SUSTAINABLE NITROGEN FERTILIZER REGIMES FOR SNAP BEANS IN VIRGINIA

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ABSTRACT

Over 5,500 acres of snap beans (*Phaseolus vulgaris*) are grown in Virginia per year within the environmentally sensitive Chesapeake Bay watershed. The objective of this study was to pinpoint correct nitrogen (N) rates and fertilizer sources containing varying amounts of ammonium, nitrate, or other N forms. The experiment was arranged as a factorial arrangement of 3 N rates (40, 80, and 120 lbs N/acre) × 5 N sources [liquid urea-ammonium nitrate (UAN, 30% N), calcium nitrate (CN, 17% N), ammonium nitrate (AN, 34% N), ammonium sulfate nitrate (Sulf-N26, 26% N and 14% S), and urea + dicyandiamide (DCD) nitrification inhibitor (UDCD, 46% N)] plus a 0-N control on a Bojac sandy loam. Two additional treatments of AN and UAN had gypsum applied at the equivalent 43 lbs sulfur (S)/A along with 80 lbs N/A to allow sulfur treatment comparison (ANS and UANS, respectively). The study was repeated as a spring and fall planting. For the spring crop, we suspect that record rain events leached N fertilizer below the root zone as no source had significantly higher yields than the 0-N control, except UDCD (4477 vs. 5639 lbs/acre, respectively). Fall treatments suggested that all N sources had statistically similar yields and were higher than the 0-N control (6703 vs. 4296 lbs/acre, respectively). A quadratic relationship indicted that 80 lbs N/acre was optimum for maximum yields (7200 lbs/acre). Sulfur did not appear limiting in this study and did not offer a yield advantage to no-S treatments, but did reduce rust disease incidence.

INTRODUCTION

The Commonwealth of Virginia has substantial snap bean (*Phaseolus vulgaris*) acreage and currently ranks seventh out of the 12 commercial fresh market snap bean producing states in the nation (USDA-NASS, 2010). On average, Virginia produces 5,500 acres of fresh market snap beans annually that are worth 4.5 million dollars (USDA-NASS, 2010). Nearly all commercial Virginia fresh market snap bean production occurs in the Chesapeake Bay watershed with most occurring on the Eastern Shore of Virginia. Of all the snap beans produced, nearly all are produced using conventional tillage regimes due to trash concerns during harvest and disease problems (Reiter, 2009). Eastern Shore of Virginia production systems have similar soils, production, and environmental concerns as other large vegetable producing areas in the Mid-Atlantic and utilizing conservation agricultural systems would be beneficial. However, conservation tillage systems need more research for snap bean production; therefore, improving nitrogen fertility is a way to make these vegetable production systems more sustainable in the short term. Farmers utilizing intensive vegetable production systems in the Mid-Atlantic understand the sensitivity of the ecosystem in which they operate and are establishing sustainable farming practices to increase fertilizer use efficiency to reduce nutrient losses to the environment.

Overall, N fertilizer is the most difficult nutrient to manage in crop production systems because it can be lost from the effective root zone or immobilized into unavailable N forms via numerous environmental pathways. Plant uptake and utilization of N fertilizer is a major concern to farmers because it impacts fertilizer use efficiency. In 2008, nitrogen (N) fertilizer prices doubled in a year and were over 400% higher than baseline values 10 years earlier (USDA-NASS, 2009). Nitrogen prices have since decreased, but we are still experiencing fertilizer prices nearly double 10 years earlier and we expect prices to increase again in the future as the economy improves and energy prices rise again. 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 add value.

Value-added fertilizer sources may contain other nutrients, such as sulfur (S), or additives that increase nitrogen fertilizer use efficiency. Sulfur may be added to fertilizer sources since S is used in large quantities by snap beans and readily leaches through the soil profile out of the effective root zone. Since sulfur reacts similar to nitrogen regarding movement from irrigation and rainfall, it is intuitive to mix these two nutrients and apply them similarly. Additives, such as dicyandiamide (DCD), can be included with fertilizer sources to effectively reduce nitrification following fertilizer application. Keeping fertilizer sources in the ammonium forms may retard leaching since the cation can fix to the soil's cation exchange complex. The objective of this study is to determine if sulfur containing fertilizers, fertilizers with varying amounts of ammonium or nitrate, or fertilizers with a nitrification inhibitor will increase yields in Mid-Atlantic snap bean production systems.

MATERIALS AND METHODS

Research plots were established at the Virginia Tech Eastern Shore Agricultural Research and Extension Center near Painter, Virginia in Spring and Fall 2009 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) (USDA-NRCS, 2010). Painter, Virginia averages 43 inches of precipitation per year, has a mean annual temperature of 59°F and 210 frost free days per year (NOAA-NWS, 2010).

The experiment was arranged as a factorial arrangement of 3 N rates (40, 80, and 120 lbs N/acre) × 5 N sources [liquid urea-ammonium nitrate (UAN, 30% N), calcium nitrate (CN, 17% N), ammonium nitrate (AN, 34% N), ammonium sulfate nitrate (Sulf-N26, 26% N and 14% S), and urea + DCD nitrification inhibitor (UDCD, 46% N)], plus a 0-N control. Two additional treatments were applied and analyzed separately to test for sulfur response. Sulfur as gypsum was applied at Sulf-N26 equivalent rates for 80 lbs N/A (43 lbs S/A) to additional plots fertilized using UAN (UAN + S = UANS) and AN (AN + S = ANS). Sulf-N26, AN, ANS, UDCD, and gypsum were weighed and broadcast applied by hand to plots. Liquid UAN, UANS, and CN 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 early bloom (band applied to soil surface). Phosphorus, potassium, other macro and micronutrients, and production practices were based on Virginia Cooperative Extension Recommendations (Wilson et. al., 2010). Conventionally tilled 'Bronco' snap beans were planted in 4 row plots that were 30 ft long and set on a 36" row spacing. The second row of each plot was mechanically harvested and pods were graded according to size. During the fall experiment, common rust (*Uromyces* *appendiculatus*) naturally occurred and spread due to cool and wet conditions. Disease was assessed by rating the percentage of infected leaf area using a visual rating at early bloom (James, 1971). The experiment was arranged in a randomized complete block design and replicated four times in a factorial arrangement of 5 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

Spring snap bean yield data did not have a significant N source × N rate interaction and was not significant by N rate; therefore, only N source will be discussed and data is averaged across N rate treatments (Table 1). Overall, it appears that most of the N applied was lost via leaching or denitrification. The 2009 Spring growing season was extremely wet (Fig. 1) and it is evident that fertilizer N was not present during the growing season since nearly all N source applications were statistically similar to the 0-N control (Table 1). The urea treatment that included DCD did have higher yields (5639 lbs/A) than the no-fertilizer control, AN, and UAN (4477, 4341, and 4219 lbs/A, respectively) (Table 1). Comparing the subset of data that included UAN, AN, UANS, ANS, and Sulf-N26 at 80 lbs N/A, no treatment was statistically different than the 0-N control. Generally, snap bean size distributions mirrored total yield regarding N source effects.

Fall snap bean treatments varied significantly from the Spring fertilizer trial. Similar to the Spring trial, the N source × N rate interaction was not significant and only main effects will be discussed. For N source, all treatments were statistically similar but higher than the 0-N control (4296 lbs/A), averaged across N rates (Table 2). No differences were observed between N sources regarding yield for sieve sizes 1, 2, 3, and 4, but CN, Sulf-N26, and UAN trended towards larger pods (size 5) than other sources (Table 2). For N rate, 80 lbs N/A was necessary for highest yields (7200 lbs/A), averaged across N sources (Table 3). Sulfur treatments were compared by comparison of a sub-set of data that was applied at 80 lbs N/A and 43 lbs S/A (Table 4). Overall, sulfur did not appear to be deficient in these soils as treatments without sulfur application were statistically similar to treatments that had sulfur applications. However, the sulfur containing Sulf-N26 fertilizer (5.7%) had significantly less leaf area infected with rust disease then the control, UAN, UDCD, and AN (22.5, 13.8, 11.8, and 11.4%, respectively) (Table 5).

CONCLUSION

Overall, the preliminary data indicate that DCD may increase snap bean yields by increasing N fertilizer use efficiency. In wet years, keeping N fertilizer in the ammonium form may increase sorption on the cation exchange complex and reduce leaching due to nitrate formation. Reduction of nitrate losses will reduce N fertilizer loading into groundwater that ultimately ends up in sensitive waterways such as the Chesapeake Bay. Sulf-N26 and CN are acceptable fertilizers for snap bean producers in the Mid-Atlantic utilizing sandy loam soils; however, they may not offer increased yields or fertilizer use efficiency over more common N sources such as UAN or AN when applied using current fertilizer regimens. Sulfur additions did not appear to significantly increase yield, but did reduce overall disease incidence. More research needs to be conducted concerning N source, N rate, and S fertilization for snap bean production systems and the economic and environmental benefits of using fertilizer additives such as nitrification inhibitors.

REFERENCES

James, W.C. 1971. A manual of assessment keys for plant diseases. APS Press, Saint Paul, MN.

NOAA-NWS. 2010. Observed weather reports. Available at: http://mi.nws.noaa.gov/climate/index.php?wfo=akq (verified 12 July 2010). National Oceanic and Atmospheric Administration, National Weather Serv., Washington, D.C.

Reiter, M.S. 2009. Conservation tillage trends in Virginia agricultural production. p. 2-11. *In* M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Ext. Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1417.html (verified 12 July 2010).

USDA-NASS. 2009. Prices paid: Indexes for non-farm sector by month, US. Available at: http://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/prod1.asp (verified 22 Feb. 2010). USDA-National Agric. Statistics Serv., Washington, D.C.

USDA-NASS. 2010. Virginia statistics. Available at: http://www.nass.usda.gov/Statistics_by_State/Virginia/index.asp (verified 22 Feb. 2010). USDA-National Agric. Statistics Serv., Washington, D.C.

USDA-NRCS. 2010. Bojac series. Available at: http://www2.ftw.nrcs.usda.gov/osd/dat/B/BOJAC.html (verified 12 July 2010). USDA-Natural Resources Conserv. Serv., Washington, D.C.

Wilson, H.P., T.P. Kuhar, S.L. Rideout, J.H. Freeman, M.S. Reiter, R.A. Straw, T.E. Hines, C.M. Waldenmaier, H.B. Doughty, U.T. Deitch, and J.D. Aigner. 2010. Commercial vegetable production recommendations - Virginia. Publ. 456-420. Virginia Coop. Extension, Blacksburg.

TABLES AND FIGURES

Table 1. Spring snap bean total yield and yield passing each grade sieve size for various nitrogen treatments on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N rates.

Nitrogen Source	Snap Beans Passing Sieve Size 1, 2, 3	4	5	Total Yield
	----------lbs/A----------			
Control	1041 b†	1476 ab	1960 b	4477 b
Ammonium nitrate	1008 b	1105 b	1976 b	4341 b
Calcium nitrate	1089 b	1230 ab	2291 ab	5278 ab
Sulf-N26	1004 b	1226 ab	2408 ab	4638 ab
Urea ammonium nitrate	988 b	1150 ab	2081 b	4219 b
Urea + nitrification inhibitor	1363 a	1545 a	2731 a	5639 a

†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. Fall snap bean total yield and yield passing each grade sieve size for various nitrogen treatments on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N rates.

Nitrogen Source	Snap Beans Passing Sieve Size 1, 2, 3	4	5	Total Yield
	----------lbs/A----------			
Control	1476 b†	2432 b	387 c	4296 b
Ammonium nitrate	1920 a	3400 a	960 b	6280 a
Calcium nitrate	2033 a	3804 a	1291 a	7127 a
Sulf-N26	1952 a	3352 a	1085 ab	6389 a
Urea ammonium nitrate	1964 a	3864 a	1347 a	7175 a
Urea + nitrification inhibitor	1896 a	3666 a	980 b	6542 a

†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. Fall snap bean total yield and yield passing each grade sieve size for various nitrogen rates on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N sources.

	Snap Beans Passing Sieve Size			
Nitrogen Rate	1, 2, 3	4	5	Total Yield
	---------------	lbs/A	---------------	
0	1476 b†	2432 c	387 c	4296 c
40	1752 b	3158 b	796 b	5706 b
80	2018 ab	3937 a	1244 a	7200 a
120	2089 a	3756 a	1358 a	7202 a

†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. Fall snap bean total yield and yield passing each grade sieve size for various nitrogen treatments applied at 80 lbs N/A plus 43 lbs. S/A. Plots were located on the Eastern Shore of Virginia on a Bojac sandy loam.

	Snap Beans Passing Sieve Size			
Nitrogen Source	1, 2, 3	4	5	Total Yield
	---------------	lbs/A	---------------	
Control	1476 b†	2432 b	387 a	4296 b
Ammonium nitrate	1960 b	3654 ab	1077 a	6691 ab
Ammonium nitrate + Sulfur	3468 a	4356 a	1307 a	8131 a
Sulf-N26	1670 b	3291 b	1029 a	5990 b
Urea ammonium nitrate	2118 ab	4392 a	1452 a	7962 a

†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. Fall snap bean disease incidence for various nitrogen sources on the Eastern Shore of Virginia on a Bojac sandy loam, averaged across N rates.

Treatment	Infected leaf area
	------%------
Control	22.5 a†
Ammonium nitrate	11.4 bc
Calcium nitrate	8.5 cd
Sulf-N26	5.7 d
Urea ammonium nitrate	13.8 b
Urea + nitrification inhibitor	11.8 bc

†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. Rainfall for Painter, VA