W 1221

PERFORMANCE OF ENHANCED EFFICIENCY NITROGEN FERTILIZERS AND SIDEDRESS NITROGEN PLACEMENT METHODS IN DRYLAND CORN

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Broadcast application of sidedress nitrogen (N) fertilizer allows an applicator to cover a significant number of acres in less time. However, urea-based N left on the soil surface within the first three days after application without incorporation is susceptible to ammonia volatilization. The advent of high clearance applicators has promoted the use and adoption of different methods of sidedress N placement of liquid urea ammonium nitrate (UAN) fertilizers'. Producers may use injection nozzles behind a coulter (in-ground) or surface application using sprayer that is outfitted with broadcast nozzles, row middle drop nozzles, or precision placement near rows with a Y-Drop-type dribble system. Depending on availability and logistical constraints such as equipment failures, a grower may opt for a particular application technique. Evaluations of N stabilizers across different cropping systems have revealed that the choice of N placement method at planting can limit the effectiveness of N stabilizers on ammonia volatilization and crop yield. Previous studies have focused on the impact of placement method on the efficacy of enhanced efficiency N fertilizer (EENF) products at planting. Detailed information on EENF is addressed in the UT Extension publication PB 1888 Enhanced Efficiency Nitrogen Fertilizer as a Tool to Control Nitrogen Loss in Row Crop Production. Research on the performance of N stabilizers on sidedress N placement method has been limited hence the necessity to address this knowledge gap.

A three-year trial was conducted at the West Tennessee AgResearch and Education Center at Milan, Tennessee, to (i) measure N volatilization losses from sidedress surface UAN and urea treatments, (ii) evaluate commonly used sidedress liquid and dry N materials with and without ANVOL urease inhibitor, and (iii) compare typical sidedress UAN placement methods (broadcast spray, row middle, Y-drop, in-ground behind coulter) for corn yield. Plots were four rows wide by 30 feet long and each treatment was replicated four or six times depending on the year in a randomized complete block design (Figure 1). At-planting, 60 lbs N/acre (ammonium nitrate or treated urea) was spread with a 10-foot Gandy drop spreader. Side-dress N was applied between V4 to V6 stage corn at 120 lbs N/acre. The 13 N treatments evaluated in this trial were a combination of N stabilizers with sidedress N placement methods (Table 1). Only 9 N treatments (the treatments with asterisks in Table 1) were evaluated for ammonia volatilization due to logistical constraints. Information about the EENFs used in this work are listed in Table 2.

All dry N fertilizers were weighed according to N content and rate, bagged, and then hand spread uniformly across plots. Ammonia volatilization losses were monitored using a semi-open, static chamber method by Dillion et al., 2012 (Figure 2). Chambers were installed in the middle row within plots. The air temperature both inside and outside the tube was measured using HOBO Pendant Temp/Alarm 8K data loggers. Ammonia loss was measured on 1, 3, 5, 7, 9, 11, 13 and 21 days after fertilizer application. The two center rows in each plot were harvested for grain yield at maturity. The four UAN placement methods are described briefly below.

Broadcast — The UAN (32 percent) was broadcast applied onto the soil surface with a small plot tractor mounted with a 10-foot spray boom (Figure 3a).

Dribble — Drop tubes were attached to the broadcast boom for row middle dribble application onto the soil surface (Figure 3b).

Y-Drop — Split drop tubes directed UAN four to six inches on both sides of each row for Y-drop treatments (Figure 3c).

Injected — A four-row rig injected UAN into slot behind coulters running in each row middle (Figure 3d).

Treatment #	Treatment Name
1*	Urea
2*	Urea + ANVOL
3*	SuperU
4*	ESN
5*	Ammonium Nitrate
6*	Dribbled UAN
7*	Dribbled UAN + ANVOL
8*	Injected UAN
9*	Injected UAN + ANVOL
10*	Y Drop UAN
11*	Y Drop UAN + ANVOL
12*	Broadcast UAN
13*	Broadcast UAN + ANVOL

Table 1. *Sideress N fertilizer treatments*

*Treatments evaluated for ammonia volatilization ESN, Environmentally Smart Nitrogen; UAN, Urea Ammonium Nitrate

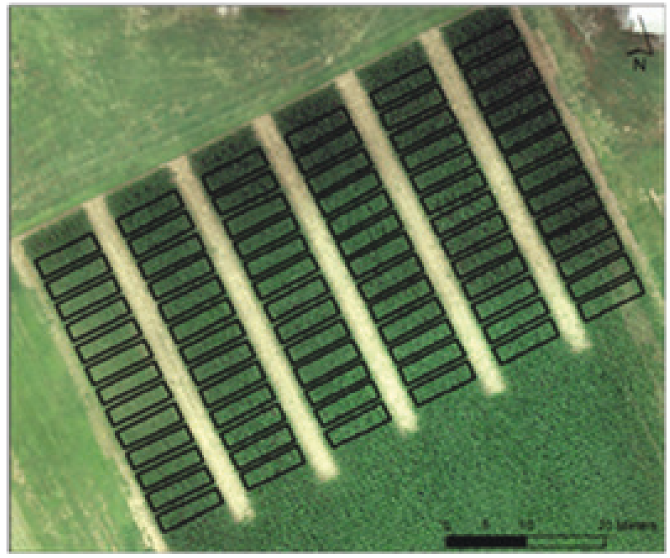

Figure 1. *Aerial image of experiment layout*

N Stabilizer	Company	Name and Concentration (%) of Active Ingredient	Rate (qt/ton)
ANVOL	Koch Inustries, Wichita, KS, USA	NBPT (10%-20%); Duromide (20%-30%); N-methyl-2-pyrrolidone (<10%)	1.50 (Urea) and 0.75 (UAN)
ESN	Agrium US Inc, Alberta, Canada	Urea (>95%); Caster oil (4%); Imidodicarbonic Diamide (<1%); Urea, reaction products with formaldehyde	N/A
SuperU	Koch Industries, Witchita, KS, USA	Urea (60%-10%); DCD (0.5-1.5%); NBPT (<0.1%); N-Methyl-2-pyrrolidone (<0.1%)	N/A

Table 2. *EENF evaluated in this trial included Environmentally Smart Nitrogen, Super U, ANVOL*

Figure 2. *Semi-chamber method. The chambers were constructed using transparent Plexiglas cylinders installed into the soil at a depth of 6 inches. A 1-inch thick circular polyurethane foam sponge treated with 0.73 M phosphoric acid and 33 percent glycerol was tightly placed in each chamber about 12 inches above the soil surface to capture volatilized ammonia from fertilizer and soil. A second treated sponge was placed flush with the top of the chamber, to absorb atmospheric ammonia. A cross section of PVC pipe was fixed on top of the chambers and then covered with 19-liter buckets to allow air circulation and to protect the chambers from rain.*

Figure 3. *UAN placement methods (a) UAN broadcast demonstration, (b) UAN row middle demonstration, (c) Y-Drop demonstration, and (d) Injecting UAN demonstration.*

Ammonia volatilization

Maximum ammonia losses occurred within three days of application for the untreated N fertilizers. However, the loss was much more pronounced for urea than UAN, regardless of the placement method (Figure 4). Urea has a higher volatilization potential than UAN because it has twice as much urea per unit of N when compared to UAN. Also, more than 90 percent of the total ammonia loss during the 21-day sampling period occurred within the first five days. Urea hydrolysis following urea-based fertilizer application spike soil pH. So, this temporarily rise in pH increases the rate of the conversion of ammonium to ammonia. The rapid loss during this short window is a result of the hydroxide (OH-) ions released during the urea hydrolysis process. When ammonium ions react with hydroxide ions, they form ammonia and water. The ammonia can easily escape to the atmosphere. The peak ammonia loss from untreated urea or UAN fertilizers occurred earlier with a significantly higher loss compared to their EENF forms. Therefore, EENF products such as ANVOL, Super U and ESN are recommended if incorporation of urea or UAN into the soil by tillage, rainfall or irrigation is not possible or desirable within a few days after N fertilizer application. In addition, EENFs that are classified as urease inhibitors such as ANVOL are also recommended when urea-based fertilizers will be applied onto a saturated soil without standing water.

Over the three years, ammonia loss from untreated urea (24 percent of applied sidedress N) was higher than the untreated UAN that was surface broadcast (17 percent of applied side-dress N) or dibbled between the rows (13 percent of applied sidedress N) (Figure 5). This suggests that surface broadcast urea is much more susceptible to ammonia volatilization when compared to surface broadcast UAN at the same application rate. Also, surface broadcast UAN was more susceptible to ammonia volatilization compared to UAN dribbled in between rows. All the EENFs products evaluated for ammonia volatilization in these trials reduced ammonia loss from untreated urea by 50 to 90 percent and untreated UAN by 40 to 51 percent (Figure 5).

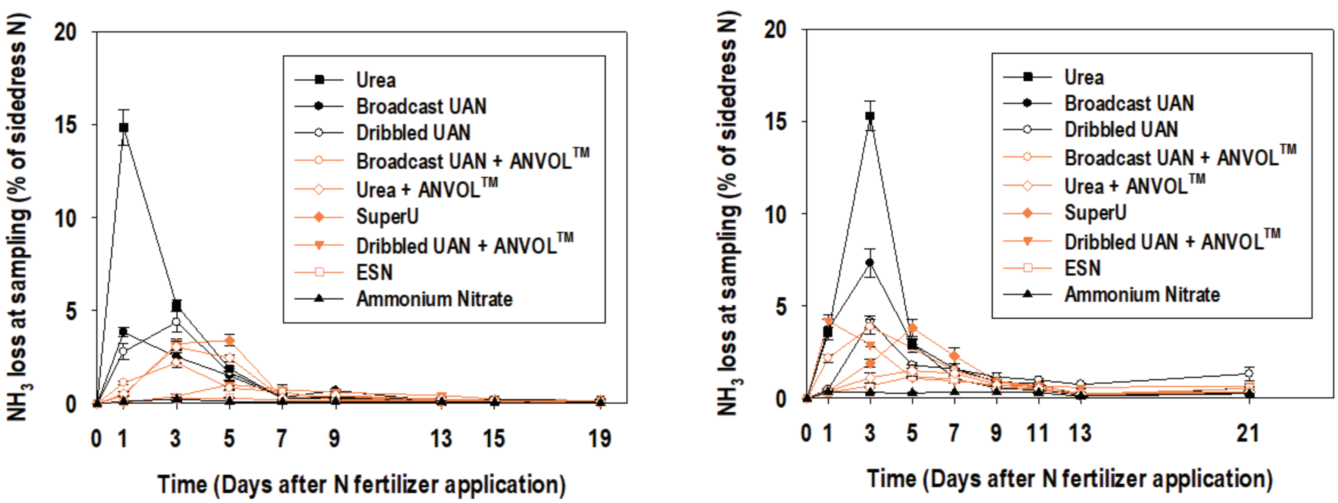

Figure 4. *Mean ammonia loss from N fertilizer treatment combination at time over (a) 19-day period in 2020 and (b) 21-day period in 2021 and 2022.*

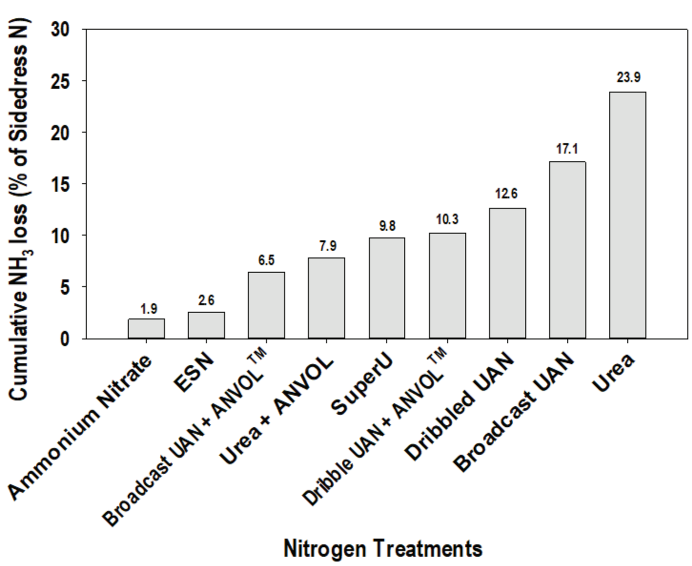

Figure 5. *Mean cumulative ammonia loss from N fertilizer treatments (2020-2022).*

Grain yield

Generally, yields were supported by ammonia loss measurements. Grain yield was highly but negatively correlated (R2 = 0.88) with ammonia volatilization (Figure 6), implying that yield differences could be explained by the ammonia loss measurements. Ammonia volatilization loss resulted in a yield penalty.

Due to in season drought, grain yield data in 2022 was not included in data analysis. Among the liquid fertilizer placement methods, the average yield of broadcast UAN across both years was lower than the other placement methods (Figure 7). The Y-drop placement and dribble between the rows were as effective as injecting UAN behind a coulter without any ANVOL stabilizer. Yield was not improved by adding ANVOL stabilizer when injecting UAN in-ground. However, a yield increase was observed when ANVOL stabilizer was added to both dribble and Y-drop applications. Addition of ANVOL to row-middles (dribble) increased yield the most (+11 bu/A), followed by broadcast UAN (+9 bu/A), and then Y-drop. Of the granular materials tested, untreated urea and ammonium nitrate yielded the least and highest respectively. Super U, urea + ANVOL, and ESN out-yielded the untreated urea by +15, +18, +19 bu/A, respectively.

Generally, the untreated UAN out-yielded untreated urea by 5 to 15 bu/A. However, when urea and UAN were treated with ANVOL, only the row middle dribble treatment out-yielded ANVOL urea.

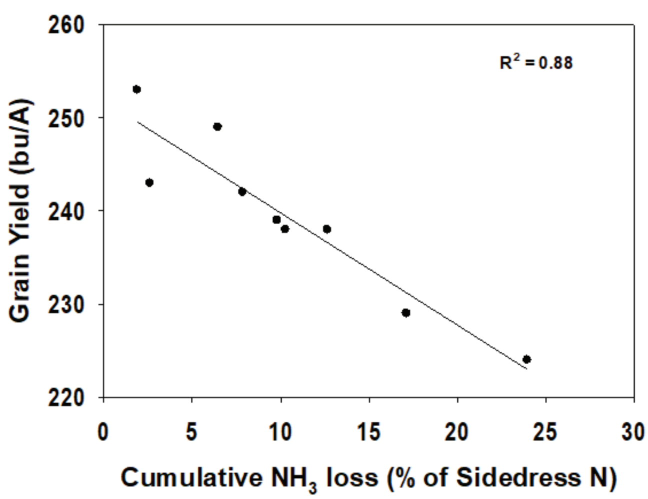

Figure 6. *Relationship between ammonia volatilization loss and grain yield*

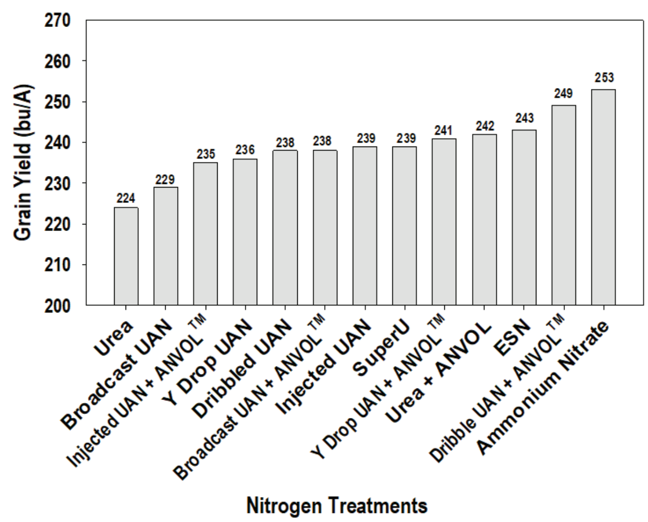

Figure 7. *Mean grain yield of N fertilizer treatment combination (2020 and 2021). Due to in season drought, grain yield data in 2022 was not included in data analysis.*

In conclusion, yield results from this study demonstrate Tennessee producers have multiple options to apply sidedress liquid or dry N successfully in corn for optimal grain yield. Surface-applied urea or UAN tends to more susceptible to N loss via ammonia volatilization, therefore, require an EENF for optimal results.

Further reading

Adotey, N., M.A. McClure and X. Yin. Enhanced Efficiency Nitrogen Fertilizer as a Tool to Control Nitrogen Loss in Row Crop Production, PB 1888. https://extension.tennessee.edu/publications/Documents/PB1888.pdf

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