Evaluation of Ammonium Sulfate Nitrate in Virginia Sweet Corn Production

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INTERPRETIVE SUMMARY

Virginia farmers produce over 3,000 commercial acres of fresh market sweet corn (*Zea mays*) yielding 35 cwt/A and valued in excess of 2.5 million dollars. Fertilizer costs are now a major crop input and farmers are interested in ways to increase their fertilizer use efficiency. Research plots were established at the Virginia Tech Eastern Shore Agricultural Research and Extension Center near Painter, Virginia in Spring 2010 on a Bojac sandy loam (Coarse-loamy, mixed, semiactive, thermic Typic Hapludults). The experiment was arranged as a factorial arrangement of 3 N rates (60, 120, and 180 lbs N/acre) × 3 nitrogen (N) sources [liquid urea-ammonium nitrate (UAN, 30% N), ammonium nitrate (AN, 34% N), and ammonium sulfate nitrate [Sulf-N26, 26% N and 14% sulfur (S)], plus a 0-N control. Two additional treatments were applied and analyzed separately to test for S response. Sulfur as gypsum was applied at Sulf-N26 equivalent rates for 120 lbs N/A (65 lbs S/A) to additional plots fertilized using UAN (UAN + S = UANS) and AN (AN + S = ANS). Yield and ear quality parameters were measured. Sulf-N26 reached maximum yield at 181 lbs N/A (13,654 lbs corn/A) and overall had a lower curve than UAN or AN. Ammonium nitrate had highest yields at 168 lbs N/A while UAN peaked at 120 lbs N/A (15,791 and 15,582 lbs corn/A, respectively). No S fertilizer response was observed in 2010. We are not sure why Sulf-N26 yielded lower than other fertilizer sources in 2010, but feel this N and S fertilizer source warrants further investigation as it had superior yields during 2009 field trials.

INTRODUCTION

The Mid-Atlantic region of the United States produces significant acreage of commercial fresh market sweet corn. Virginia ranks twentieth out of the 26 states with reportable commercial fresh market sweet corn production (USDA-NASS, 2010). On average, Virginia farmers produce over 3,000 commercial acres of fresh market sweet corn yielding 35 cwt/A and valued in excess of 2.5 million dollars (USDA-NASS, 2011). Similar to most vegetable crops, most commercial production occurs in the Chesapeake Bay watershed on the Eastern Shore of Virginia; which is similar to other large vegetable producing states in the Mid-Atlantic. Farmers are cognizant of the environmental and financial consequences of poor fertilizer use efficiency and are always looking for improved fertilizer sources and methods to increase their overall yield and profit.

Nitrogen (N) and sulfur (S) fertilizers are difficult nutrients to manage in crop production systems because they can be leached below the effective root zone with rainfall or irrigation. Plant uptake and utilization of N and S fertilizers are major concerns to farmers because they impact fertilizer use efficiency. Adjusting for inflation, we are experiencing increased fertilizer prices compared to historic values where most fertilizer recommendations were made (USDA-NASS, 2009). Fertilizer costs have increased to the point where they are now a major crop input and farmers no longer have the luxury to over-apply as “insurance” for top yields and are looking for ways to increase their fertilizer use efficiency and profits.

Sulfur may be added to fertilizer sources since S is used in large quantities by sweet corn and readily leaches through the soil profile out of the effective root zone. Varying results have been obtained regarding S fertilization in the Mid-Atlantic. For instance, Kline and coworkers (1989) found that S fertilizer usually increased plant tissue concentrations but rarely increased yields (3 out of 12 site-years). However, when S fertilizer was beneficial, Reneau (1983) found that up to 31 lbs S/A was necessary to achieve 90% maximum yield. The objective of this study is to determine if S containing fertilizers or fertilizers with varying amounts of ammonium or nitrate will increase sweet corn yields in Mid-Atlantic production systems grown using sandy loam soils.

MATERIALS AND METHODS

Research plots were established at the Virginia Tech Eastern Shore Agricultural Research and Extension Center near Painter, Virginia in Spring 2010 on a Bojac sandy loam (Coarse-loamy, mixed, semiactive, thermic Typic Hapludults; surface horizon = 65% sand, 25% silt, 10% clay, and 0.75% organic matter). Painter, Virginia averages 43 inches of precipitation per year, has a mean annual temperature of 59°F and 210 frost free days per year.

The experiment was arranged as a factorial arrangement of 3 N rates (60, 120, and 180 lbs N/acre) × 3 N sources [liquid urea-ammonium nitrate (UAN, 30% N), ammonium nitrate (AN, 34% N), and ammonium sulfate nitrate (Sulf-N26, 26% N and 14% S), plus a 0-N control. Two additional treatments were applied and analyzed separately to test for S response. Sulfur as gypsum was applied at Sulf-N26 equivalent rates for 120 lbs N/A (65 lbs S/A) to additional plots fertilized using UAN (UAN + S = UANS) and AN (AN + S = ANS). Sulf-N26, AN, ANS, and gypsum were weighed and broadcast applied by hand to plots. Liquid UAN and UANS were applied with a calibrated backpack CO_2 sprayer. All N treatments were 50-50% split applied between at-planting (broadcast applied and incorporated) and knee high (~18 inches tall; band applied to soil surface). Phosphorus, potassium, other macro and micronutrients, and production practices were based on Virginia Cooperative Extension Recommendations (Kuhar et. al., 2010). Conventionally tilled 'Devotion' sweet corn was planted in 4 row plots that were 30 ft long and set on a 30" row spacing. The middle two rows of each plot were harvested by hand. Corn ear diameter, ear length, and percentage kernel fill were measured from 5 ears from each plot. The experiment was arranged in a randomized complete block design and replicated four times in a factorial arrangement of 3 N sources × 3 N rates + 2 S comparisons + a 0-N/S control. Data were analyzed using the SAS system and means separated using Fisher's protected least significant difference test (LSD) at $p = 0.10$ that was established *a priori*.

RESULTS AND DISCUSSION

Comparing the data subset that had 120 lbs N/A applied and 65 lbs S/A, it does not appear that corn plots were S deficient during the 2010 growing season (Table 1). Overall, plots fertilized with S were statistically similar in total yields, marketable yields, and overall percentage of ears that were marketable. Similarly, corn ear quality parameters of ear diameter, length, and percentage fill were statistically the same whether or not S fertilizer was included (Table 2). However, it is clear that N fertilizer benefited corn as no fertilizer control plots had lower marketable yields, total yields, percentage ears that were marketable, smaller ear diameters, and shorter ear lengths than N fertilized plots (Table 1 and 2).

Comparing the factorial treatment structure of N source × N rates, regression equations were established for each N source used and graphed against N rate applied (Fig. 1). Overall, all N sources reacted in a quadratic fashion as N rates increased. Sulf-N26 reached maximum yield at 181 lbs N/A (13,654 lbs corn/A) and overall had a lower curve than UAN or AN. Ammonium nitrate had highest yields at 168 lbs N/A while UAN peaked at 120 lbs N/A (15,791 and 15,582 lbs corn/A, respectively) (Fig. 1). Overall, UAN had the highest partial factor productivity of the three N sources by producing 130 lbs corn per lb N fertilizer applied (94 and 75 lbs corn/lb N for AN and Sulf-N26, respectively). Plots were not responsive to Sulf-N26 S fertilizer additions, possibly due to the low S leaching potential during the 2010 growing season from a moderate drought (Fig. 2). However, we are not sure why Sulf-N26 did not have similar yields to traditional AN and UAN fertilizer sources as all fertilizers were applied on a N-basis.

The factorial N source × N rate treatment structure was also compared using ANOVA. Overall, the N source × N rate interaction was not significant and all data is presented as main effects. Therefore, N source data is averaged across all N rate treatments and all data presented as N rates is averaged across all N source treatments. For the N source yield main effect, AN and UAN had higher marketable and total yields than Sulf-N26 (Table 3). Ear length was shorter using Sulf-N26 when compared to UAN or AN, suggesting less fertilizer availability or delayed maturity (Table 4). Comparing the N rate main effect, 120 lbs N/A was sufficient for producing highest marketable yields, highest total yields, highest percentage of marketable yields, and widest ear diameter (Tables 5 and 6), averaged across N sources.

CONCLUSION

In conclusion, 2010 data varied from 2009 where Sulf-N26 was similar to other N fertilizers. We did not see a S fertilizer response regarding yield or ear quality. Using Sulf-N26, yield was decreased compared to AN and UAN fertilizer sources. However, we do not understand why yields or ear quality was decreased using Sulf-N26. More research is necessary to quantify Sulf-N26 S and N release patterns to ensure that this fertilizer source is timed properly with sweet corn plant uptake and irrigation regimes. Sulf-N26 was a superior fertilizer sources during the 2009 growing season and warrants further investigation as a sweet corn N and S fertilizer source for Mid-Atlantic vegetable producers.

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TABLES AND FIGURES

Table 1. Average sweet corn ear weight, marketable yield, total yield, and percent of yield that was marketable for various nitrogen sources applied at 120 lbs N/A on the Eastern Shore of Virginia on a Bojac sandy loam. Sulfur containing sources had 65 lbs S/A applied.

Nitrogen Source	Ear Weight	Marketable Yield	Total Yield	Marketable
	---grams---	----------------lbs/A----------------		----%----
Control	211 a†	6,795 c	9,111 c	73.8 c
Ammonium nitrate	251 a	12,857 ab	14,498 ab	88.5 ab
Ammonium nitrate + Sulfur	240 a	13,199 ab	14,411 ab	91.5 a
Sulf-N26	233 a	11,006 b	13,358 b	82.0 b
Urea ammonium nitrate	199 a	14,346 a	15,682 a	91.5 a
Urea ammonium nitrate + Sulfur	244 a	11,420 b	13,489 ab	84.3 b
$LSD_{0.10}$	60	2,466	2,203	6.9

†Within each column, means followed by different letters are significantly different at *p*=0.10 and were separated using Fisher's protected least significant difference tests.

Table 2. Average sweet corn ear diameter, ear length, and percentage filled kernels for various nitrogen sources applied at 120 lbs N/A on the Eastern Shore of Virginia on a Bojac sandy loam. Sulfur containing sources had 65 lbs S/A applied.

Nitrogen Source	Diameter	Length	Fill
	-----mm-----	-----cm-----	----%----
Control	42.9 c†	18.2 c	95.7 ab
Ammonium nitrate	43.8 bc	19.0 abc	91.5 b
Ammonium nitrate + Sulfur	44.6 ab	18.5 bc	95.2 ab
Sulf-N26	45.1 ab	18.4 c	96.0 a
Urea ammonium nitrate	46.0 a	19.4 ab	98.5 a
Urea ammonium nitrate + Sulfur	45.8 a	19.5 a	98.3 a
$LSD_{0.10}$	1.7	0.9	4.3

†Within each column, means followed by different letters are significantly different at *p*=0.10 and were separated using Fisher's protected least significant difference tests.

Table 3. Average sweet corn ear weight, marketable yield, total yield, and percent of yield that was marketable for various nitrogen sources on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N rates.

Nitrogen Source	Ear Weight	Marketable Yield	Total Yield	Marketable
	---grams---	----------------lbs/A----------------		----%----
Control	211 a†	6,795 c	9,111 c	73.8 b
Ammonium nitrate	248 a	13,066 a	14,806 a	87.9 a
Sulf-N26	226 a	10,757 b	12,761 b	83.7 a
Urea ammonium nitrate	29 a	12,620 a	14,481 a	86.7 a
$LSD_{0.10}$	30	1,553	1,242	4.9

†Within each column, means followed by different letters are significantly different at *p*=0.10 and were separated using Fisher's protected least significant difference tests.

Table 4. Average sweet corn ear diameter, ear length, and percentage filled kernels for various nitrogen sources on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N rates.

Nitrogen Source	Diameter	Length	Fill
	-----mm-----	-----cm-----	----%----
Control	42.9 c†	18.2 c	95.7 ab
Ammonium nitrate	44.4 b	19.2 ab	93.2 b
Sulf-N26	44.8 ab	18.8 b	94.1 b
Urea ammonium nitrate	45.8 a	19.5 a	97.3 a
$LSD_{0.10}$	1.0	0.5	2.9

†Within each column, means followed by different letters are significantly different at *p*=0.10 and were separated using Fisher's protected least significant difference tests.

Table 5. Average sweet corn ear weight, marketable yield, total yield, and percent of yield that was marketable for various nitrogen rates on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N sources.

Nitrogen Rate	Ear Weight	Marketable Yield	Total Yield	Marketable
	---grams---	----------------lbs/A----------------		----%----
0	211 a†	6,795 c	9,111 c	73.8 c
60	231 a	10,827 b	13,037 b	82.6 b
120	228 a	12,737 a	14,513 a	87.3 ab
180	244 a	12,879 a	14,498 a	88.4 a
$LSD_{0.10}$	30	1,553	1,242	4.9

†Within each column, means followed by different letters are significantly different at *p*=0.10 and were separated using Fisher's protected least significant difference tests.

Table 6. Average sweet corn ear diameter, ear length, and percentage filled kernels for various nitrogen rates on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N sources.

Nitrogen Rate	Diameter	Length	Fill
	-----mm-----	-----cm-----	----%----
0	42.9 c†	18.2 b	95.7 a
60	44.2 b	19.1 a	93.2 a
120	45.0 ab	18.9 a	95.3 a
180	45.9 a	19.4 a	96.1 a
$LSD_{0.10}$	1.0	0.5	2.9

†Within each column, means followed by different letters are significantly different at *p*=0.10 and were separated using Fisher's protected least significant difference tests.

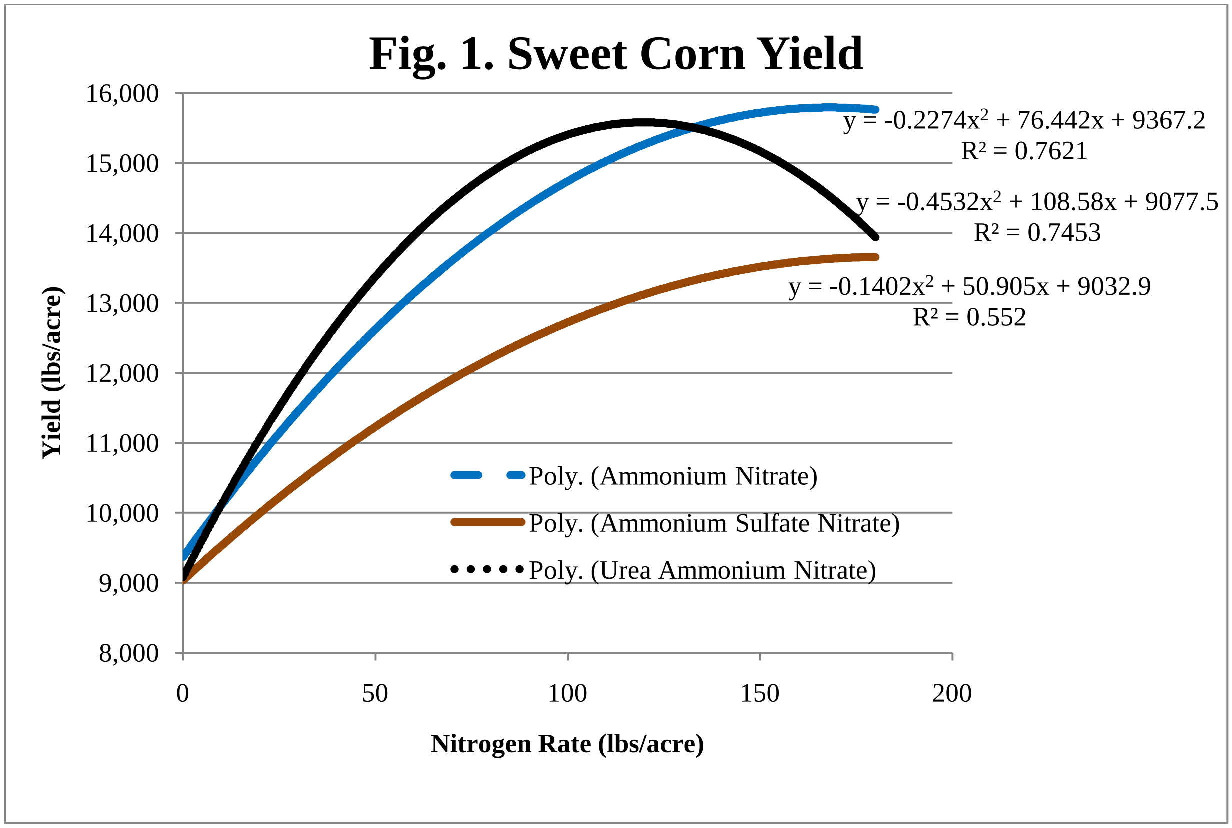
Fig. 1. Sweet Corn Yield
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
Yield (lbs/acre)
0
50
100
150
200
Nitrogen Rate (lbs/acre)
y = -0.2274x2 + 76.442x + 9367.2
R² = 0.7621
y = -0.4532x2 + 108.58x + 9077.5
R² = 0.7453
y = -0.1402x2 + 50.905x + 9032.9
R² = 0.552
Poly. (Ammonium Nitrate)
Poly. (Ammonium Sulfate Nitrate)
Poly. (Urea Ammonium Nitrate)

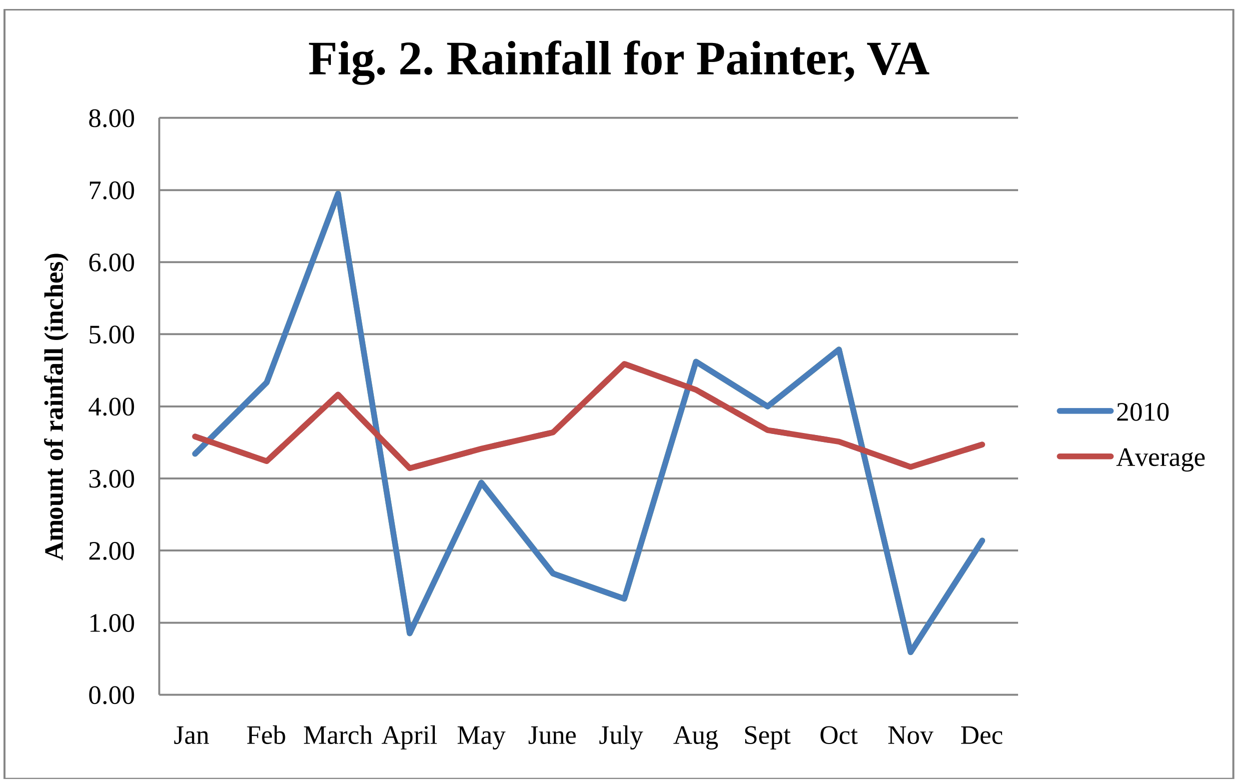
Fig. 2. Rainfall for Painter, VA
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Amount of rainfall (inches)
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
2010
Average