate the standard errors. T1-T7 refers to treatment numbers in Table FL6.

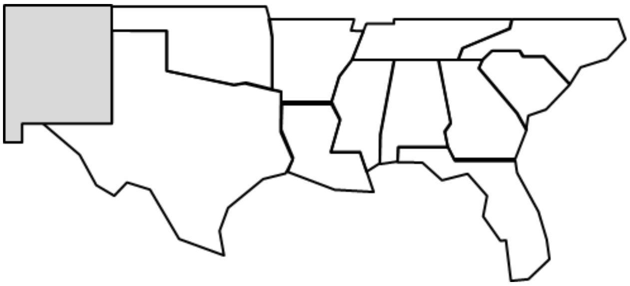
Table FL6. Tomato yield as influenced by various treatments

No	Treatment	Yield (tons/A)
1	Absolute Control	12.7
2	Absolute Control + One spray of product at 2 week interval	17.4
3	100 percent SRP*	22.2
4	50 percent SRP* + 50 percent product spray	19.4
5	75 percent SRP* + 25 percent product spray	24.0
6	50 percent product granules as basal (25 kg/A New Suryamin®) + 50 percent product spray	16.7
7	100 percent SRP* + product spray	24.7
	ANOVA	
	Treatments	***
	CD at (p=0.05)	2.3

*SRP= Standard Recommended Practices for Florida

New Mexico

Robert Flynn



Years in study: 2010

Soils/locations: Reeves loam (fine-loamy, gypsic, thermic Typic Gypsiorthids) and Reakor loam fine-silty, mixed, thermic Typic Calciorthids) in Artesia, New Mexico

Crops: Corn, irrigated cotton

Products evaluated: Urea, UAN, Agrotain®, dairy manure

Data collected: Yield, crude protein, pounds of milk/acre

Methods

Two replicated field trials were conducted at the New Mexico State University Agricultural Science Center at Artesia. Each trial was a randomized complete block with four replications. All cotton plots were furrow irrigated and all corn plots were flood irrigated between two irrigation borders. Corn received 47.5 centimeters of irrigation water and 18.85 centimeters of rain during the growing season (April through August). Cotton received 54 centimeters of irrigation water and 23.48 centimeters of rain from April through September.

Corn was seeded at 48,000 seeds per acre. Cotton was seeded at 54,000 seeds per acre. Nitrogen rates were calculated using NMSU Soil Test Interpretation Workbook. Nitrogen rate for corn silage was 200 pounds N per acre for a 30-ton-per-acre yield goal at 35 percent dry matter. Nitrogen was applied at 147 pounds N per acre for a four-bale-per-acre yield goal. All cotton plots received 26 pounds P_2O_5 per acre and all corn plots received 52 pounds P_2O_5 per acre from 10-34-0.

The following treatments were incorporated into the plots. (Other slow release fertilizers were requested from local fertilizer dealers but none were available at the time of application.) Manure was applied to supply the needed nitrogen based on a 35 percent mineralization rate (previous studies) (Manure A) or 60 percent mineralization (based on C:N ratio of 7) (Manure B). Urea was applied all at once at V4 stage of growth for corn (Urea A) or half at V4 and the other half at V8 (Urea B). Treatments are described in Table NM1.

Corn was harvested for silage with a Hege plot harvester equipped with an automated weighing basket to determine fresh weight at harvest. Subsamples of each plot were dried to determine dry matter percentage. Samples were submitted to the University of Wisconsin for forage quality components using Milk2000.

Cotton plots were harvested by hand from two 1-meter lengths within in each plot. Boll samples were collected from 25 plants and ginned to determine lint and seed yield.

Results/Conclusions

There was no effect of nitrogen source or timing on fresh weight of corn (Table NM2). Dry matter yield was similar to applying 11-52-0 only, suggesting that nitrogen was not sufficiently mineralized from the manure application in time to contribute to yield. Crude protein content was lower in the corn plant from both manure application rates as compared to UAN and urea treatments. Estimated milk production on a per acre basis tended to be greatest from corn treated with one application of UAN, urea, or urea treated with Agrotain over two applications (greatest numerical yield). Applying manure at an application rate that estimates 35 percent mineralization may have contributed excessive salt to the soil and decreased plant dry matter accumulation. Fertilization of cotton had no impact on cotton yield. The N sources used had no impact on cotton yield or fiber quality (Table NM3).

Table NM1. Treatments used on each crop

N Treatment	Rate applied to corn	Rate applied to cotton
Zero	17 lb N/A from 10-34-0	7.5 lb N/A from 10-34-0
Manure A (dry wt basis)	17.7 T/A	14.8 T/A
Manure B (dry wt basis)	10.4 T/A	8.7 T/A
UAN	625 lb/A	379 lb/A
Urea A	414 lb/A	274 lb/A
Urea B	414 lb/A in two applications	274 lb/A in two applications
Urea A' with Agrotain†	414 lb/A treated	274 lb/A treated
Urea B' with Agrotain†	414 lb/A treated in two applications	274 lb/A treated in two applications

†4.0 qt / ton equivalent

Table NM2. New Mexico corn trial results, 2010

Treatment	Yield, wet	Yield, dry	CP	Milk/A	CP, no ear
	———tons/A———		DM, %	lb/A	DM,%
Zero	23.4	7.5 bc	7.61 b	22141 cd	6.53 b
Manure A	20.0	6.4 c	7.14 b	19632 d	6.39 b
Manure B	25.7	8.2 ab	7.52 b	24636 bc	6.56 b
UAN	25.5	8.3 ab	8.44 a	26132 ab	7.90 a
Urea A	24.9	8.1 ab	8.42 a	25445 abc	8.42 a
Urea B	25.9	8.1 ab	8.79 a	24312 bc	7.77 a
Urea A’	24.7	7.8 ab	8.37 a	23931 bc	8.17 a
Urea B’	26.5	8.6 a	8.45 a	28223 a	8.09 a
LSD $_{0.05}$	NS	1.05	0.74 a	3522	0.97
Pr>F	0.0903	0.0094	0.0026	0.0054	0.0012

Table NM3. New Mexico cotton trial results, 2010

Treatment	Yield, seed cotton	Yield, lint
	————lb/A————	
Zero	4383	1838
Manure A	4234	1809
Manure B	3813	1609
UAN	4327	1835
Urea A	3782	1577
Urea B	4530	1912
Urea A’	3938	1688
Urea B’	4027	1719
LSD $_{0.05}$	NS	NS
Pr>F	0.329	0.329

North Carolina

Deanna Osmond

Years in study: 2008, 2009

Soils: *Corn* – Coastal Plain, Pocalla sand (loamy, siliceous, subactive, thermic Arenic Plinthic Paleudults); Piedmont, Cecil sandy clay loam (fine, kaolinitic, thermic Typic Kanhapludults); Mountains, Dillard loam (fine-loamy, mixed, semiactive, mesic Aquic Hapludults) and Statler loam (fine-loamy, mixed, active, mesic Humic Hapludults) *Wheat* – Coastal Plain, Stallings loamy sand (Coarse-loamy, siliceous, semiactive, thermic Aeric Paleaquults); Tidewater, Portsmouth fine sandy loam (Fine-loamy over sandy or sandy-skeletal, mixed, semiactive, thermic Typic Umbraquults)

Crops: Wheat, corn

Products evaluated: UAN solution, Nitamin® (UFP), ESN®, Nutrisphere® at multiple rates

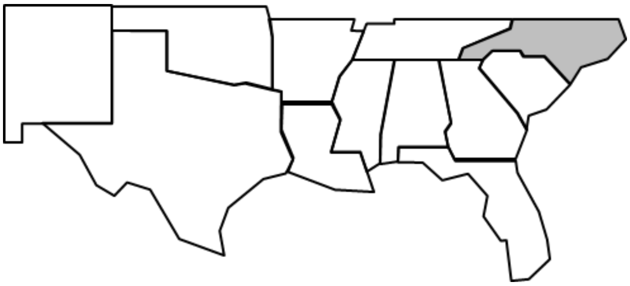
Data collected: Yield and stover

Objectives: The objectives of this study were to compare corn and wheat yield response, N tissue concentrations, N uptake, and NUE, and N release rates into the soil for various slow release N fertilizers at various rates. Data from this study were reported in the following publications:

Cahill, S.L., D.L. Osmond, R. Weisz and R. Heiniger. 2010. Evaluation of Nutrient Efficiency and Yield in Corn and Wheat. Agron. J. 102:1226-1236.

Cahill, S.L., D.L. Osmond, and D.W. Israel. 2010. Nitrogen Release from Coated Urea Fertilizers in Different Soils. Communications in Soil Science and Plant Analysis 41:1-12. ISS 10.

Cahill, S.L., D.L. Osmond, C.R. Crozier, R.Weisz, and D.W. Israel. 2007. Winter wheat and maize response to urea ammonium nitrate and a new urea formaldehyde polymer fertilizer Agronomy J. 99:1645-1653.



Conclusions

The wheat data suggest that UAN, NutriSphere®, and UCAN® produced similar grain yields for all four site years (Figures NC1-NC4). The ESN® yields were lower than the other fertilizers for one site year. The use of ESN® for wheat straw production is not recommended as it produced lower yields 75 percent of the site years. The use of any of the alternative N fertilizer products over UAN for wheat grain production would be heavily influenced by fertilizer pricing.

Over the six site years of corn grain yield data, five demonstrated no agronomic advantage of the alternative fertilizer products over UAN for grain production. In the one site year, UAN produced less grain than the alternative fertilizer products; this may have been due to a change in tillage system. In three of the six site years, NutriSphere® and ESN® produced higher corn stover yields than UAN. Two of those years were in the mountains, suggesting that NutriSphere® may offer an agronomic advantage over UAN in the production of corn stover in the mountains under the field conditions in this study.

A separate incubation study (data not shown) demonstrated that UCAN® and NutriSphere® released N on a time scale similar to UAN under the laboratory conditions. The release time for ESN® in the five soils was approximately 7 to 42 days and was slower than UAN, NutriSphere®, or UCAN®.

Overall, the use of these alternative N fertilizers in North Carolina provides little agronomic benefit to corn or wheat grain production. Producers who use the products for stover or straw production should be aware of cost differences between products.

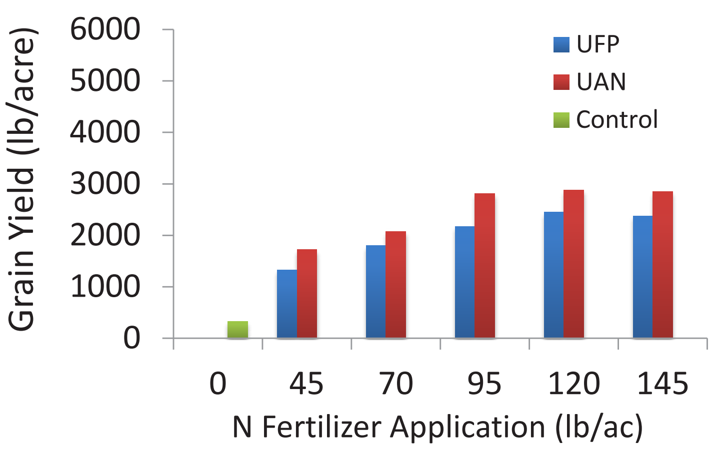


Figure NC1. Wheat yield during a 2-year trial in the Piedmont of North Carolina demonstrated that UAN at the same rate was better than Nitamin® (UFP). Rate differed and the optimum rate was 95 lb N per ac.

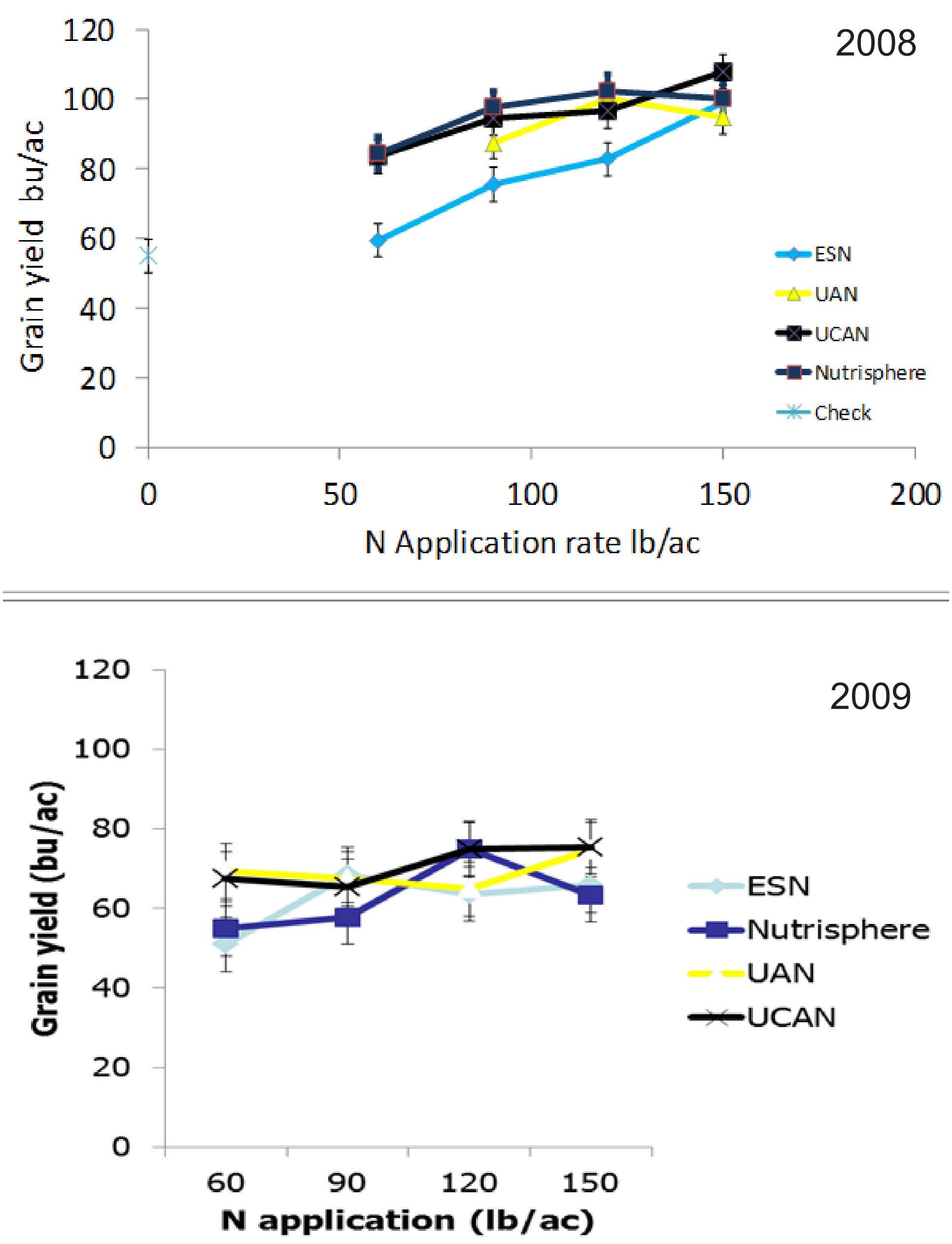


Figure NC2. Wheat yield during a 2-year trial in the Piedmont of North Carolina demonstrated that fertilizer source made no difference, except one year when ESN® yielded less. Optimum nitrogen rate ranged between 95 and 145 pound N per acre, depending on the year.

Figure NC3. Irrigated corn in the Piedmont of North Carolina had an optimum nitrogen rate of 175 pounds N per acre. One year (2005) Nitamin (UFP) performed less well than UAN. In the Tidewater, non-irrigated corn had an optimum N rate also of 175 lb N per acre and there was no difference between UAN and Nitamin (UFP).

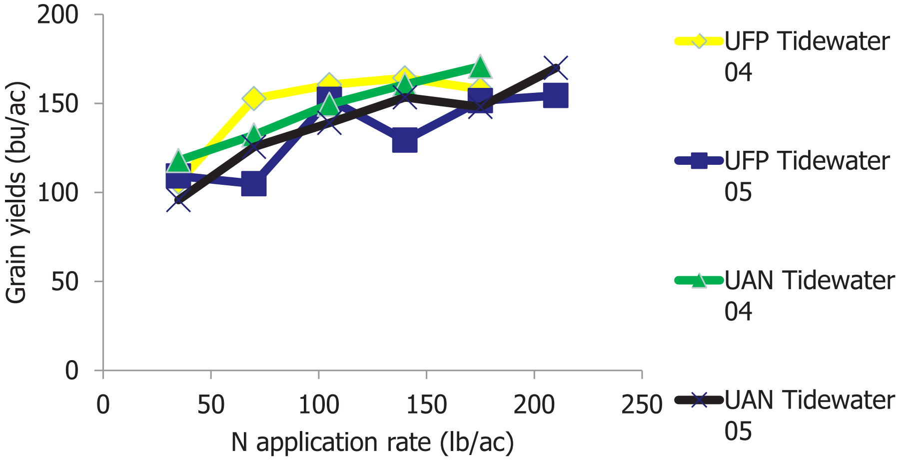
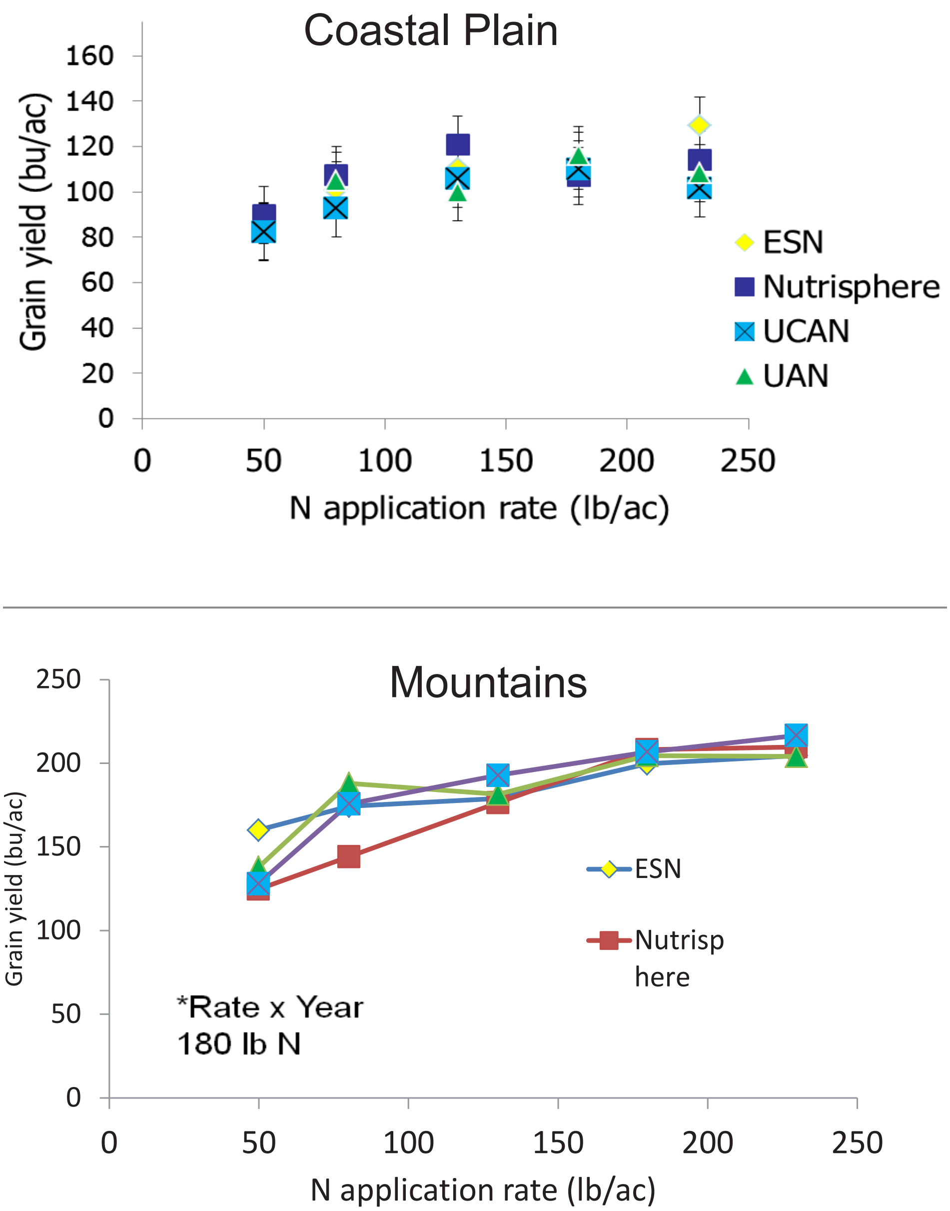
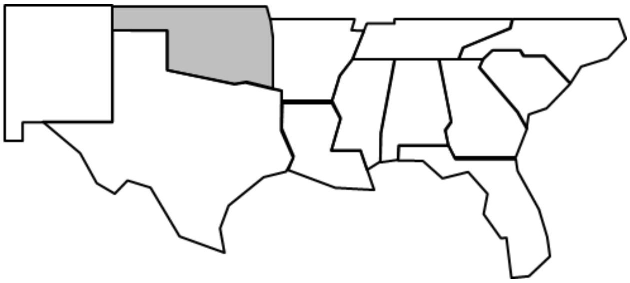


Figure NC4. Irrigated corn in the Mountains had an optimum nitrogen rate of 145 pounds N per acre, and there was no difference between any of the nitrogen sources tested (UAN, ESN®, UAN-Nutrisphere, UCAN). In the Coastal Plain, non-irrigated corn had an optimum N rate of 185 pounds N per acre and there was no difference between fertilizer sources.



Oklahoma

Brian Arnall



Years in study: 2010, 2011

Soils: Pulaski fine sandy loam (Coarse-loamy, mixed, superactive, nonacid, thermic Udic Ustifluvents)

Crops: Winter wheat

Management: Conventional Tillage and No-till

Products evaluated: Urea; Nutrisphere-N®, Agrotain®, ESN® (Table OK1)

Data collected: Yield, protein, residual soil nitrate

Conclusions

Across both location and years there was no significant difference in wheat grain yield, protein, or residual soil nitrate levels when a product or additive was added when compared to urea at the same N rate. Regardless of tillage practice, there was no benefit in terms of yield or nitrogen concentration of using a slow release nitrogen source or a nitrogen stabilizer product (Figures OK1-OK3).

Figure OK1. Winter wheat grain yields recorded at Lake Carl Blackwell research station (near Stillwater, Oklahoma) in 2010 and 2011 in two management systems: conventional tillage and no-till. In all sites years N rate was significant; however, there was no significant difference across sources. Yield was optimized at a rate of 75 pounds and 100 pounds N per acre in the conventional system in 2010 and 2011, respectively, and at 75 N per acre in the no-till system both years. Yields of the 2010-2011 growing season were below normal as the year was one of the driest in recorded state history.

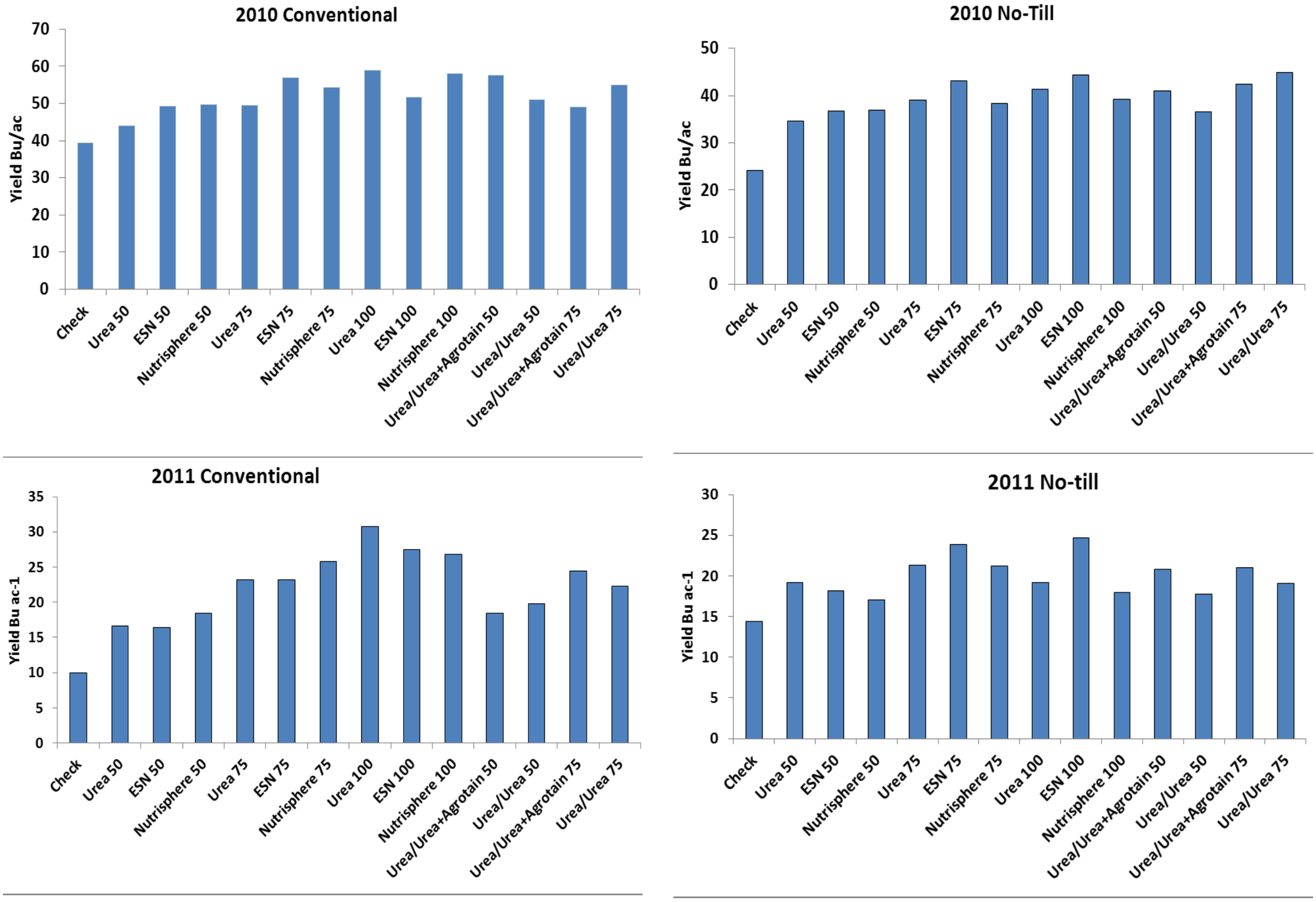
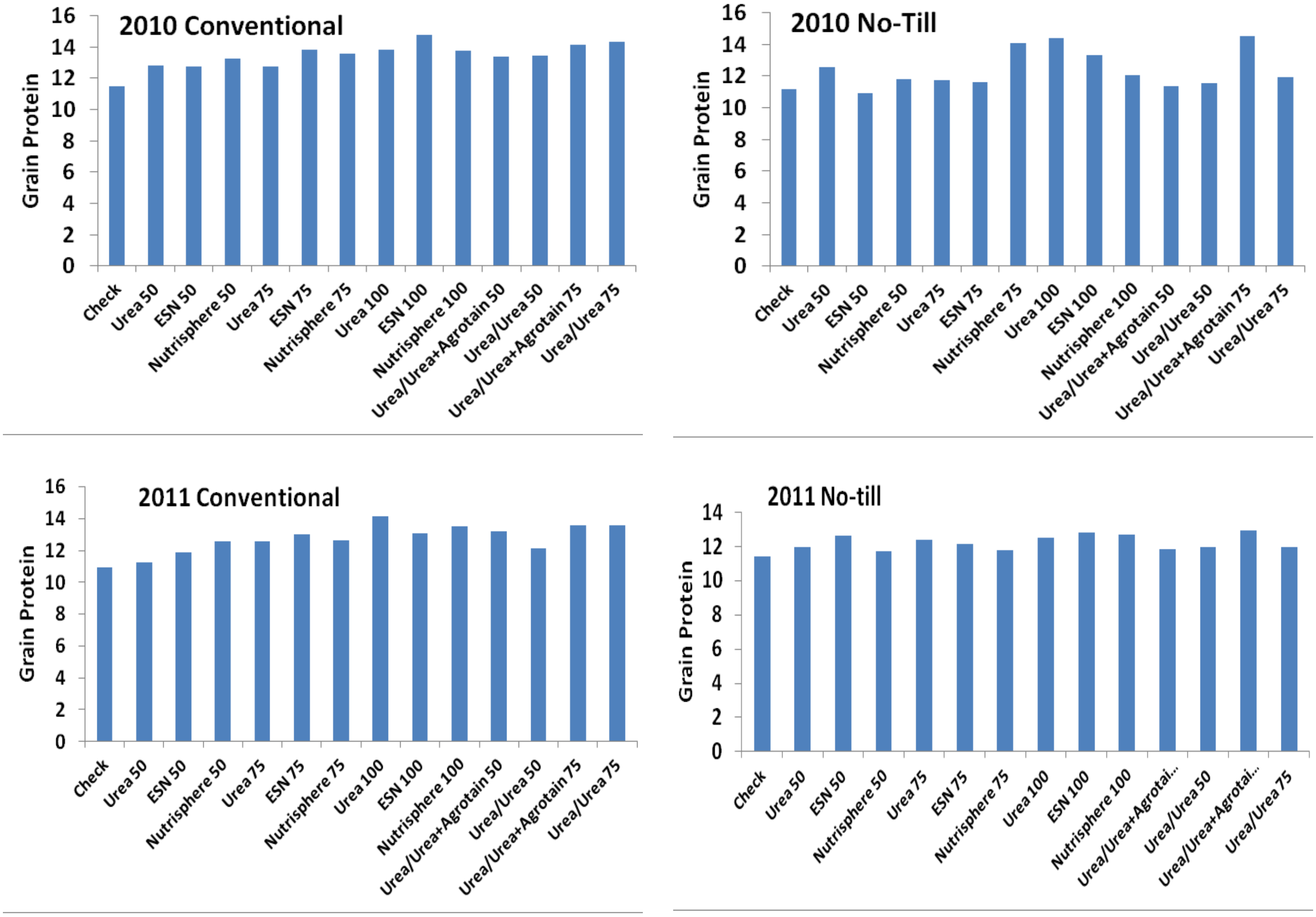


Table OK1. Treatment structure

Preplant source	Preplant N rate lb/A	Top dress source	Top dress N rate lb/A	Preplant source	Preplant N rate lb/A	Top dress source	Top dress N rate lb/A
NA	0	NA	0	Urea	100	NA	0
Urea	50	NA	0	ESN®	100	NA	0
ESN®	50	NA	0	Urea + Nutrisphere	100	NA	0
Urea + Nutrisphere	50	NA	0	Urea	25	Urea + Agrotain	50
Urea	75	NA	0	Urea	25	Urea	50
ESN®	75	NA	0	Urea	25	Urea + Agrotain	75
Urea + Nutrisphere	75	NA	0	Urea	25	Urea	75

Figure OK2. Protein levels in winter wheat grain recorded at Lake Carl Blackwell research station (near Stillwater, Oklahoma) in 2010 and 2011 in two management systems: conventional tillage and no-till. In all site years there was no significance difference in protein level across sources of source at any rate. N rate was significant, however, in the 2011 conventional tillage location.

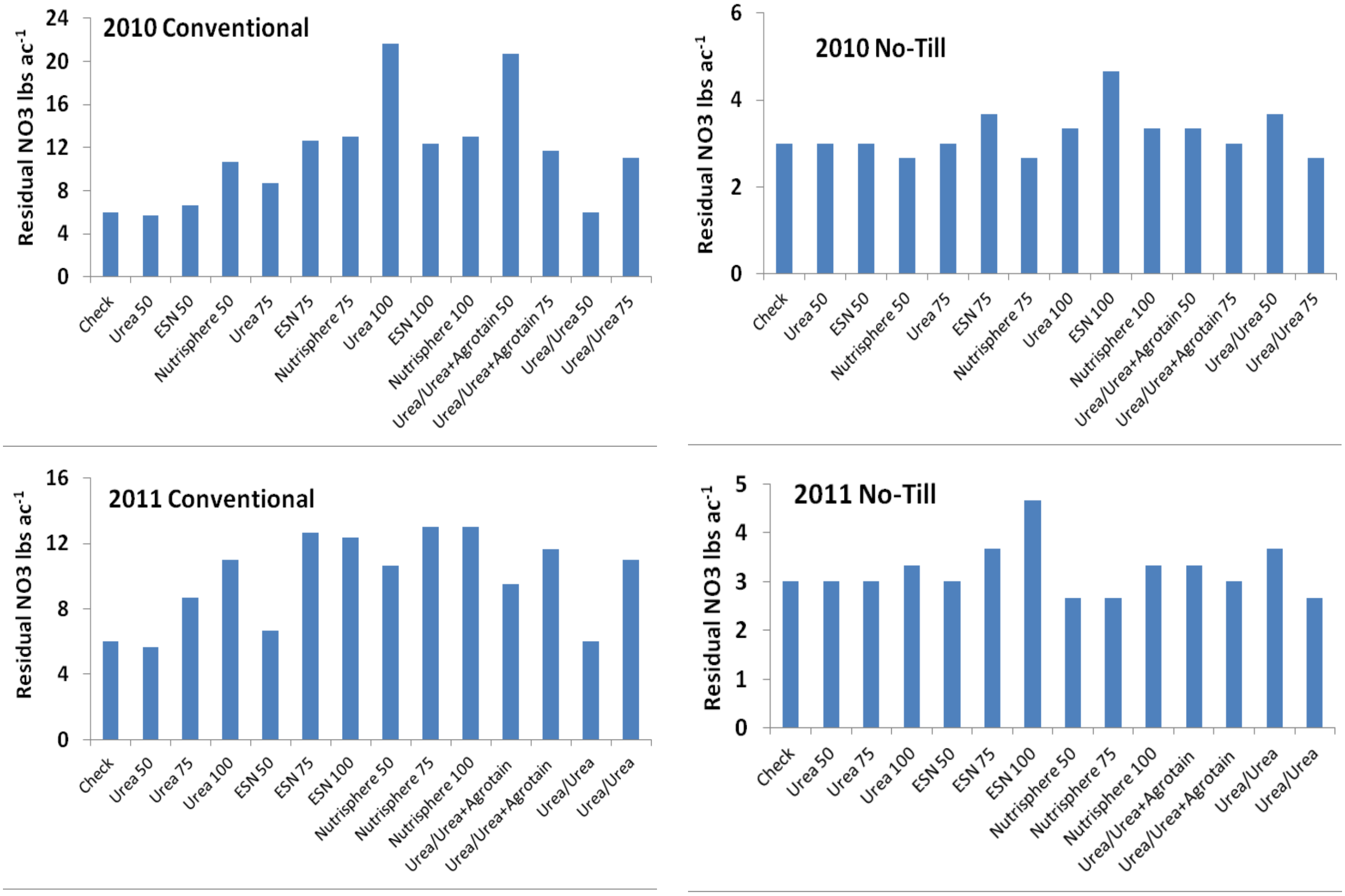

2010 Conventional

2010 No-Till

2011 Conventional

2011 No-till

Figure OK3. Residual soil test nitrate levels (0-6 in) recorded after winter wheat harvest at Lake Carl Blackwell research station (near Stillwater, Oklahoma) in 2010 and 2011 in two management systems: conventional tillage and no-till. In all site years there was no significance difference in residual soil nitrate level across sources at any rate. N rate was significant, however, in the 2010 and 2011 conventional tillage site years.



Texas

Dennis Coker and Mark McFarland

Years in study: 2010

Crops/Soils: *Corn* – Burleson clay (fine, montmorillonitic, thermic Udic Pellusterts)
Cotton – Ships clay loam (very fine, mixed, thermic Udic Chromusterts)
Grain sorghum – Houston Black clay (fine, montmorillonitic, thermic Udic Pellusterts)

Products evaluated: UAN (32-0-0); urea; Nutrisphere-N® – 2 quarts per 100 gallons 32-0-0; Agrotain Ultra® – 1.5 quarts per 180 gallons 32-0-0; N-Sure® (28-0-0) – 50:50 (v:v) blend with 32-0-0 for 30 percent N; NDemand® (30-0-0) – 50:50 (v:v) blend with 32-0-0 for 31 percent N; and CoRoN® (25-0-0) – 50:50 (v:v) blend with 32-0-0 for 28 percent N

Data collected: Yield, cotton fiber quality

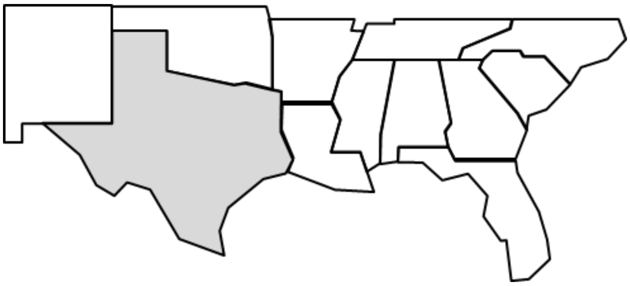
Results/Conclusions

Corn: No differences in grain yield or test weight were observed between the control and treatments receiving UAN, UAN with urease-nitrification inhibitors, or UAN blended with any of the three slow-release N products (Table TX1).

Table TX1. Yield response of corn to subsurface-band applied urease-nitrification inhibitors, or slow-release nitrogen sources blended with UAN

Treatment	N rate lb/A	Grain yield† bu/A	Test weight lb/bu
None	0	73.7	57.1
UAN	50	76.2	57.8
UAN	75	85.5	57.3
UAN	100	77.4	56.7
UAN + Nutrisphere-N®	100	73.1	56.4
UAN + Agrotain Ultra®	100	74.2	56.6
UAN + N-Sure®	100	78.5	57.7
UAN + CoRoN®	100	80.5	56.5
UAN + NDemand®	100	88.2	57.5
UAN	130	85.1	57.5
UAN + Nutrisphere-N®	130	74.3	57.2
UAN + Agrotain Ultra®	130	81.8	57.2
UAN + N-Sure®	130	83.4	57.2
UAN + CoRoN®	130	77.8	56.7
UAN + NDemand®	130	78.7	56.6
LSD $_{0.05}$		NS	NS
Pr>F		0.07	0.08

†Yields corrected to 15.5 percent moisture.



Plant stress due to lack of moisture during the tassel-silk stage in early June severely limited crop yields.

Cotton: No differences in lint yield (Table TX2), gin turnout, or fiber quality parameters (not shown) were observed between the control and other treatments, including rates of N fertilizer using UAN, UAN with urease-nitrification inhibitors, or UAN blended with any one of three slow-release N products.

Grain Sorghum: Grain sorghum yield responded to increasing rates of coulter-banded N fertilizer applied at the second leaf stage (Figure TX1). Dry, hot conditions that persisted through June and July likely limited greater differences in yield due to N rate. At 30 and 60 pounds N per acre using surface dribble application, grain sorghum yield did not respond differently to alternative, slow-release N products (liquid or granular) compared to conventional, UAN, or granular urea (Figures TX2 and TX3, respectively).

Table TX2. Yield response of irrigated cotton to subsurface-banded urease-nitrification inhibitors or slow-release nitrogen sources blended with UAN

Treatment	N rate lb/A	Lint yield lbA	Gin turnout %
None	0	1,075	43.9
UAN	40	1,053	43.7
UAN	60	971	44.4
UAN	80	1,057	43.1
UAN + Nutrisphere-N®	80	984	43.7
UAN + Agrotain Ultra®	80	926	43.7
UAN + N-Sure®	80	937	44.3
UAN + CoRoN®	80	961	43.6
UAN + NDemand®	80	974	43.0
UAN	100	1,040	42.9
UAN + Nutrisphere-N®	100	937	43.4
UAN + Agrotain Ultra®	100	1,073	44.2
UAN + N-Sure®	100	1,020	42.9
UAN + CoRoN®	100	1,010	43.5
UAN + NDemand®	100	1,064	43.2
LSD$_{0.05}$		NS	NS
Pr>F		0.107	0.47

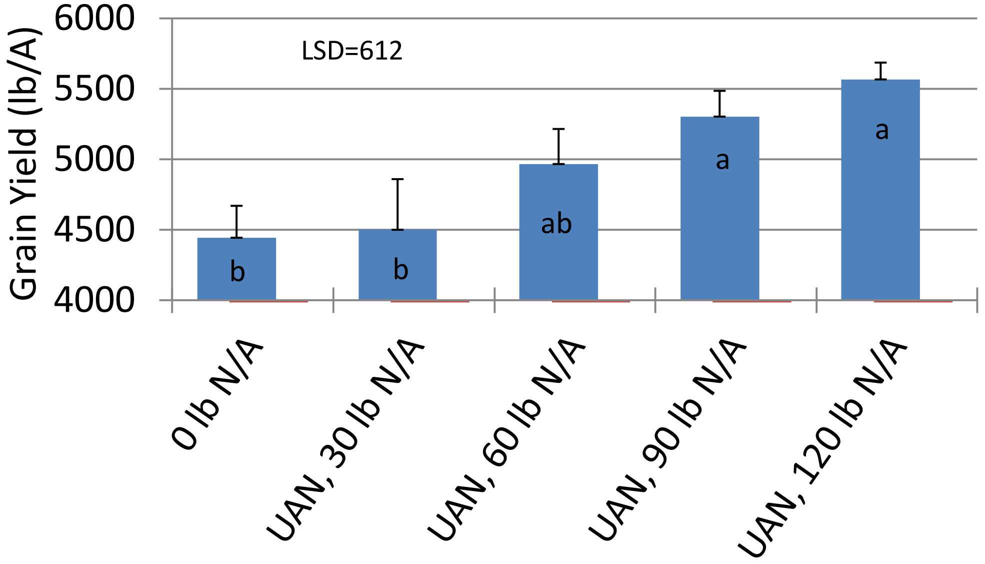


Figure TX1. Grain sorghum yield (mean and standard error) as a function of N fertilizer rate in the Northern Blacklands Region of Texas.

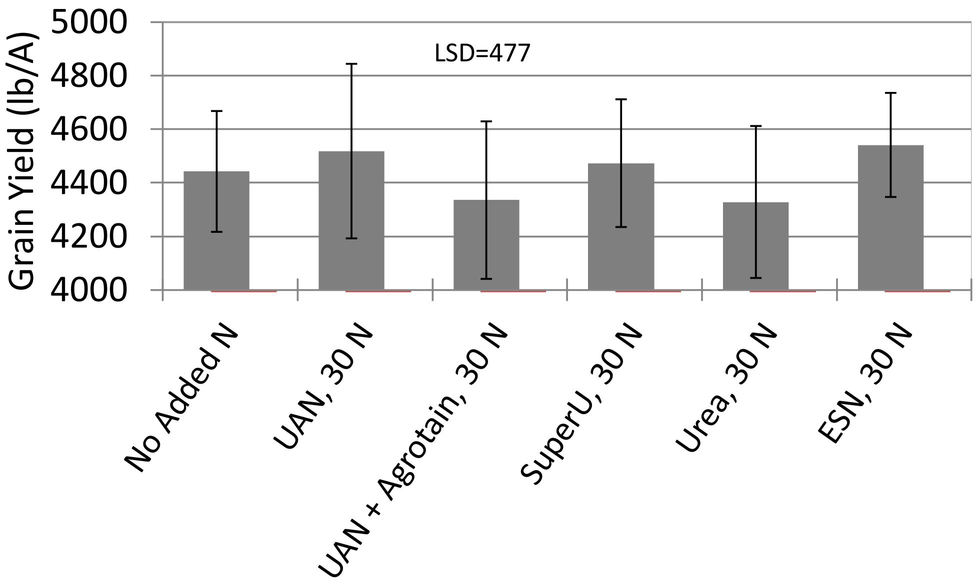


Figure TX2. Grain sorghum yield (mean and standard error) for a control, UAN, UAN with a urease-nitrification inhibitor, and slow-release N fertilizer sources applied at 30 pounds N per acre in the Northern Blacklands Region of Texas.

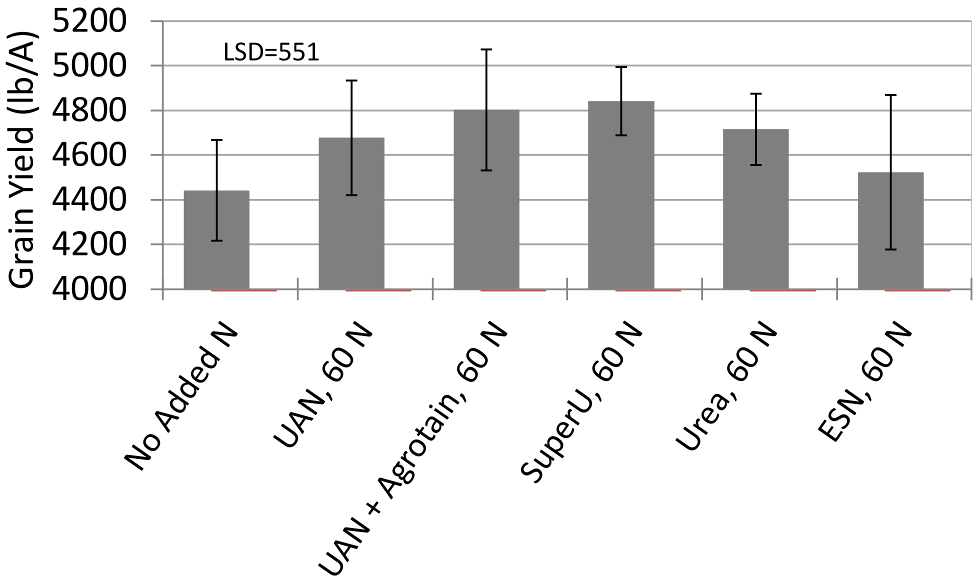


Figure TX3. Grain sorghum yield (mean and standard error) for a control, UAN, UAN with a urease-nitrification inhibitor, and slow-release N fertilizer sources applied at 60 pounds N per acre in the Northern Blacklands Region of Texas.

Alabama's Agricultural Experiment Station
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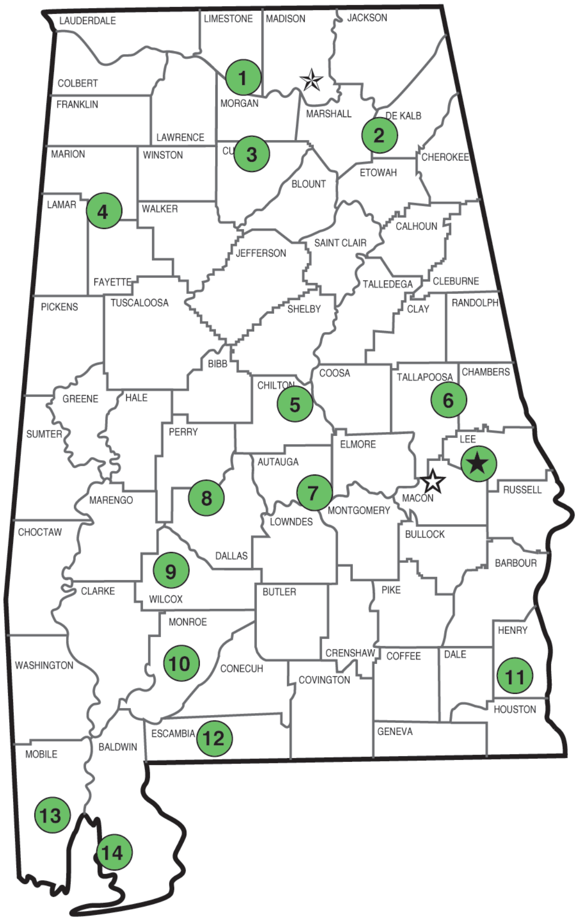
With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the state has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
✯ Alabama A&M University.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Research and Extension Center, Belle Mina.
2. Sand Mountain Research and Extension Center, Crossville.
3. North Alabama Horticulture Research Center, Cullman.
4. Upper Coastal Plain Agricultural Research Center, Winfield.
5. Chilton Research and Extension Center, Clanton.
6. Piedmont Research Unit, Camp Hill.
7. Prattville Agricultural Research Unit, Prattville.
8. Black Belt Research and Extension Center, Marion Junction.
9. AU Natural Resources Education Center, Camden (inactive).
10. Monroeville Agricultural Research Unit, Monroeville.
11. Wiregrass Research and Extension Center, Headland.
12. Brewton Agricultural Research Unit, Brewton.
13. Ornamental Horticulture Research Center, Spring Hill.
14. Gulf Coast Research and Extension Center, Fairhope.