MANAGING COTTON WITH ENVIRONMENTALLY SMART NITROGEN (ESN) UNDER RAIN-FED AND IRRIGATED CONDITIONS IN THE MID-SOUTH

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Abstract

Managing nitrogen (N) for cotton continues to be a key focal topic for many research programs across the country and particularly in the Mid-south. This input along with planting seed and technology fees continue as the more costly inputs. For the perennial, cotton, N management has been complicated. Perennial plants often adjust growth and development based on the environment and micro-climate and may or may not produce fruit. Environmental stresses during reproductive growth can and often does result in fruit shed. The sudden loss of fruit causes the plant to shift back to vegetative growth. Annual plants shift from vegetative growth to reproductive growth and exert all energy to producing the next generation. Most of the recent work with respect to N has dealt with fertilizer use efficiency. Efforts continue to gain the most economical yield with the least cost of inputs. Nitrogen management can be quite varied, especially with respect to N applications. Application systems often spread the applications from prior to planting through blooming and even beyond. The most desirable timing of application allows for maximum uptake with the least loss to the environment or to other non-target species such as weeds. Phosphorus (P) and potassium (K) application timing is not as critical as these nutrients are not as mobile. Fall applications are often the desired timing and allows the nutrients to stabilize in the soil solution.

Many input factors are specific for varying soils, climate, crop, and management systems and can now even be varied on the move. All have a significant impact on fertilizer management and should always be considered when selecting fertilizer Best Management Practices (BMP's). Getting nutrients into plants as close to the time they are needed leads to the most efficient use of nutrients whether coming from organic or inorganic sources. The plants themselves do not distinguish between nutrient sources. However, some crops such as rice preferentially take up certain forms while others, through a symbiotic relationship with bacteria, get most of their N from the atmosphere. Many products are being brought to the market place with claims of increased nutrient use efficiency, reduced nutrient loss, nutrient stabilizers, or various other mechanisms to reduce nutrient loss or enhanced nutrient uptake. Not always are the mechanisms of activity evident from the literature provided by the marketer. In recent years products have been marketed to reduce ammonia volatilization, nitrification, denitrification or even some combinations that involve more than one mechanism. One of the newer materials on the market is a polymer-coated product, ESN® (environmentally Smart Nitrogen) developed by Agrium Advanced Technologies, Inc. This product is being evaluated along with other N sources, urea (U, 46% N) and urea-ammonium nitrate (UAN) solution (32% N) under dryland (rain-fed) and irrigated conditions and on different soil types. The product ESN® is a urea granule within a micro-thin polymer coating. The coating allows water within the soil to move into the granule and dissolve the urea inside. The urea solution then moves out through the coating into the soil where it becomes available to the growing crop. Another product included in the original studies has been Agrotain® (N-*(n-Butyl*) thiophosphoric triamide (NBPT) from Koch Agronomic Services. This NBPT product has been touted as the world's leading urease inhibitor and is meant to reduce ammonia volatilization when coated on urea granules. Other companies have similar materials but generally the same active ingredient. NutriSphere-N® (Specialty Fertilizer Products, Leawood, KS, now owned by Verdesian Life Sciences) has also been included. The product is spray-coated onto granular urea or mixed with UAN solution to enhance nutrient uptake. In 2013, the NutriSphere-N treatments were discontinued and replaced with an ESN+UAN or ESN+U combination with these system applied just after planting. Nitrogen rates of 90, 120, and 150 lb N/acre were used to establish a range of potential responses. The high rate was removed in 2014 and a 60 lb N/acre low rate was included. Fertilizer sources prior to 2013 were applied as a split application, except ESN which was applied 100% at planting. For the split applications, 60 lb N/acre was applied just after emergence with the remaining N applied as a sidedress application (to establish rates) at the pin-head square growth stage (PHS). For the ESN+UAN and ESN+U systems, a uniform rate of either UAN or U (45 lb N/acre) was applied along with the remainder of each rate applied as ESN. All cultural practices were maintained uniformly through the season. The rain-fed (non-irrigated) study was located at the Tribbett Satellite Farm (TSF) on a Dundee-Forestdale silty clay loam with some Dowling soil intermingled. The experimental design was a factorial arrangement of treatment in a randomized complete block (RCB) design with five replications and grown as a continuous cotton system.

The study was initiated in 2010 and continued through 2013. The irrigated site was established in 2011 at the Delta Research and Extension Center (DREC) on a Dubbs silt loam. Since the irrigated study is rotated with corn, the study location varies from year to year and was located on a Newellton silty clay in 2012 and 2014 and back to the Dubbs in 2013. Treatments were arranged in an RCB design with four replications. All granular treatments at each location were hand-applied pre-weighed samples applied after emergence. Each plot was harvested with a commercial spindle picker adapted for individual plot harvest. Grab-samples were taken at the time of harvest and ginned through a 10-saw micro-gin to determine the lint percent and subsequent lint yields. All data was then analyzed with the Statistical Analysis System (SAS Institute, Cary, NC) utilizing Analysis of Variance (ANOVA) with mean separation by Waller-Duncan K-ration t-test and Fisher's Protected Least Significant Difference. Previous research has shown a decrease in lint percentage as N rates increase so only lint yields will be discussed.

The first study at TSF was initiated in 2010 under rain-fed (non-irrigated) growing condition. Lint yields were not significantly increased with increasing N rates and had no significant effect due to the varying N source or combination of N source and enhancer Table 1. Lint yields ranged from 1170 to 1218 lb/acre across the different sources. In 2011, lint yields ranged from 592 to 643 lb/acre and again no significant difference. A new system, urea+Agrotain, was added in 2011 but showed no difference. As with the previous year, there was no N rate response. In 2012, lint yields were more than two times what they had been in 2011 and ranged from 1350 to 1398 lb lint/acre. Again there was no significant difference among the different sources when averaged across N rates.

Table 1. Summary of cotton yields averaged across N rates under rain-fed conditions for various N sources and amendments. Tribbett Satellite Farm, Tribbett, MS

Nitrogen Source	Cotton Lint Yield, lb/acre			
(+ Amendment)	2010	2011	2012	Average
UAN Solution	1213.1	611.3	1382.8	1069.1
Urea	1191.0	623.7	1397.5	1070.7
UAN + NutriSphere-N®	1218.2	598.6	1350.5	1052.4
Urea + NutriSphere-N®	1169.5	643.3	1354.3	1055.7
Urea + Agrotain®	----	609.3	1383.1	----
ESN®	1183.9	592.3	1355.3	1043.8
LSD (0.05)	76.5 ns	61.1 ns	73.9 ns	

In 2013, the U+NutriSphere-N (U+NS) and UAN+NutriSphere-N (UAN+NS) systems were replaced with ESN+UAN and ESN+U systems and continued in 2014 only at lower N rates for the non-irrigated soil. For both systems, 45 lb N/acre was applied to each plot as either U or UAN and the remaining N (45, 75, and 105 lb N/acre) was applied as ESN. The UAN was "knifed-in" while the U and ESN were surface-applied as a broadcast. Cultivation was then used to help with incorporation of the dry materials. Cotton lint yields in 2013 were much higher than those measured in 2012. Lint yields ranged from 1400 to 1605 lb/acre. The lower yields were associated with the UAN+ESN system with no explanation why this system was significantly lower than all others. There was a significant response to N in 2013 with the greatest lint yield measured with 150 lb N/acre. In previous years, with lower lint yields there had been no response to increasing N rates indicating that sufficient N was available at the lowest N rates.

An irrigated study with the treatments previously describe was initiated in 2011 on the Delta Research and Extension Center. Lint yields under the irrigated conditions and sandy loam soil were twice those measured at TSF under rain-fed conditions the same year. The lint yields (Table 2) with ESN and U+Agrotain (averaged across N rates) were about 4% lower than the other systems but that difference was not significant. Yields at the150 lb N/acre were about 6% lower than the 120 lb N/acre rate, again not significant. The 2012 lint yields ranged from 1497 to 1568 with no significant difference between the N sources when averaged across the three N rates. The only system that tended lower was the ESN and was only 2.6 to 4.5% lower than the range of the other sources. In 2012, there was again no response to increasing N rates indicating that 90 lb N/acre was at least sufficient for the yields produced under rain-fed conditions.

Table 2. Cotton lint yields for irrigated cotton at the Delta Research and Extension Center averaged across N rates for varying nitrogen sources with and without amendments.

Nitrogen Source	Cotton Lint Yield, lb/acre			
(+ Amendment)	2011	2012	Average	2013*
UAN Solution	1285.1	1552.5	1418.8	1692.8 a
Urea	1272.6	1537.3	1405.0	1585.2 ab
UAN + NutriSphere-N®	1272.6	1565.8	1419.2	1715.5 a
Urea + NutriSphere-N®	1263.8	1567.8	1415.8	1655.5 a
Urea + Agrotain®	1211.6	1550.0	1388.8	1641.0 a
ESN®	1222.8	1496.9	1359.8	1479.9 b
LSD (0.05)	101.4 ns	83.9 ns	-----	160.3*

*NOTE**: NutriSphere-N replaced in 2013 with UAN+ESN and Urea+ESN

The DREC yields in 2013 were much more variable than in any previous year of the study. Lint yields ranged from 1480 to 1716 lb/acre when averaged across N rates (Table 2), and significantly different at the 5% level as determined by the Analysis of Variance ($LSD_{(0.05)}$ = 160 lb lint/acre). The lower yields were with ESN alone and with urea alone. The higher yields were with UAN and UAN+ESN. There was no significant N rate response on the sandy loam site (DREC) even with yields over 1600 lb lint/acre.

At both the rain-fed location (TSF) and the irrigated location (DREC), there has been little response to increasing N rates. In 2014, scientist replaced the high N rate with 60 lb N/acre rate in each study. At the time of presentation only seedcotton yields were available for analysis. At the TSF (rain-fed) location, there was a significant N rate effect with the 60 lb N/acre rate yielding significantly lower seedcotton than the other two rates. The ESN alone and UAN+ESN systems produced significantly less seedcotton than the other systems when averaged across N rates. Seedcotton yields were not significantly affected by N source or combination at the DREC location when averaged across N rates. There was a significant N rate effect when averaged across all of the N sources and combination. The studies initiated in 2014 will be continued in 2015.