Influence of Nitrogen and Tillage on cotton

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ABSTRACT

Nitrogen (N) is an important nutrient for cotton growth and development. The objective of the experiments conducted from 1995 to 1997 at the North Florida Research and Education Center (NFREC) near Quincy, FL was to determine the influence of N application (0, 60, 120, and 180 lbs N acre^{-1}) on 'DP 5409' cotton (*Gossypium hirsutum* L.) planted in strip and conventional tillage. The results showed no significant difference between tillage systems for the N uptake on leaves, bolls, and the whole plant, except higher uptake for stems from strip than conventional tillage. Generally, increasing the N fertilization increased the uptake of this element. Higher N (NO_3-N) content in the soil was obtained from strip than conventional tillage at the depth of 36-48 inches and higher N rates significantly increased N content in the soil. Cotton grown in strip tillage gave higher lint yields as compared to conventional tillage, but applying more than 60 lbs N acre^{-1} did not significantly increase yield. Higher N efficiency was obtained with low N application on cotton. Higher lint yield increases were obtained from conventional than strip tillage for the application levels of 0-60 and 0-120 lbs N acre^{-1}. This was due to lower yields from treatments with no N application on conventional than strip tillage.

KEYWORDS

Conservation tillage, rotation, soil health, nitrogen, N uptake

INTRODUCTION

In the U.S.A., strip tillage (minimum tillage) for crop production is mainly used to reduce soil erosion. Minimum tillage also increases soil organic matter, soil moisture, and improves soil structure, which results in increased yield of plants (Hargrove, 1990). Minimum tillage into previous crop residue may significantly reduce water erosion, especially on areas that are highly erodible (Hutchinson *et al.*, 1994). Minimum tillage influences the chemical, physical and biological aspects of soils and these changes depend on the soil quality and climate conditions (Gordon *et al.*, 1990). According to Nabors and Jones (1991) using minimum tillage protects cotton during emergence against injury from wind and sand. Minimum tillage saves soil moisture due to less evaporation (Philips and Young, 1973) and decreased surface water flow (Yoo and Touchton, 1989). However, increased permeability may increase the N flow from soil (Philips, 1980; Tyler and Thomas, 1977), increase denitrification (Olson *et al.*, 1979; Gilliam and Hoyt, 1987), and immobilization of N (Gilliam and Hoyt, 1987). The effect of minimum tillage and N rates on cotton growth in Florida has not been determined.

The purpose of this study was to determine the influence of strip and conventional tillage, and N rates on cotton growth and yields in northwest part of Florida.

MATERIALS AND METHODS

Plot preparation

Field research with cotton was conducted during 1995 - 1997 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudults) at the North Florida Research and Education Center / University of Florida in Quincy. The soil profile depth of 1 ft. contained 97 ppm K, 24.7 ppm P, 68 ppm Mg, 318 ppm Ca, and 0.5 ppm NO_3-N. Cotton cultivar 'DP 5409' was planted in strip and conventional tillage with N rates of 0, 60, 120, and 180 lbs N acre^{-1}. The study area was sprayed with glyphosate [N-(phosphonomethyl) glycine] at 1.5 qt acre^{-1} 2 weeks before planting. The rows in strip-till sections were ripped about 38-cm deep with a Brown Ro-till implement (Brown Manufacturing Co., Ozark, AL). On the conventional section, a disk-harrow was used (3 times). The disked soil was then sub-soiled, and then s-tine harrowed (2 times).

IN E. van Santen (ed.) 2002. Making Conservation Tillage Conventional: Building a Future on 25 Years of Research. Proc. of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Auburn, AL 24-26 June 2002. Special Report no. 1. Alabama Agric. Expt. Stn. and Auburn University, AL 36849. USA.

Plant culture

Cotton was planted in 3 ft. row spacing at the rate of 4 seed per ft of row with KMC planters (Kelly Manufacturing Co., Tifton, GA). Each plot was 12 ft. wide by 20 ft. long and consisted of four rows. Cotton was sprayed with fluometuron [1,1-dimethyl-3-(α, α, α-trifluoro-*m*-totyl)urea] at 2 pt acre^{-1} and pendimethalin (N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine) at 2 pt acre^{-1} after planting and direct sprayed with fluometuron at 2 pt acre^{-1} and MSMA (monosodium salt of methylarsonic acid) at 2 pt acre^{-1} 3 weeks later. Four weeks after planting, N fertilizer in the form of ammonium nitrate was applied on cotton plots. The rate of 180 lbs N acre^{-1} treatment was divided into 2 applications with 120 lbs N acre^{-1} applied four weeks after planting and additional 60 lbs N acre^{-1} applied three weeks later. Cotton was defoliated with thidiazuron (N-phenyl-N'-1,2,3-thiadiazol-5-ylurea) at 0.166 lbs acre^{-1} and ethephon (2-chloroethyl phosphonic acid) at 1.4 pt acre^{-1} and ethephon plus cyclanilide [(2-chloloethyl)phosphoric acid plus 1-(2,4-dichlorophenylaminocarbonyl)-cyclopropane carboxylic acid] at 1.5 pt acre^{-1} and Agridex oil at 1 pt acre^{-1} when 60 to 70% of the cotton bolls were open. The cotton was picked by hand 2 to 3 weeks after defoliation.

The field experiments were static and conducted as split - plots with four replications. Biometric measurements were conducted on 10 plants taken from each plot.

Weather data was obtained from the weather station in Quincy (30° 36' N latitude and 84° 33' W longitude) located at 245 ft. above sea level.

All results were analyzed using ANOVA, GLM, and REG procedures of SAS (SAS Institute, 1985 a, b). Analyses of linear and quadratic regression were added to the analysis of variance.

RESULTS AND DISCUSSION

Yield of cotton depend on N acquired by plants (Doss and Scarsbrook, 1969; Oosterhuis *et al.*, 1983). Constable and Rochester (1988) showed that the amount of N acquired by cotton, without N fertilization, was from 22.7 to 92.3 lbs N acre^{-1}. According to Hern (1981) total N uptake, especially irrigated, may be up to 205 lbs N acre^{-1}, and half of it is removed with harvested yield. Even with the N immobilization under minimum tillage (Rice and Smith, 1984), strip tillage with leaving plant residues on the top of the soil, showed better utilization of applied N (Torbert and Reeves, 1994).

Our research showed that among analyzed plant parts, N uptake was higher from strip than conventional tillage for stems only (Table 1). There was no significant difference between tillage systems for the N uptake by leaves, bolls, and in the whole plant. Table 2 shows the influence of N application on N uptake in cotton. Increasing the N rate increased the uptake of this element. Highest uptake of N was obtained with the application of 180 and 120 lbs acre^{-1}. Significantly lower N uptake was received from the treatment with no N application on cotton.

According to calculated regressions, increasing the N rate by 1 lbs increased the N uptake by 0.336 lbs N acre^{-1}, where 0.192 lbs was allocated for bolls, 0.096 lbs for leaves, and 0.048 lbs for stems (Table 3).

Evaluating the N content in the soil, Lamb *et al.* (1985) found that soil had a better ability to hold N where plowing was done as compared to minimum tillage for the first few years, but these differences get smaller later. Eck and Fanning (1962) and Johnson *et al.* (1974) showed that higher accumulation of NO_3–N on clay soil occurred after

Table 1. Influence of tillage on nitrogen uptake.

Tillage	Stems	Leaves	Bolls	Whole plant
	---------------- lbs acre^{-1}	--------------		
Strip-till	11.6	26.2	63.3	100.9
Conventional	10.0	23.5	58.7	92.2
$LSD_{(0.05)}$	1.52	NS	NS	NS

Table 2. Influence of fertilization on nitrogen uptake.

N rate	Stems	Leaves	Bolls	Whole plant
lbs acre^{-1}	----------- lbs acre^{-1}	------------		
0	6.1	15.2	40.4	61.7
60	9.4	22.5	57.5	89.4
120	13.1	29.5	72.0	114.6
180	14.5	32.0	74.0	120.5
$LSD_{(0.05)}$	1.52	4.06	13.3	18.9

Table 3. Functions of nitrogen production in cotton 120 days after planting

Parts of plant	Regression	Determination Coefficient
Stems	$y = 6.44 + 0.048N$	$r^2 = 0.97$
Leaves	$y = 16.2 + 0.096N$	$r^2 = 0.96$
Bolls	$y = 43.7 + 0.192N$	$r^2 = 0.91$
Whole plant	$y = 66.3 + 0.336N$	$r^2 = 0.94$

plowing than after leaving plants residue on the top of the soil. Fenser and Peterson (1979) showed that lower accumulation of NO_3–N in soil with minimum tillage than after plowing.

According to our studies, significantly higher soil N (NO_3-N) content was obtained from strip than conventional tillage at the depth of 36-48 inches and there was no significant difference between tillage systems at 0-12, 12-24, 24-36 inch, and the total soil depth (Table 4). Higher N rates significantly increased the N content in the soil at the measured levels. The N content at 0-48 inch depth was 101.5 and 101.0 lbs acre^{-1} with the application of 0 and 60 lbs N acre^{-1}, respectively, 107.2 and 118.3 lbs acre^{-1} with 120 and 180 lbs N acre^{-1}, respectively (Table 5).

Research conducted in 1987-92 (Hutchinson *et al.*, 1993) showed that yields of cotton grown in minimum tillage were similar to yields obtained from conventional tillage. Burmester *et al.* (1997) showed that yields may vary in different years comparing minimum and conventional tillage. According to Matocha and Barber (1992) and Smart and Bradford (1996), different tillage and fertilization have a direct effect on cotton yield. Many experiments show that cotton yields from minimum tillage are lower or similar to yields from conventional tillage (Brown *et al.*, 1985; Stevens *et al.*, 1992; Burmester *et al.*, 1993; Hutchinson, 1993).

The optimum N rate lies within the range of 31 to 120 lbs N acre^{-1} (Howard and Hoskinson, 1986; Lutrick *et al.*, 1986; Maples and Frizzel, 1985; Phillips *et al.*, 1987; Thom and Spurgeon, 1982; Touchton *et al.*, 1981). According to research conducted by Gordon *et al.* (1990), for cotton grown in strip-tillage, the optimum rate of N to get maximum yield is 76.5 lbs N acre^{-1}.

Our studies showed that cotton grown in strip tillage gave 6.3% higher lint yields as compared to conventional tillage, but applying more than 60 lbs N acre^{-1} did not significantly increase the yield (Table 6). For conventional tillage, yields were lower with application of 180 lbs N acre^{-1} as compared to yields with the application of 60 lbs N acre^{-1}.

Agricultural efficiency was calculated by dividing the differences between the lint yields by N rates. The productivity of 1 lbs N changed from 3.35 and 4.48 lbs lint acre^{-1} with the application of 60 lbs N acre^{-1} to 1.37 and 1.17 lbs acre^{-1} with 180 lbs N acre^{-1} for strip and conventional tillage, respectively (Table 7). Higher N productivity was obtained with low N application on cotton. Higher lint yields increases were obtained from conventional than strip tillage for the application levels of 0-60 and 0-120 lbs N acre^{-1}. This was due to lower yields from treatments with no N application on conventional than strip tillage.

Table 4. Influence of tillage on nitrogen content in the soil.

Tillage	Depth level (inch)				
	0-12	12-24	24-36	36-48	0-48
	lbs acre^{-1}				
Strip-till	27.1	26.3	27.4	28.6	109.4
Conventional	26.5	25.9	26.0	26.4	104.8
$LSD_{(0.05)}$	NS	NS	NS	1.41	NS

Table 5. Influence of fertilization on nitrogen content in the soil.

N rate (lb/a)	Depth level (inch)				
	0-12	12-24	24-36	36-48	0-48
lbs acre^{-1}	lbs acre^{-1}				
0	25.5	24.6	25.0	26.4	101.5
60	26.3	26.1	24.7	23.9	101.0
120	26.6	27.4	27.3	25.9	107.2
180	28.7	26.4	29.5	33.7	118.3
$LSD_{(0.05)}$	1.56	1.42	1.37	1.78	2.94

CONCLUSIONS

Nitrogen uptake was higher from strip than conventional tillage for the stems only. Increased N rate increased the uptake in plants with highest uptake from the application of 180 and 120 lbs acre^{-1}. Increasing the N rate by 1 lbs increased the N uptake by 0.336 lbs N acre^{-1}. Significantly

Table 6. Influence of tillage and nitrogen rates on lint yield.

Tillage	N rate (lbs acre^{-1})				
	0	60	120	180	Mean
	lbs acre^{-1}				
Strip-till	1136	1337	1307	1382	1291
Conventional	1033	1302	1282	1244	1215
Mean	1084	1319	1295	1313	-

$LSD_{(0.05)}$ for tillage - 23.1 lbs acre^{-1}
$LSD_{(0.05)}$ for N rates - 32.9 lbs acre^{-1}
$LSD_{(0.05)}$ for interaction - 46.3 lbs acre^{-1}

higher N (NO_3-N) content was obtained from strip than conventional tillage at the depth of 36-48 inches and higher N rates significantly increased the N content in the soil at the measured levels. Cotton grown in strip tillage gave higher lint yields as compared to conventional tillage, but applying more than 60 lbs N acre^{-1} did not significantly increase the yield. Higher N productivity was obtained with low N application on cotton and higher lint yields increases were obtained from conventional than strip tillage for the application levels of 0-60 and 0-120 lbs N acre^{-1}.

Table 7. Efficiency of nitrogen fertilization on lint yield increase.

Tillage	Level of N fertilization (lbs acre^{-1})				
	0-60	0-120	0-180	60-120	120-180
Strip-till	3.35	1.43	1.37	-	1.25
Conventional	4.48	2.07	1.17	-	-

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