FERTILIZER N AND LEGUME COVER CROP MANAGEMENT EFFECTS ON NO-TILL COTTON PRODUCTION

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Abstract

A field study was conducted from 1992 through 1995 to determine the effects of fertilizer and legume N in no-tillage cotton production on lint yield, total cotton N uptake, and apparent fertilizer N recovery. Fertilizer N rates of 0, 40, 80, 120, and 160 lb/acre were applied in combination with winter fallow cover management using either broadcast ammonium nitrate (AN) or subsurface banded urea-ammonium nitrate (UAN) solution. Additionally, there was a winter cover system using a hairy vetch cover crop in combination with all N rates used with winter fallow except the highest. The four year predicted maximum lint yields with corresponding N rates were as follows: broadcast AN - 962 lb lint/acre at 108 lb N/acre; banded UAN solution - 918 lb lint/acre at 98 lb N/acre; and vetch-UAN - 907 lb lint/acre at 45 lb/N acre. Vetch plots with no added fertilizer N had high cotton total N uptake values and proved to be more efficient at N uptake when compared to fertilized winter fallow plots at the same N uptake value, but less efficient in terms of lint produced per unit of N applied. Apparent fertilizer N recovery in the vetch UAN system was much less than that of the winter fallow UAN system demonstrating that a fertilizer N addition in an already large vetch and soil N pool did little to increase apparent fertilizer N recovery.

Introduction

Since the introduction of the 1985 farm bill, no-tillage cotton acreage in Mississippi has increased from less than 500 acres in 1985 to more than 55,000 acres in 1995 (National Crop Research Mgt. Survey, 1995). Both federal compliance and diminished soil productivity have caused many producers with highly erodible land to rethink their cropping strategies. As a result, producers and researchers alike have found that yields from no-tillage crops are similar to those from conventional tillage while many soil properties like temperature, evaporation, organic matter, drainage and nutrient availability are modified somewhat between the two systems (Thomas and Frye, 1984). Nitrogen dynamics, in particular, are greatly affected by changes in the soil environment. Biological denitrification (Rice and Smith, 1982), nitrate leaching through macropores (Thomas et al., 1973), and N immobilization (Rice and Smith, 1984) tend to increase in no-tillage, while mineralization tends to be slower (Thomas and Frye, 1984) because of a cooler, wetter and undisturbed surface. Depending upon the soil type and amount of surface residue, all of these reactions have the effect of decreasing the amount of N available in a no-tillage site.

Because N dynamics can be negatively altered in no-till production, fertilizer N management has become an area of great interest to both producers and researchers. Legume cover crops, while suppressing weed growth, adding organic matter and reducing erosion and soil water evaporation, have been shown to have a positive effect on N management in no-till cotton by reducing fertilizer N requirements (Touchton et al., 1984; Brown et al., 1985; Varco, 1993; Boquet et al., 1994). Even though the dry matter yield and N content of legume cover crops has been widely reported, little work has been done to determine the actual N contribution from legumes to the cotton. One method used to estimate this contribution is to measure total cotton N and determine relative efficiencies of legume and fertilizer N. Using soil N uptake as a baseline value, estimates of apparent fertilizer and legume N recovery can be made.

The objective of this study was to determine the effects of fertilizer and legume N in no-tillage cotton production on lint yield, total cotton N uptake, and apparent fertilizer N recovery.

Materials and Methods

A field experiment was conducted from 1992 through 1995 on a Marietta fine sandy loam (fine-loamy, mixed, thermic, siliceous Aquic Fluventic Eutrocrept) at the Plant Science Research Center at Mississippi State. A 3 x 5 factorial arrangement of N-cover management systems and fertilizer N rates was used in a randomized complete block design with four replications. The N-winter cover management systems evaluated include broadcast ammonium nitrate (AN), 32% subsurface banded urea-ammonium nitrate (UAN) solution, and a hairy vetch (*Vicia villosa Roth.*) cover crop with subsurface banded UAN solution. One-half of the fertilizer was applied shortly after planting with the remainder being applied at early square. Fertilizer N was applied on the AN and UAN plots at a rate of 0, 40, 80, 120 and 160 lb/acre, while the vetch-UAN plots received rates of only 0, 40, 80 and 120 lb/acre. Plot size was 12.67 ft. wide by 30 ft. long.

Each fall, after chopping the cotton stalks, vetch seed was inoculated with *Rhizobium leguminosarum* and broadcast at a rate of 25 lb/acre between mid-October and mid-November. At approximately 25 days prior to planting, 10.8 square feet of vetch was harvested from each plot. The cover crop and any winter annual vegetation was then burned down with a 0.5 lb ai/acre Bladex and 0.625 lb ai/acre Gramoxone Extra mixture. Just prior to planting, a 1.0 lb ai/acre Roundup application was made for a final

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burn down. Cotton variety 'DES 119' was planted 13 May 1992, 17 May 1993, and 5 May 1994, while 'SUREGROW 125' was planted 5 May 1995. Cotton was planted in 38" solid rows with postemergence and residual weed and insect control following recommended guidelines. Approximately the second week of boll opening, a 3.3 foot length of whole cotton plants was harvested at ground level together with leaf litter on the ground. Both the vetch and cotton plant samples were dried to determine dry matter production and then ground and analyzed using a Carlo Erba 1500 C:N dry combustion analyzer to determine aboveground N content. Cotton dry matter and N content values are not yet available for 1995. The cotton was harvested at maturity and representative seed cotton samples were ginned to determine lint yields.

Results and Discussion

Vetch Yield and Aboveground N Content

Cover crop yields and N content values averaged across N rates for each year are shown in Table 1. Legume yields ranged from 1262 to 1923 lb/acre containing from 47 to 80 lb N/acre. The four year average yield was 1593 lb/acre with a N content of 62 lb N/acre. Legume yields and N contents for 1993 and 1994 were similar, but those for 1995 were higher probably due to a mild winter that permitted extra vetch growth and biological N fixation. From 1992-1994, the four year vetch with no fertilizer N plots had an average N content of 61 lb/acre.

Cotton Lint Yield

The four year average lint yield response to fertilizer N rates and N systems is shown in Fig. 1. All three N systems calculated had a quadratic response to N rates. The predicted maximum yields with corresponding N rates were as follows: broadcast AN - 962 lb lint/acre at 108 lb N/acre; banded UAN solution - 918 lb lint/acre at 98 lb N/acre; and vetch-UAN - 907 lb lint/acre at 45 lb/N acre. The legume UAN system was able to achieve a comparable yield with only 46% as much fertilizer N as the nonlegume UAN system. The greatest response to a vetch cover crop as compared to the other two systems was seen with no N where the lint yield was 887 lb lint/acre. With no exogenous fertilizer N, lint yield at this rate was equivalent to applying 39 lb N/acre as broadcast AN and 50 lb N/acre as banded UAN solution. The relative efficiencies of each N system at a lint yield of 884 lb/acre were as follows: 39 lb N/acre AN produced 23 lb lint/lb N; 50 lb N/acre UAN produced 18 lb lint/lb N; and 61 lb N/acre vetch N produced only 15 lb lint/lb N used. Thus, legume N was 66% as efficient as broadcast AN and 85% as efficient as banded UAN at producing cotton lint.

Cotton Total N Uptake

The three year average cotton total N uptake response to fertilizer N rates and N systems is shown in Fig. 2. Broadcast AN and banded UAN solution again had a quadratic response to N rates, while vetch response to fertilizer N was linear. As with lint yield, the greatest response to a vetch cover crop as compared to the other two systems was seen at a 0 N rate, where the total N uptake was 105 lb/acre. With no exogenous fertilizer N, total uptake at this rate was equivalent to applying 60 lb N/acre with broadcast AN and 74 lb N/acre with banded UAN solution. In consideration of the three year vetch 0 average aboveground N content being 56 lb N/acre, the aboveground vetch N was 107% as efficient as broadcast AN and 131% as efficient as banded UAN solution at being taken up by the cotton plants. This greater efficiency of vetch N may be due in part to the proximity and synchronization of the mineralized vetch N in relation to cotton plant growth as well as to the increased water availability and root activity due to the mulching effect of the cover crop. The increase in total N uptake by the first two vetch UAN N rates was relatively small as compared to the increases of the first two N rates of both the AN and UAN systems. This difference is due to the fact that vetch N alone almost totally satisfied the cotton N requirement as evidenced by minimal increases in total N uptake from fertilizer N application.

Apparent N Recovery

The three year average apparent fertilizer N recovery response to fertilizer N rates and N systems is shown in Fig. 3. Likewise, apparent aboveground vetch N recovery, as measured by the vetch 0 plots is also shown in Fig. 3. Broadcast AN had a weakly correlated quadratic response to N rates. Apparent fertilizer N recovery for broadcast AN and banded UAN solution was obtained by subtracting the potential soil N contribution, as measured by the 0 N check plots total N uptake values from the total N uptake values for the remaining fertilized plots and then dividing the differences by the corresponding fertilizer N rate. The apparent vetch N recovery was obtained by the same method except that the difference was divided by the 3 year average aboveground vetch 0 N content. Lastly, apparent fertilizer N recovery for vetch UAN was obtained by subtracting the potential soil + vetch N contribution, as measured by the vetch 0 check plot's total N uptake values, from the total N uptake values for the remaining vetch UAN plots and then dividing the difference by the corresponding fertilizer N rate.

The three year average potential soil N contribution was calculated to be 66 lb N/acre. When the soil N pool was diluted with fertilizer N, apparent recoveries ranged from 35% for banded UAN solution at 180 lb N/acre to a predicted maximum recovery at 72% for broadcast AN at 98 lb N/acre. When the soil N pool was diluted with vetch N only, apparent legume N recovery was 69% (i.e. - 39 of the 61 total lb of vetch N/acre was apparently taken up by the cotton). When the soil N pool was further diluted with both fertilizer and legume N, apparent fertilizer N recovery was reduced significantly. The apparent UAN fertilizer recovery in the vetch UAN system ranged from only 10 to 30% across all N rates. Obviously, a fertilizer N addition

in an already large vetch and soil N pool did little to increase apparent fertilizer N recovery.

Conclusions

Under similar climatic and soil conditions, fertilizer N requirements in no-till cotton can be reduced at least 50% with the use of a hairy vetch cover crop. Lint production per pound of aboveground vetch N was not as great as fertilizer N. Total cotton N uptake, however, per pound of aboveground vetch N was greater than fertilizer N. Across all N rates, apparent fertilizer N recovery was reduced in the presence of a hairy vetch cover crop.

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Table 1. Hairy vetch yield and N content values for no-till cotton.

	1992	1993	1994	1995	Avg.
Legume Yield (lb/A)	1923	1310	1262	1879	1593
N Content (lb/A)	80	47	57	63	62

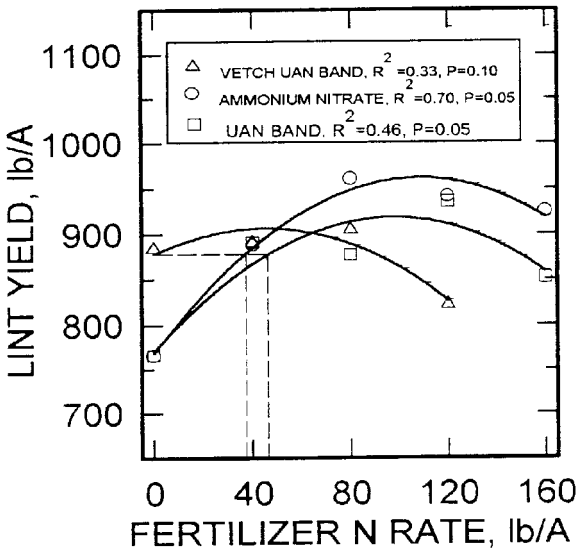

Figure 1. N system and fertilizer N rate effects on no-till cotton lint yield for the years 1992-1995.

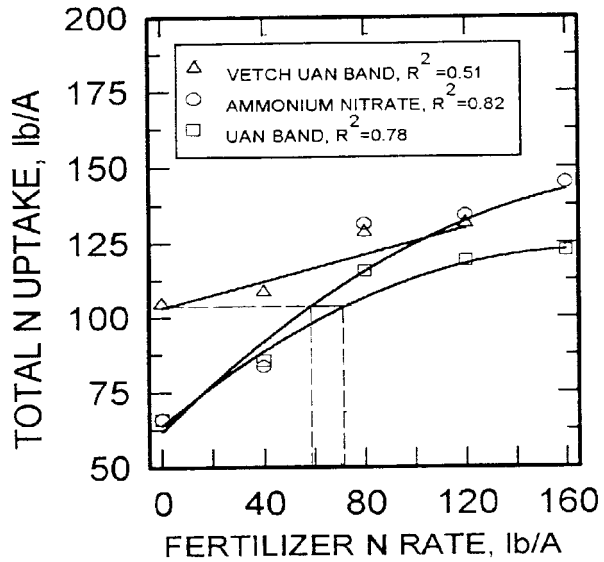

Figure 2. N system and fertilizer N rate effects on total N uptake of no-till cotton for the years 1992-1994.

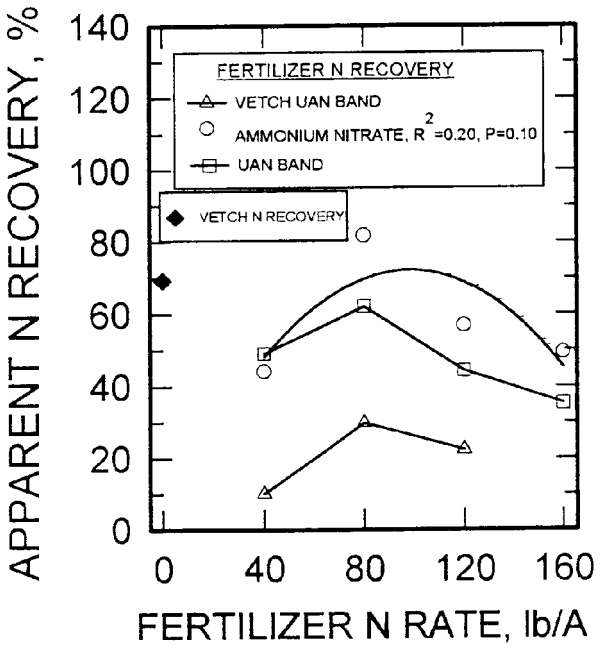

Figure 3. N system and fertilizer N rate effect on no-till cotton apparent fertilizer N recovery for the years 1992-1994.