Bulletin 677
January 2012

Alabama Agricultural Experiment Station
William Batchelor, Director
Auburn University, Auburn, Alabama

Alternative N Sources for Corn and Cotton in Alabama

C. C. Mitchell, D. B. Watts, and D. P. Moore

INTRODUCTION

Rapidly increasing N fertilizer costs have left Alabama cotton and corn producers with few alternatives. Using legumes as winter cover crops and applying poultry broiler litter as a nutrient source are about the only alternatives for many producers. Ammonium nitrate (34-0-0), the most popular dry form of N used in Alabama, has been difficult to find and transport. The best dry substitute is a urea/ammonium sulfate blend (33-0-0), which is very acid forming and also subject to some ammonia loss. Another attractive and less expensive alternative to ammonium nitrate is dry urea (46-0-0); however, the risks of volatilization losses from surface application can be high especially when it is applied during the hot, sometimes dry, summer months on residue in a well-limed soil. Reduced tillage and high-residue management in cotton production leave no alternative but to surface-apply dry urea. Yet another alternative is liquid urea-ammonium nitrate solutions (UAN), currently the most popular N source for row crops.

There are also many new products on the market.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 actually worth the extra cost? Do some of these materials work under the heat and humidity in the southern U.S. and with the crops grown there? Most have been developed and tested in the Midwestern U.S. and are heavily promoted nationwide.

The purpose of this study was to compare some of these 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.

Mitchell is a professor in the Department of Agronomy and Soils, Auburn University; Watts is a soil scientist at the USDA-National Soil Dynamics Lab, Auburn, Alabama; Moore is Director of the Prattville Agricultural Research Unit, Alabama Agricultural Experiment Station.

PROCEDURES

Cotton and Corn Yield

Two experiments were conducted with cotton and corn from 2007 through 2011 on a Lucedale sandy clay loam (fine, loamy, siliceous, Thermic Rhodic Paleudults) at the Prattville Agricultural Research Unit in Central Alabama. No additional P and K were recommended and none was applied. Treatments were designed to compare N products (Table 1). Because different products were available each year, treatments changed from year to year.

Ammonium nitrate was the standard of comparison, and the rates selected were chosen based upon a recommended standard rate of 120 pounds total N per acre for non-irrigated corn and 90 pounds total N per acre for cotton. Two rates of ammonium nitrate were used in 2008 and 2010 to verify the optimum N rate (Tables 2 and 4). All materials were applied as a sidedress or topdress at the V8 stage for corn and before first bloom for cotton. Twenty pounds N per acre as ammonium nitrate were applied to all crops at planting except the no-N plot and the poultry litter plots. Both cotton and corn were planted using strip tillage into a killed rye cover crop. Because of the severe drought in 2007, there was no yield to harvest.

Corn (‘Pioneer 31G97’) was planted no-till into the previous crop’s residue in early April and harvested by machine in late August. Cotton (‘Phytogen 440W’) was planted no-till into the previous crop’s residue in late April and harvested by machine in October. A cover crop of rye was planted in the fall of 2007 after the severe drought to take advantage of any residual N from the failed

Table 1. Alternative N Sources Used

Ammonium nitrate (34-0-0)
The most popular, dry form of N used in Alabama on forages and crops. 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. Ammonium nitrate is not subject to volatilization losses and was used as the standard of comparison.

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

Liquid Urea-ammonium nitrate (UAN solution)
The most widely used N source for cotton and corn in Alabama. In this study, a 28-0-0 UAN solution with 5% S was used from a local fertilizer dealer. It was applied by spraying a band about 8 inches wide on either side of the row as a sidedress N application.

continued

Table 1. Alternative N Sources Used (cont.)

Dry urea (46-0-0)

Usually the least expensive per pound of N and most concentrated N material available in Alabama. Widespread concerns about ammonia volatilization losses on hot, dry, soils with a good residue cover often discourage its use as a sidedress N source on no-till/conservation tilled corn and cotton in Alabama.

Agrotain®

The standard urease inhibitor product currently being used in the Southeastern U.S. (Agrotain International, LLC). Agrotain was mixed with dry urea at the highest recommended rate to give 14-day protection under adverse soil conditions. The rate was 5 quarts per ton (24 ml Agrotain per 10 pounds urea). For 28% or 32% UAN solutions, the rate was 2.4 quarts per ton or about 11 ml per 10 pounds UAN solution (~1 gallon).

Nutrisphere N® (SFP, Leawood, KS)

Formulated to be used with both dry urea and UAN solutions. Both formulations were included at the manufacturers recommended rate. The Nutrisphere website claims that the product "controls urease, keeping it from robbing your nitrogen — or your yield potential" and "protects nitrogen in its ammonium state before it gets converted, giving you the greatest return on your nitrogen fertilizer investment." (http://www.nutrisphere-n.com/howitworks.aspx).

Nitamin Nfusion®

A Georgia-Pacific product (22% N, of which 94% is slowly available) to be blended with UAN solutions. However, in this study it was used at the full rate as a sidedress N application. It is marketed by Kock Agronomic Services who claim it is ". . . formulated to provide growers and turf professionals with safe and efficient slow-release nitrogen fertilizers." (http://www.kochfertilizer.com/nitamin/)

ESN® SMART NITROGEN® (44-0-0)

A polymer-coated, controlled release urea product from Agrium Advanced Technologies (U.S.) Inc. The website states, "Its controlled-release technology delivers nitrogen to crops all through the growing season" and that ". . . ESN promotes yield." (http://www.smartnitrogen.com/)

Poultry litter

Abundant in most areas of Alabama. 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 showed rather conclusively that it could be used on conservation tillage corn and cotton based on the total N in the litter. Conservatively, most growers assume about 2/3 available N. In this study, poultry broiler litter was applied at two rates of total N (120 and 180 pounds total N/acre for corn and 90 and 120 pounds total N/acre for cotton). All poultry litter was applied as a sidedressing in these tests; usually, it is applied all at planting. No additional N was applied to these treatments.

Calcium chloride

In 2007, 2008, and 2009, a liquid calcium chloride solution was included with urea and UAN solutions. There were claims that calcium chloride could help reduce volatilization losses of urea-based N sources. We saw no evidence of this during 2008 and 2009 so calcium chloride was dropped as a treatment in 2010.

2007 crop. The 2008 crop was planted into this residue using strip tillage. Plot size was 12 feet wide (four, 36-inch rows) and 35 feet long. Yields were harvested from the two center rows. In 2010, corn ear leaf samples were collected and analyzed for total N at early silking and the uppermost, mature cotton leaf blades were collected and analyzed for total N at early bloom.

Ammonia Volatilization Studies

Ammonia volatilization estimates were made in the field in 2007, 2008, and 2009 for two weeks after applying the sidedress N treatments. Because of the time and effort needed to take these measurements, only selected treatments were used. Because of the crop failure and drought in 2007, a separate experiment was set up at E.V. Smith Research Center for 2007 on a Compass loamy sand (coarse-loamy, siliceous, thermic Plinthic Paleudults) using both a high residue site and a conventionally tilled site just to measure ammonia volatilization losses.

A relatively simple, low-cost method was used for estimating ammonia (NH_3) loss using static chambers (Fig. 1). This technique utilizes glass tubes coated

Figure 1 (left) Placement of static chambers used to collect ammonia volatilized in selected treatments; (top right) A heavy residue cover in 2008 may have enhanced ammonia volatilizations losses from UAN solution sprayed on the top. Agrotain® did not seem to reduce losses under these conditions; (bottom right) Static chamber.

with oxalic acid to adsorb NH_3 from the air inside static chambers. The advantage of this procedure is that it can be used to quantify NH_3 emissions from field plots for the evaluation of different management methods for reducing NH_3 emissions from agricultural fields (K.E. Smith and H.A. Torbert, USDA-ARS Soil Dynamics Lab, unpublished data and personal communications). Ammonia was measured for 60 minutes each day. The rest of the time, the chambers were open to the atmosphere. Measurements were made for 14 days after sidedress N was applied. The technique seemed to produce good relative NH_3 losses when comparing sources, but the calculated absolute values are subject to gross errors.

RESULTS

Crops Yields

Both corn and cotton yields were disappointingly low throughout this study due to periodic droughts during critical growth stages for both crops. In fact, this test was not harvested in 2007 because of a complete crop failure due to drought. In spite of low yields, there were some significant differences in treatments each year (Tables 2-5).

Table 2. Treatments and Yield for Corn and Cotton in 2011

No.	Source	Corn (bu/A)	Cotton (lb. lint/A)
1	none	13.9 c	573 c
2	Am. nitrate at std. rate	73.8 a	1307 ab
3	Am. nitrate @ 4/3 rate	74.9 a	1135 b
4	UAN solution†	84.1 a	1271 ab
5	UAN + Agrotain®	90.0 a	1282 ab
6	Urea	87.1 a	1147 b
7	Urea + Agrotain®	84.7 a	1149 b
8	Urea + Nutrisphere N®	83.4 a	1154 b
9	UAN + Nutrisphere N®	80.7 a	1377 a
10	ESN®	46.8 b	1103 b
11	Urea-am. sulfate blend	90.5 a	1200 ab
12	Poul. litter@120/90# N/A	36.8 b	1108 b
13	Poul. litter@160/120# N/A	47.3 b	1198 ab

† 28-0-0-5S

Table 3. Treatments and Yield for Corn and Cotton in 2010

No.	Source	Corn (bu/A)	Cotton (lb. lint/A)
1	none	20.0 d	390 b
2	Am. nitrate	73.1 ab	460 ab
3	Am. nitrate @ 4/3 rate	70.4 abc	460 ab
4	UAN solution†	82.0 a	420 ab
5	UAN + Agrotain®	82.4 a	420 ab
6	Urea	82.0 a	420 ab
7	Urea + Agrotain®	76.7 ab	470 ab
8	Urea + Nutrisphere N®	75.5 ab	420 ab
9	UAN + Nutrisphere N®	77.6 ab	400 b
10	Nitamin Nfusion 22-0-0®	68.0 abc	460 ab
11	Urea-am. sulfate blend	78.3 ab	560 a
12	Poul. litter @ 120# N/a	57.4 c	460 ab
13	Poul. litter@160/120# N/A	66.9 bc	510 a

† 28-0-0-5S

Table 4. Treatments and Yield for Corn and Cotton in 2009

No.	Source	Corn (bu/A)	Cotton (lb. lint/A)
1	none	18.2 g	397 f
2	none+$CaCl_2$	14.9 g	336 f
3	Urea	53.4 abc	702 abcd
4	Am. nitrate	48.8 bcd	774 ab
5	Urea-am. sulfate blend	57.5 a	743 abc
6	UAN solution at 2/3 N rate	39.6 ef	672 cde
7	UAN solution	47.1 cde	643 de
8	UAN at 2/3 rate+$CaCl_2$	40.6 def	588 e
9	UAN solution + $CaCl_2$	45.6 cde	738 abc
10	UAN solution+Agrotain®	46.8 cde	762 abc
11	Urea + Agrotain®	56.0 ab	716 abcd
12	Poul Litter @ 120/90# N/a	36.0 f	687 bcd
13	Poul. Litter @160/120#N/a	42.6def	784 a

† 28-0-0-5S

Table 5. Treatments and Yield for Corn and Cotton in 2008

No.	Source	Corn (bu/A)	Cotton (lb. lint/A)
1	None	11.2 g	360 d
2	None +. $CaCl_2$	13.6 g	300 d
3	Urea	71.2 abcd	990 a
4	Am. Nitrate	65.9 bcd	840 b
5	Am. Nitrate @ 4/3 N rate	62.0 de	950 ab
6	UAN solution† @ 2/3 N rate	57.2 de	690 c
7	UAN solution	83.1 a	700 c
8	UAN + $CaCl_2$ @ 2/3 N rate	45.2 ef	700 c
9	UAN + $CaCl_2$	79.6 ab	890 ab
10	UAN + Agrotain®	81.2 a	920 ab
11	Urea+ Agrotain®	76.6abc	950 ab
12	Nitamin Nfusion® 25-0-0 @ 2/3 N rate	41.7 f	690 c
13	Nitamin Nfusion® 25-0-0	64.7 cd	860 ab

† 28-0-0-5S

When mean relative yields (relative to ammonium nitrate treatment) are presented for all the products, there were no real differences when applied at the recommended rate of 120 pounds total N per acre for corn and 90 pounds N per acre for cotton (Fig. 2-3). 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 (Fig. 2). 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. The new-technology sources—such as Agrotain®, Nutrisphere ®, and the controlled release Nitamin®—did not increase yields or N concentration in the leaves (Table 5) compared to more conventional sources such as urea, ammonium nitrate, or UAN solution.

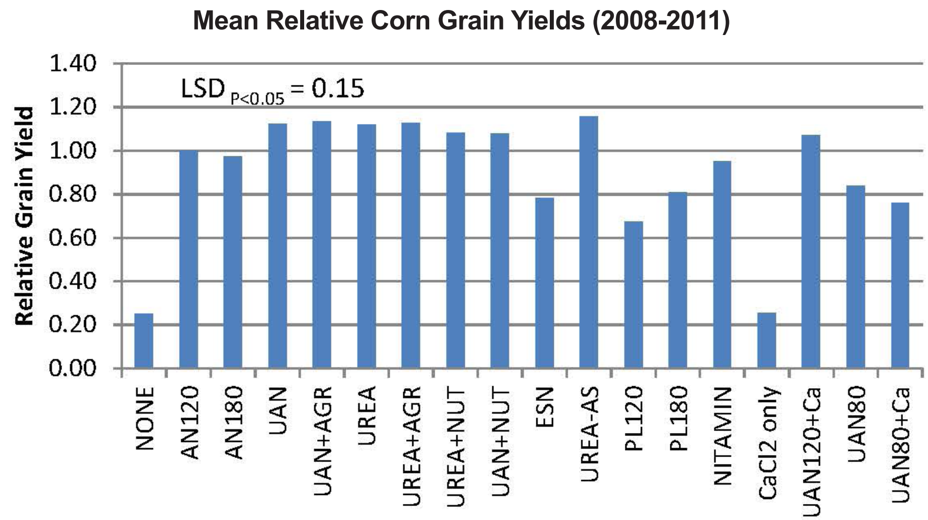


Figure 2. Mean relative corn grain yields (2008-2011) from different products when applied as a sidedress at the recommended rate of 120 pounds total N per acre. Some products were applied at a higher or lower rate as indicated in parentheses. AN=ammonium nitrate; UAN=urea-ammonium nitrate liquid; PL=poultry broiler litter; AGR=Agrotain®; NUT= Nutrisphere N®; ESN=ESN® nitrogen.

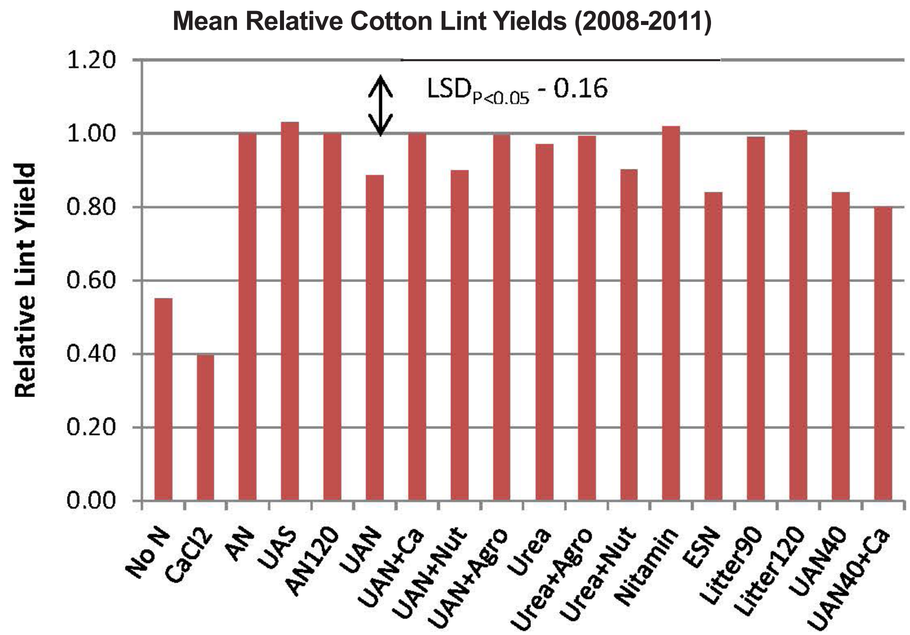


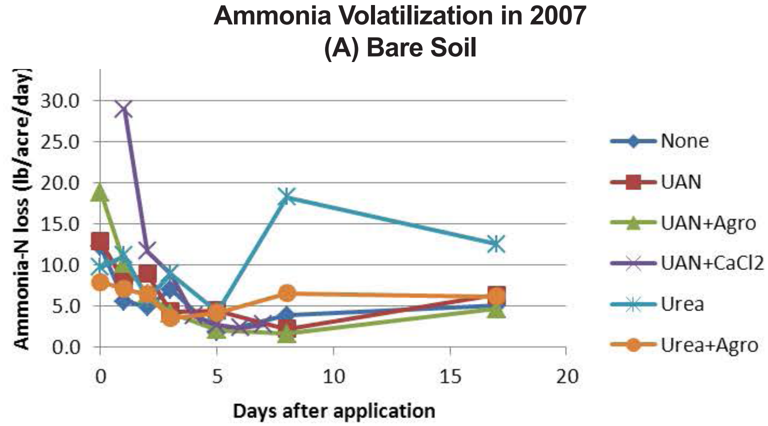
Figure 3. Mean relative cotton lint yields (2008-2010) from different products when applied as a sidedress at the recommended rate of 90 pounds total N per acre. Some products were applied at a higher or lower rate as indicated. AN=ammonium nitrate; UAN=urea-ammonium nitrate liquid; PL=poultry broiler litter; AGR=Agrotain®; NUT= Nutrisphere N®; ESN=ESN® nitrogen.

Ammonia Volatilization Losses

Most ammonia volatilization losses are measured under controlled conditions in greenhouses or laboratories. 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 in 2007, 2008 and 2009—each year that the measurements were made. However, the estimates of total ammonia loss per day as reported in Fig. 4-6 should be used only for relative comparisons. Also, the patterns of ammonia loss varied with year as would be expected due to temperature, rainfall, and field conditions.

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 (Fig. 4). Soils were very dry when the test was initiated and daytime high temperatures were near or above 100°F 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 mm (0.37 inch) rain on August 18, which was the only significant rainfall on the site in 2007 until near the end of the volatilization study (Fig. 4).

In 2008, conditions after sidedress corn were ideal for ammonia losses with almost no rainfall during the entire period. Losses peaked the first day after sidedressing with urea plus Agrotain®, UAN solution, and UAN solution plus $CaCl_2$ having the greatest losses (Fig. 5). Similar patterns were observed after sidedressing cotton a few weeks later. There was very little loss from the urea alone. Because there was a heavy rye residue cover in 2008 (Fig. 1), we suspect that the liquid N tended to adhere to the residue, promoting ammonia losses. The dry urea prills fell beneath the cover onto the bare soil where ammonia was trapped. Volatilization losses were the same for all products after day 3.



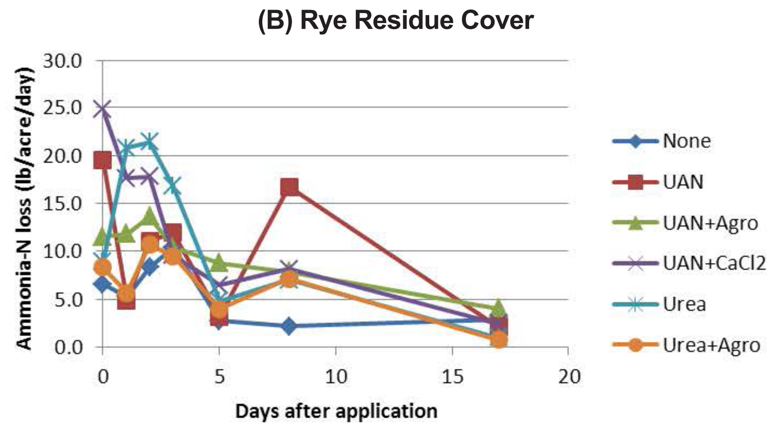
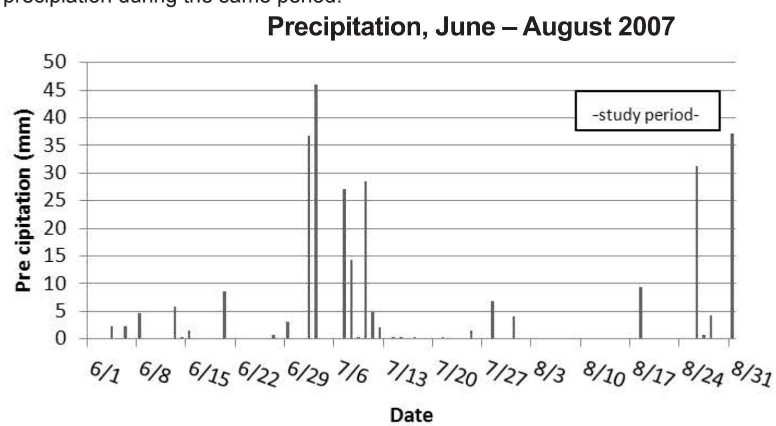


Figure 4 (above) Ammonia volatilization in 2007 from several N sources after application on August 10 to (A) bare soil and (B) rye residue cover; and (below) precipiation during the same period.



In 2009, ammonia losses from the sidedress application of poultry litter, especially on corn, far exceeded losses from other materials (Fig. 6). Again, the absolute values are questionable, but the relative losses are real. Liquid UAN solutions and urea losses were highest among the traditional product and Agrotain® appeared to reduce these losses slightly.

CONCLUSIONS

The newer controlled-release N products have not shown 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. In 2008, higher ammonia volatilization losses occurred when UAN solutions were broadcast-applied to an unusually heavy surface residue cover. Agrotain® did not reduce these losses but did reduce losses when both urea and UAN solutions were applied to a bare soil. 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.

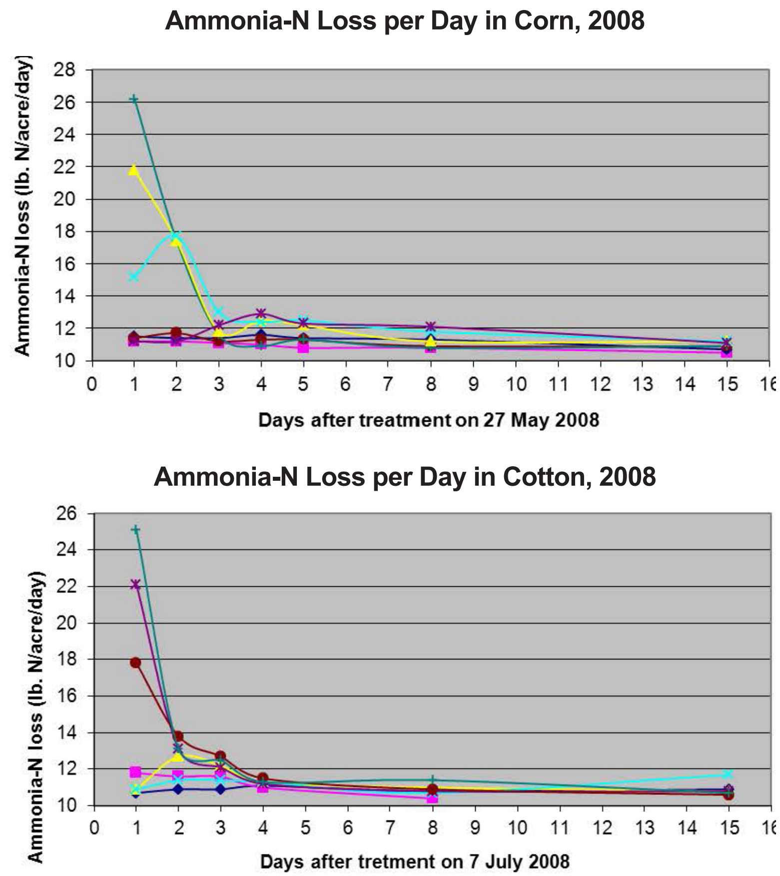
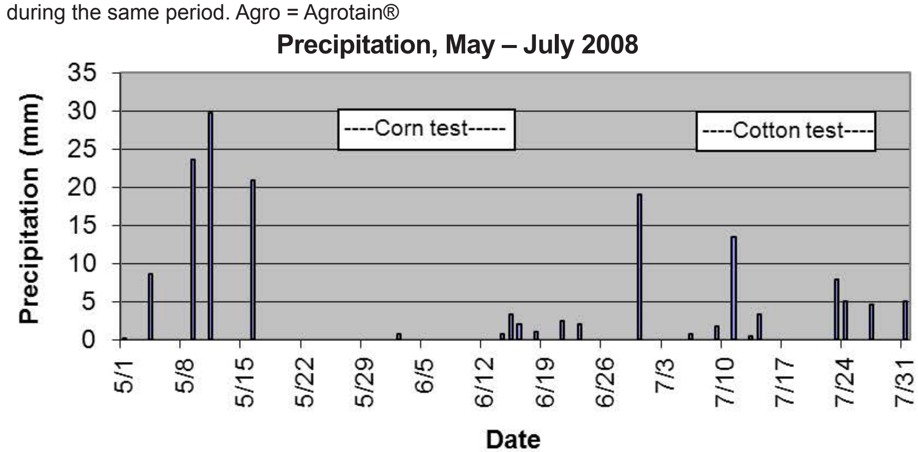
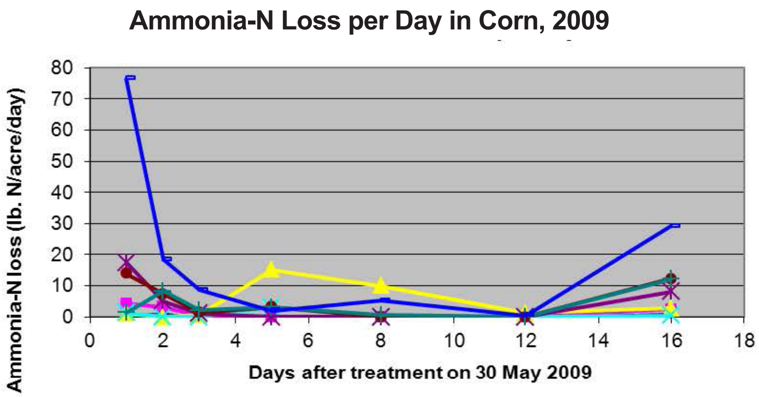


Figure 5 (above) Ammonia volatilization in 2008 from several N sources after application as sidedress on corn (May 27) and cotton (July 7) and (below) precipiation during the same period. Agro = Agrotain®





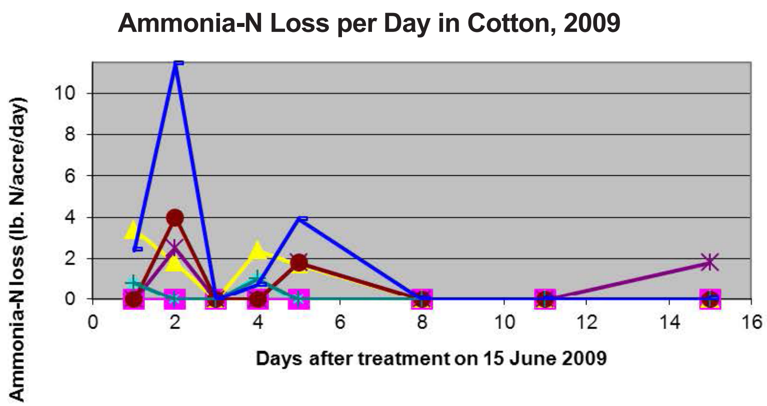
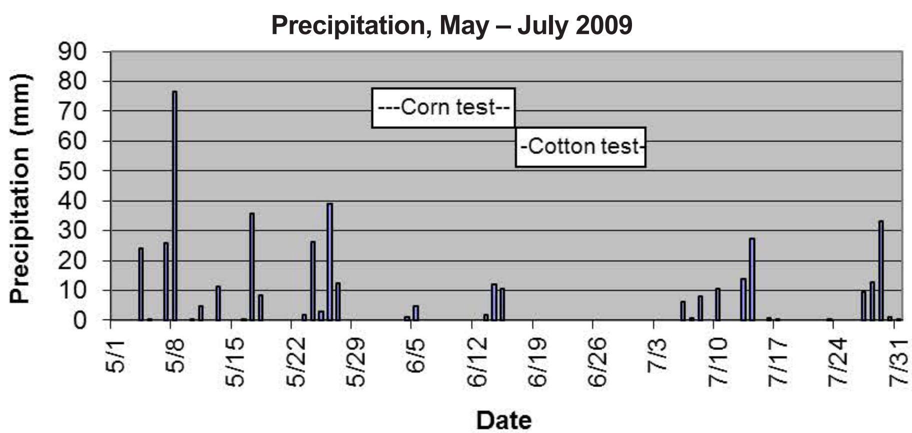


Figure 6 (above) Ammonia volatilization in 2009 from several N sources after application as sidedress on corn (May 31) and cotton (June 15) and (below) precipiation during the same period. Agro = Agrotain®



Acknowledgement

Dr. Katy Smith, a former USDA-ARA Research Soil Scientist with the Soil Dynamics Laboratory at Auburn, helped develop the static chambers for ammonia collection and helped us use them in 2007 and 2008. She is now an Assistant Professor of Biology at the University of Minnesota-Crookston, Department of Math, Science and Technology, Crookston, MN. Mr. Fernando DuCamp was a graduate research assistant at the USDA Soil Dynamics Laboratory in 2007 and did most of the ammonia volatilization field research that was presented for 2007. He presented a poster at the Southern Branch ASA meetings in 2008. He is currently a research soil scientist in his native country of Uruguay. Mr. Cody Smith did an undergraduate special problems study in 2008 and did most of the data collection for ammonia volatilization. He presented a poster at the 2009 Southern Branch ASA meetings.

Web publication, January 1012

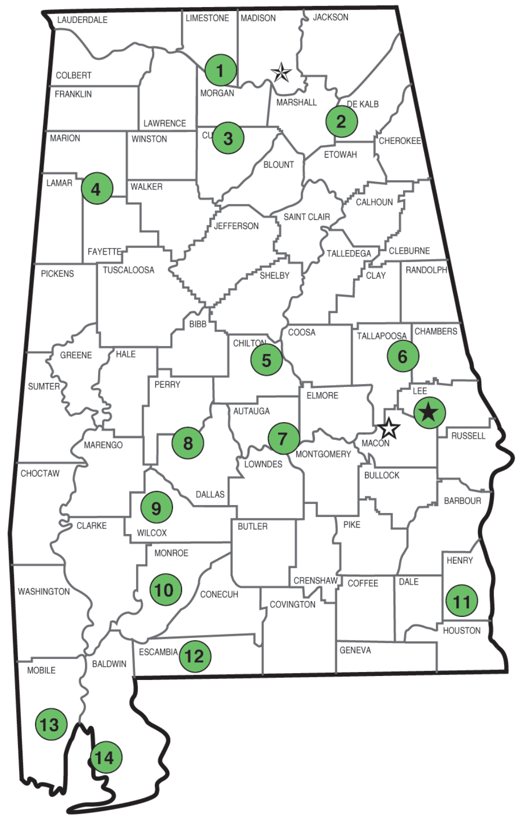
Auburn University is an equal opportunity educational institution/employer.

http:www.auburn.edu

http:www.aaes.auburn.edu

Alabama's Agricultural Experiment Station
AUBURN UNIVERSITY

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 Substation, Camp Hill.
7. Prattville Agricultural Research Unit, Prattville.
8. Black Belt Research and Extension Center, Marion Junction.
9. Lower Coastal Plain Substation, Camden.
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.