NEW TECHNOLOGY N PRODUCTS IN ALABAMA

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Background

Rapidly increasing N fertilizer costs have left Alabama cotton and corn producers with few alternatives. Using legumes as winter cover crops and using poultry broiler litter as a source of nutrients are about the only alternatives for many producers. Dry urea (46-0-0) is an attractive and less expensive alternative to ammonium nitrate (34-0-0) however; the risks of volatilization losses from surface application can be high. This is especially true when 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. Liquid urea-ammonium nitrate solutions (UAN) are currently the most popular N source for row crops. Ammonium nitrate 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. There are 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 of our Southern U.S. climate and with the crops we grow? 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 some of these products under Alabama conditions.

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 Research Unit in Central Alabama. No additional P and K were recommended and none was applied. Treatments were designed to compare N products. Each year there were different products available to compare so 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 lb. total N per acre for non-irrigated corn and 90 lb. total N per acre for cotton. The two rates of ammonium nitrate used in 2008 and 2010 were to verify the optimum N rate (Tables 1 and 2). 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. Some of the materials used during the study are described below:

> Ammonium nitrate (34-0-0) has been 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.
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> Urea-Ammonium sulfate blend (33-0-0) has become 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.
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> Liquid Urea-ammonium nitrate (UAN solution) is 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.

Dry urea (46-0-0) is 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® has become 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 lb. urea). For 28% or 32% UAN solutions, the rate was 2.4 quarts per ton or about 11 ml per 10 lb. UAN solution (~1 gallon).

Nutrisphere N® (SFP, Leawood, KS) is 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® is 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) is 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 is 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-yr 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 lb. total N/acre for corn and 90 and 120 lb. 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.

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 2007 crop. The 2008 crop was planted into this residue using strip tillage. Plot size was 12 feet wide (4, 36-inch rows) and 35 feet long. Yields were harvested from the 2 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.

Fig. 1. Static chambers used to collect Ammonia volatilized in selected treatments.

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 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 seems 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 1-2).

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 lb. total N per acre for corn and 90 lb. N per acre for cotton (Fig. 3-4). 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 lb. total N per acre was not adequate for optimum grain yields compared to the other treatments (Fig. 3). 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 3) compared to more conventional sources such as urea, ammonium nitrate, or UAN solution.

Ammonia volatilization losses

Most ammonia volatilization losses are measured under controlled conditions in greenhouse or laboratory conditions. 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 that the measurements were made in 2007, 2008 and 2009. However, the estimates of total ammonia loss per day as reported in Fig. 5-7 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. 5). 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 (Fig. 2). 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 18 August which was the only significant rainfall on the site until near the end of the volatilization study in 2007 (Fig. 4).

Fig. 2. A heavy residue cover in 2008 may have enhanced ammonia volatilization losses from UAN solution sprayed on the top. Agrotain® did not seem to reduce losses under these conditions.

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. 6). 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 (see photo), we suspect that the liquid N tended to adhere to the residue promoting ammonia losses. The dry urea pills fell beneath the cover onto the bare soil where ammonia was trapped. Volatilization losses were the same for all products after day 3.

In 2009, ammonia losses from the sidedress application of poultry litter, especially on corn, far exceeded losses from other materials (Fig. 7). 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 were occurring 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.

Acknowledgements

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.

Table 1. Treatments and CORN yields, 2007-2011†

Source	Total N @ planting‡	Total N @ sidedressing‡	Year				
			2007	2008	2009	2010	2011
	-------pounds/acre--------		------------------bu/acre-------------				
No N	0	0		11 g	18 g	20 d	14 c
$CaCl_2$	0	0		14g	15 g	--	--
Am. nitrate	20	100		66 bcd	49 bcd	73 ab	74 a
Am. nitrate 4/3	20	120		62 de	--	70 abc	75 a
Urea-am. sulfate blend	20	100		--	58 a	78 ab	91 a
Urea	20	100	No Yield – Severe drought	71 abcd	53 abc	82 a	87 a
Urea + Agrotain®	20	100		77 abc	56 ab	77 ab	85 a
Urea + Nutrisphere N®	20	100		--	--	76 ab	83 a
UAN solution	20	100		83 a	47 cde	82 a	84 a
UAN + $CaCl_2$	20	100		45 ef	46 cde	--	--
UAN + Agrotain®	20	100		81 a	47 cde	82 a	90 a
UAN + Nutrisphere N®	20	100		--	--	78 ab	81 a
UAN 2/3	20	60		--	41 def	--	--
UAN 2/3 + $CaCl_2$	20	60		--	40 ef	--	--
Nitamin Nfusion®	20	100		65 cd	--	68 abc	--
Nitamin Nfusion® 2/3	20	60		42 f	--	--	--
ESN	20	100		--	--	--	47 b
Poultry Litter @ 120	0	120		--	--	57 c	37 b
Poultry Litter @ 160	0	160		--	--	67 bc	47 b

† Sources and treatments changed each year which accounts for missing data for those years when that treatment was not included in test. Values followed by the same letter are not significantly different within year at $P<0.05$.
‡N applied at planting as ammonium nitrate (34-0-0). Source variables were all applied as a side dressing at V8 stage.

Table 2. Treatments and COTTON yields, 2007-2011.†							
Source	Total N @ Planting‡	Total N @ sidedressing‡	Year				
			2007	2008	2009	2010	2011
	-------pounds/acre--------		------------------lb. lint/acre-------------				
No N	0	0		360 d	400 f	390 b	570 c
$CaCl_2$	0	0		300 d	340 f	--	--
Am. nitrate	20	70		840 b	770 ab	460 ab	1310 ab
Am. nitrate 4/3	20	100		950 ab	--	460 ab	1140 b
Urea-am. sulfate blend	20	70		--	740 abc	560 a	1200 ab
Urea	20	70	No Yield – Severe drought	990 a	700 abcd	420 ab	1150 b
Urea + Agrotain®	20	70		950 ab	720 abcd	470 ab	1150 b
Urea + Nutrisphere N®	20	70		--	--	420 ab	1150 b
UAN solution	20	70		700 c	640 de	420 ab	1270 ab
UAN + $CaCl_2$	20	70		890 ab	.740 abc	--	--
UAN + Agrotain®	20	70		920 ab	760 abc	420 ab	1280 ab
UAN + Nutrisphere N®	20	70		--	--	400 b	1380 a
UAN 2/3	20	40		890 ab	740 abc	--	--
UAN 2/3 + $CaCl_2$	20	40		700 c	590 e	--	--
Nitamin Nfusion®	20	70		860 ab	--	460 ab	--
Nitamin Nfusion® 2/3	20	40		690 c	--	--	--
ESN	20	70		--	.--	--	1100 b
Poultry Litter @ 120	0	120		--	690 bcd	460 ab	1110 b
Poultry Litter @ 160	0	160		--	780 a	510 a	1200 ab

† Sources and treatments changed each year which accounts for missing data for those years when that treatment was not included in test. Values followed by the same letter are not significantly different within year at $P<0.05$.
N applied at planting as ammonium nitrate (34-0-0). Source variables were all applied as a side dressing at V8 stage.

Table 3. Total N in corn ear leaves at silking and cotton leaf blades at early bloom in 2010.

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

† 28-0-0-5S

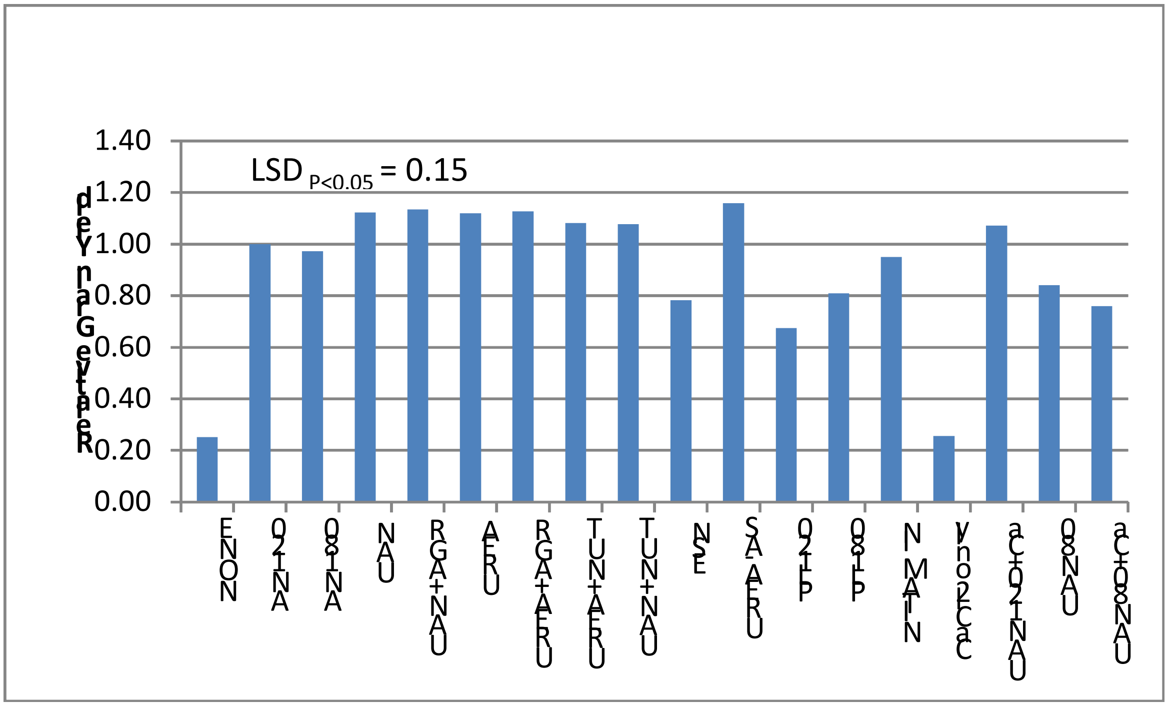

Fig. 3. Mean relative CORN GRAIN YIELDS (2008-2011) from different products when applied as a sidedress at the recommended rate of 120 pounds total N per acre. Some products were applied at a higher or lower rate as indicated in parentheses. AN=ammonium nitrate; UAN=urea-ammonium nitrate liquid; PL=poultry broiler litter; AGR=Agrotain®; NUT= Nutrisphere N®; ESN=ESN® nitrogen.

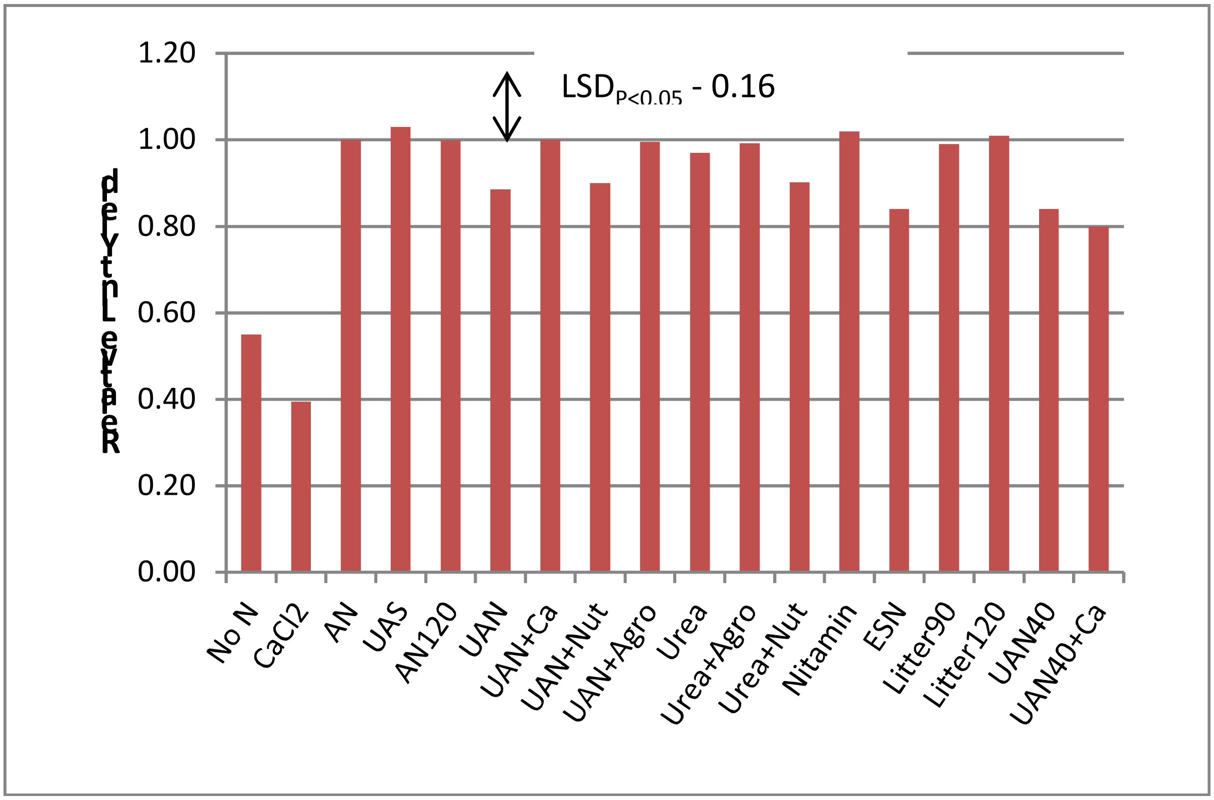

Fig. 4. Mean relative COTTON LINT YIELDS (2008-2010) from different products when applied as a sidedress at the recommended rate of 90 pounds total N per acre. Some products were applied at a higher or lower rate as indicated. AN=ammonium nitrate; UAN=urea-ammonium nitrate liquid; PL=poultry broiler litter; AGR=Agrotain®; NUT= Nutrisphere N®; ESN=ESN® nitrogen.

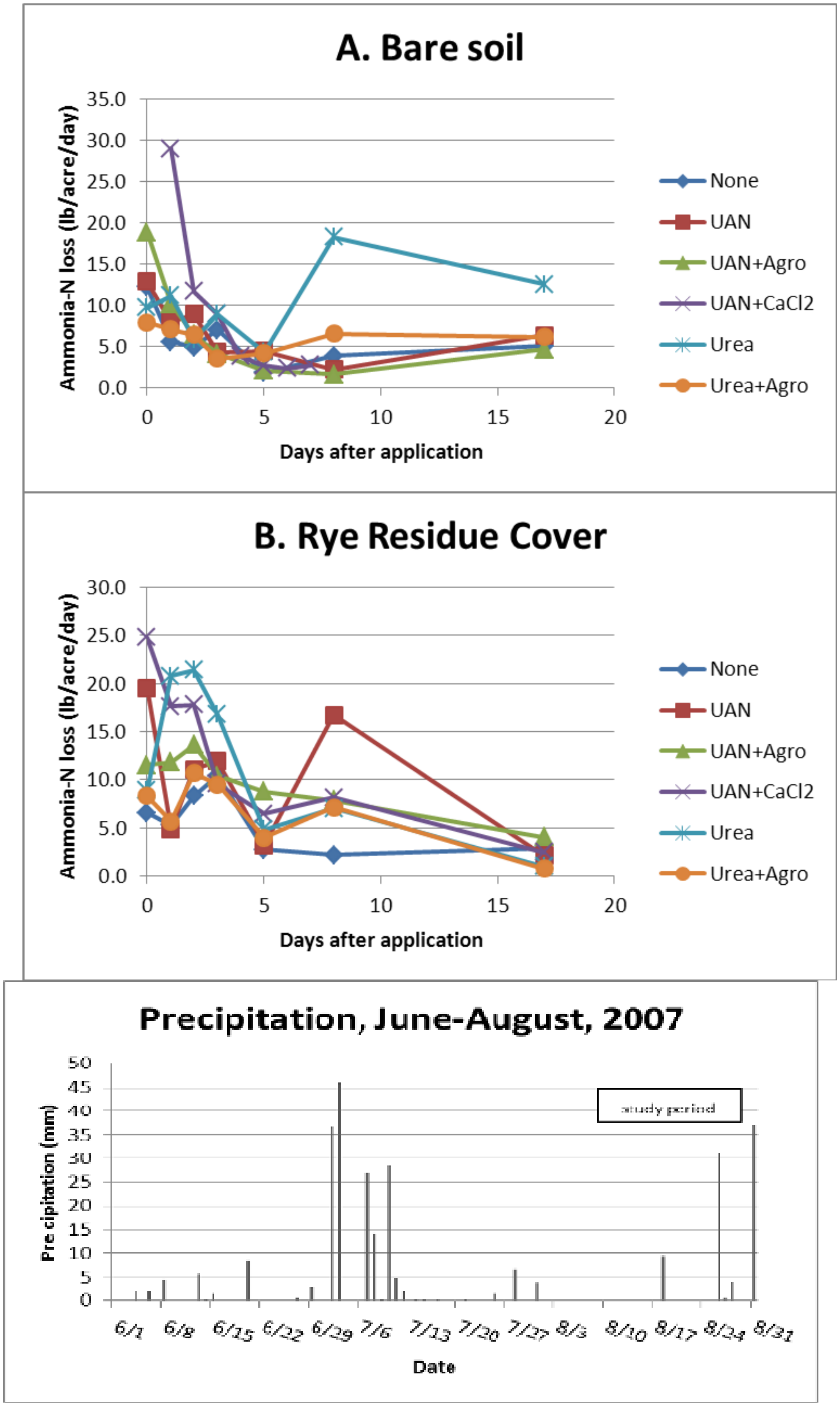

Fig. 5. Ammonia volatilization in 2007 from several N sources after application on 10 August to (a) bare soil and (b) rye residue cover.

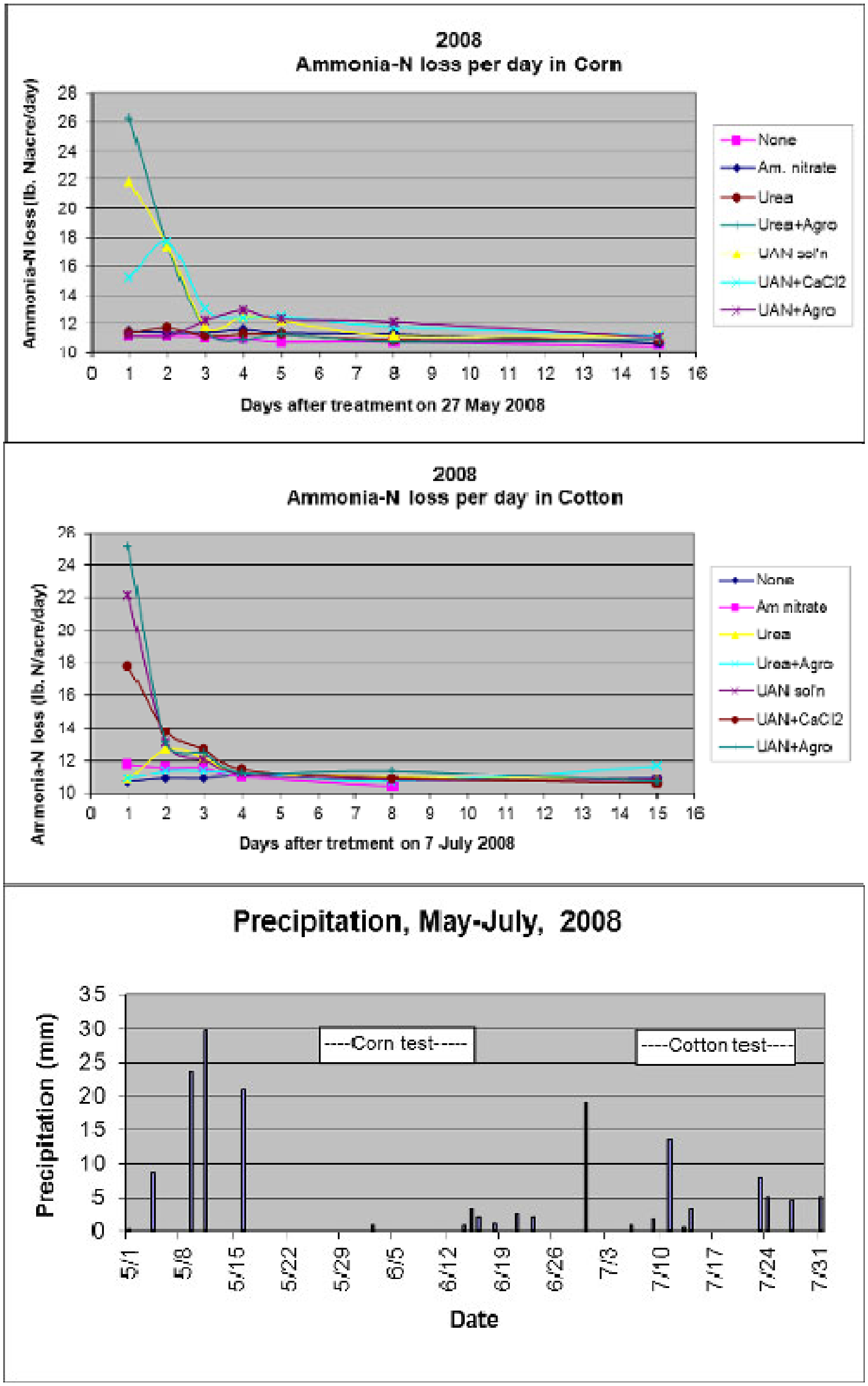

Fig. 6. Ammonia volatilization in 2008 from several N sources after application as sidedress on corn (27 May) and cotton (7 July) and precipitation during the same period. Agro = Agrotain®.

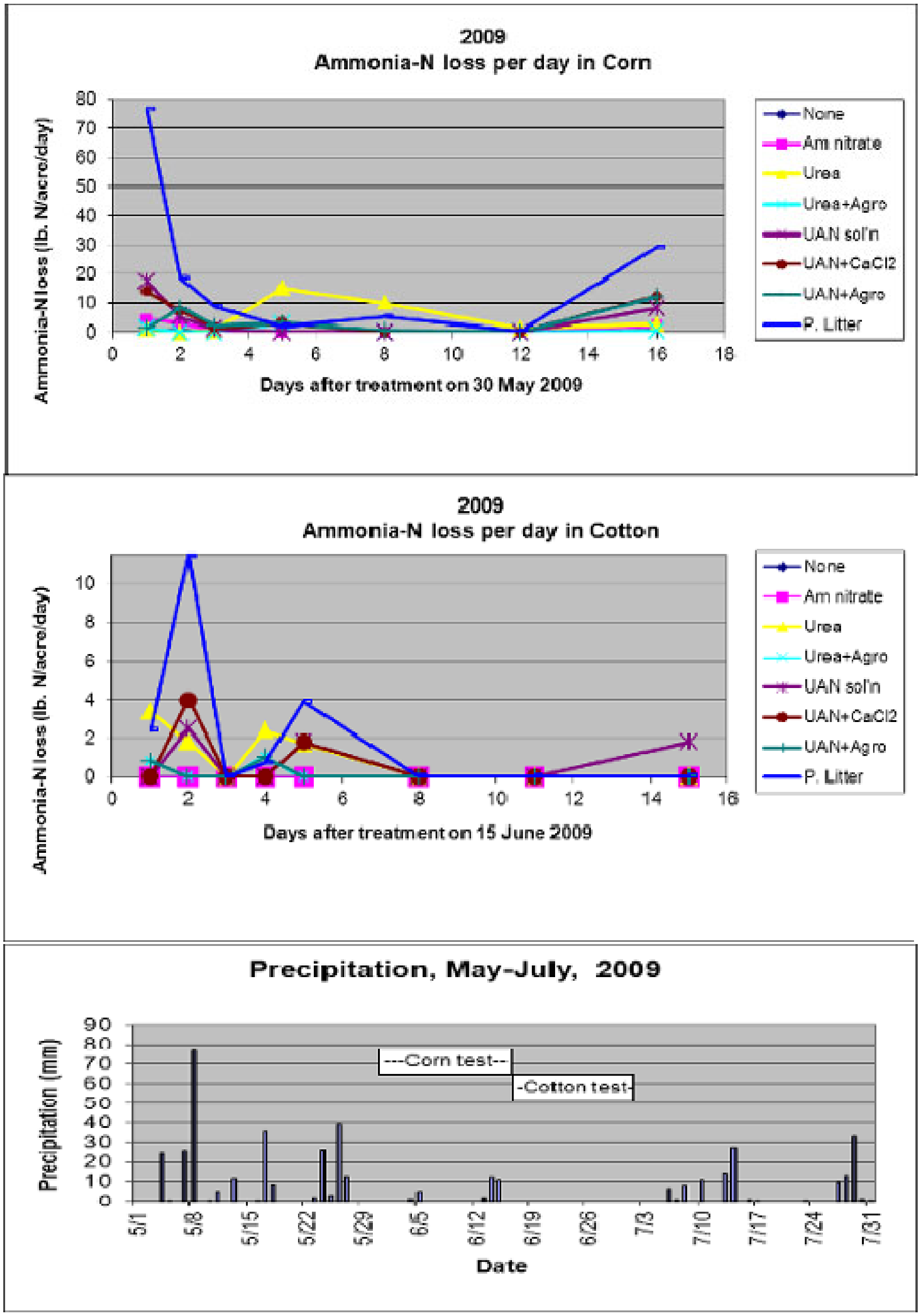

Fig. 7. Ammonia volatilization in 2009 from several N sources after application as sidedress on corn (31 May) and cotton (15 June) and precipitation during the same period. Agro = Agrotain®.