INFLUENCE OF TILLAGE AND WINTER COVER CROPS ON NITROGEN STATUS OF COTTON

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INTRODUCTION

In fields where moderate to high yields of cotton can be obtained, the profit potential of cotton is often greater than that of alternative crops. It is not surprising, then, that many producers throughout the Cotton Belt elect to maintain productive acreage in continuous cotton until pressure from pests suggests the necessity of rotation with another crop. During the past several years, research in Louisiana has emphasized the use of conservation tillage systems and winter cover crops to ensure the continued productivity of land used in intensive cotton production (Boquet and Hutchinson, 1992; Hutchinson et al., 1993).

Reduced tillage systems minimize the potential for soil erosion and offer the additional advantage of permitting more timely early season field operations in the humid mid-south (Boquet and Coco. 1991; Crawford, 1992). Management systems that combine reduced tillage systems with winter cover crops can offset the depletion of soil organic matter that results from continuous cotton production (Boquet and Hutchinson, 1992). Most soils used for cotton production in the mid-South contain low amounts of organic matter. Increasing soil organic matter tends to improve soil aeration. drainage, water infiltration and retention, and the ability of soil to retain and supply nutrients to crops.

When legumes are used as winter covers, appreciable amounts of biologically fixed N can accumulate (Oyer and Touchton, 1988). Legume cover crops can supply all or a substantial portion of the N required by a cotton crop and reduce the need for purchased inorganic N fertilizers (Touchton and Reeves, 1988; Millhollon et al., 1991). Covers of wheat and other non-legume crops may also enhance the N fertility of cotton soils by immobilizing residual soil N into organic forms. Immobilization prevents accumulation of residual N as nitrate (NO_3^-), a form of N easily lost by leaching and denitrification during winter and spring rains.

Recent field studies in Louisiana indicate that cotton production systems that employed both reduced tillage and legume cover crops to produce cotton on Sharkey clay soils resulted in yields that exceeded those obtainable using conventional production practices regardless of the amount of fertilizer N applied (Boquet et al., 1994). It is well known that an adequate supply of soil N during the growing season is essential to high cotton yields. It is difficult to determine from yield responses alone whether the beneficial effect of reduced tillage and legume covers result from improved N availability, from other beneficial effects of conservation practices on the soil environment, or from a combination of these factors.

Monitoring the N status of cotton grown under different management regimes can provide additional information regarding the influence of tillage practices and cover crops on the ability of soils to supply cotton crops with N. Petiole NO_3 concentrations during fruiting have been used successfully to assess the N status of cotton (Maples et al. 1977). Because petiole NO_3 concentrations are influenced by rainfall and other climatic factors, concentrations are more variable in the humid lower Mississippi River Valley where their ability to reflect the N status of cotton is less than in arid and semiarid regions (Phillips et al., 1987).

The N status of developing cotton plants has also been assessed by determining the total N content of upper leaves (Sabbe et al., 1972). When N uptake by plant roots is not sufficient to adequately supply developing tissue with N, a portion of *N* in older vegetative tissue can be mobilized and transported to allow continued growth. Recent studies indicate that the average N contents of leaf blades collected from uppermost fully expanded leaves during the maturation of cotton are not greatly affected by environmental

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influences and provide a reliable indicator of N status of cotton (Breitenbeck et al., 1994).

The principal objective of this work was to monitor N status of cotton during boll development to determine whether the beneficial effects of reduced tillage and legume cover crops on cotton yields are due primarily to improved N nutrition or to other advantageous changes caused by these practices.

MATERIALS AND METHODS

Tissue samples were collected from field experiments located in Winnsboro, LA. This experiment was established in 1991 on a Gigger silt loam to compare the effects of tillage (conventional and no-till). cover crops (fallow. hairy vetch and wheat) and various annual rates of N fertilization (0, 35, 70, 105, and 140 lbs N/ac) with three replications. Nitrogen fertilizer was applied as 32% N urea-ammonium nitrate solution (UAN) 17-21 days after planting. The liquid fertilizer was applied approximately 10 inches from the drill. In 1991 a surface dribble band was applied and immediately incorporated with a conservation-tillage cultivator. In 1992 and 1993, N fertilizer was knifed-in behind a coulter at a depth of 3 inches. The design and management of this experiment are described in detail by Hutchinson et al. (1994).

Petioles were collected from the most recent fully expanded leaves of 10 plants from each replicate plot in 1991, 1992 and 1993 beginning at first bloom and at weekly intervals for 5 additional weeks. The affixed leaf blades were also collected from these leaves. Nitrate concentrations of petioles were determined in hot H_2O extracts using a Wescan Ammonium Analyzer (Wescan Instruments, Inc., Deerfield, IL) fitted with a Zn column to reduce NO_3^- to NH_4^+. Total N content of leaf blades was determined by a dry combustion technique using a Heraeus CHN Rapid Analyzer (UIC, Inc., Joliet, IL).

Before termination of winter cover crops by tillage (conventional-till) or herbicide application (no-till), samples of wheat or vetch biomass were harvested from each plot by clipping at the soil surface all plant material contained within a square frame 40" on each side. Samples were dried (65°C), weighed and finely ground for determination of N content by dry combustion. Total N contained in the aboveground biomass of each cover crop plot was calculated by multiplying plant biomass by N concentration.

Immediately prior to fertilization in 1991, 1992 and 1993, composite soil samples consisting of replicate soil cores (1.5" dia.) were collected at depths of 0-6", 6-12" and 12-24" from each plot. Soils were air-dried, crushed to pass a 2-mm sieve, and the amounts of NH_4^+ and NO_3 determined in 10:l 1 N KCl:soil extracts.

Table 1. Average N content of cotton leaf blades collected at weekly intervals from the uppermost fully expanded leaves between first bloom and end of effective blooming in 1991, 1992 and 1993.

	Conventional-till'				No-till'			
N rate	Native	Vetch	Wheat	Avg.	Native	Vetch	Wheat	Avg.
	% N							
0	2.96	3.78	2.92	3.22	3.19	3.59	3.08	3.29
35	3.27	4.11	2.86	3.41	3.35	3.98	3.22	3.52
70	3.75	4.23	3.61	3.86	3.89	4.28	3.76	3.98
105	4.16	4.47	4.00	4.21	4.21	4.35	4.04	4.20
140	4.21	4.30	4.18	4.23	4.28	4.25	4.29	4.27
Avg.	3.67	4.18	3.52	3.79	3.79	4.09	3.68	3.85

† Values in bold correspond to the lowest N treatments resulting in optimum seedcotton yield for each combination of tillage and cover crop. LSD (0.05) to compare values for tillage x cover crop x N rate combinations, 0.26 %N; LSD (0.05) to compare values for tillage x N rates averaged across cover crops, 0.15 %N; LSD (0.05) to compare values for tillage x cover crops averaged across N rates, 0.11 %N.

RESULTS AND DISCUSSION

Average leaf blade N contents during maturation of cotton indicated that the N status of unfertilized cotton following vetch was similar to that obtained by applying 70 lbs N/Ac to cotton in plots where native vegetation was permitted to grow without a planted cover crop (Table 1). Volunteer native species consisted primarily of annual bluegrass and sibara. Petiole NO_3 concentrations during fruiting confirm that the use of a vetch cover was equivalent to applying approximately 70 lbs N/Ac (Fig. 1). The profile of petiole NO_3 in unfertilized cotton following vetch was remarkably similar to those of cotton receiving 70 lbs N/Ac after native vegetation or wheat. These findings are consistent with 3-yr average seedcotton yields indicating that 0 and 70 lbs of fertilizer N were adequate to produce maximum yields following vetch and native vegetation, respectively (Hutchinson et al., 1994). It is noteworthy that when 70 lbs N/Ac was applied to cotton following vetch, N uptake increased substantially but an increase in cotton yield was not obtained. This supports the conclusion of Boquet et al. (1993) that the ability of N to increase the yield potential of cotton is limited. Excessive N availability, whether caused by application of inorganic fertilizers or a combination of fertilizer and N derived from legume covers, can delay crop maturity and adversely affect harvestability.

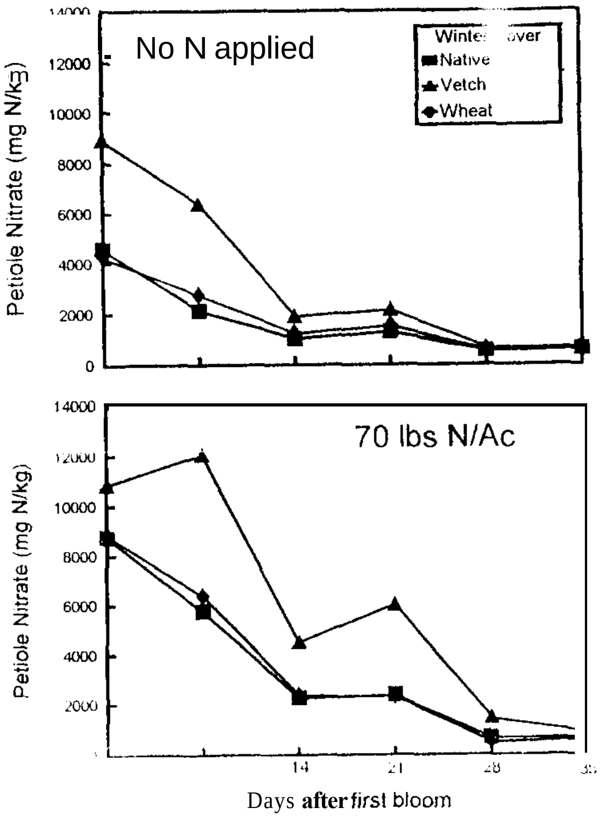

Fig. 1. Effects of cover crops on petiole nitrate concentrations between first bloom and end of effective blooming of cotton receiving 0 or 70 lbs N/Ac.

The N status of cotton after a wheat cover as indicated by leaf blade N content was consistently less than that of cotton grown after native vegetation receiving an equivalent amount of fertilizer N (Table 1). It is not clear from these data, however, that the slight differences evident in N status adequately account for that fact that cotton after wheat required approximately 35 lbs/Ac more N than cotton after native vegetation to obtain similar seedcotton yields (Hutchinson, 1994). Petiole NO_3 concentrations during fruiting indicate that N availability to cotton after wheat was similar to that of cotton after native vegetation (Fig. 1). It appears that additional N is needed to offset other changes in the soil environment caused by a wheat cover. Early season growth was exceptionally vigorous in cotton after wheat, and additional N may have been required to compensate for damaged early bolls. In these experiments, cotton was irrigated and therefore it is not likely that depletion of subsurface soil moisture by wheat accounts for the need for additional fertilizer N at the soil surface.

The contribution of vetch to the N nutrition of the subsequent cotton crop was somewhat greater under conventional tillage than under no-till, presumably because conventional tillage caused more rapid or complete mineralization of N in vetch residues. Averaged over all fertilizer treatments, vetch plots under conventional tillage contained about 50 lbs N/Ac more soil NO_3 before fertilization than did no-till plots (Fig. 2). No-till also reduced the concentration of soil NO_3 following native vegetation in both surface and subsurface horizons. This reduction in the amount of NO_3 accumulated before fertilization, however, did not adversely affect seasonal availability of soil N to the cotton crop. After native or wheat cover, the N status of cotton during maturation was consistently greater

Table 2. Average amount of N contained in aboveground cover crop biomass prior to tillage Iconventional-till) or herbicide application (no-till) in 1992 and 1993.

Nrate	Conventional-till'			No-till'		
	Vetch	Wheat	Difference	Vetch	Wheat	Difference
	lbs N/Ac					
0	103.0	33.4	69.5	99.4	27.0	72.4
35	101.3	16.6	84.7	108.0	17.6	90.4
70	108.8	25.6	83.2	130.2	26.4	103.8
105	103.7	41.4	62.3	124.6	32.4	92.2
140	120.9	51.5	69.4	103.8	53.2	50.5
avg	107.5	33.7	73.8	111.2	31.3	79.9

' LSD (0.05) to compare values for various tillage x cover crop x N rate combinations, 33.7 Ibs N/Ac,; LSD (0.05) to compare values for tillage x cover crops averaged across N rates, 15.1 lbs N/Ac.

under no-till than under conventional tillage (Table 1).

Soil NO_3 accumulations before fertilization of cotton were significantly lower after a wheat cover than after native vegetation or vetch under both tillage systems. Whether the observed reduction in preplant soil NO_3 after wheat was due to greater immobilization of N into organic forms or to greater denitrification losses induced by large quantities of carbon substrate available to soil microorganisms during heavy spring rains merits further study. Clearly, a wheat cover contributes substantially to soil organic matter. Wheat covers not only provided an average of 3550 lbs/Ac in aboveground plant biomass, but contributed an additional unknown quantity of organic matter upon decay of their pervasive root systems.

Wheat covers contained 17-53 Ibs N/Ac prior to termination (Table 2). The N contents of the aboveground biomass of wheat covers were similar under no-till and conventional management but tended to increase as the amount of N fertilizers previously applied to cotton increased, demonstrating the potential of wheat covers to recover residual soil N. The low amount of soil NO_3 present after wheat illustrates the value of this cover crop for preventing contamination of surface and ground water by NO_3 in run-off and leachate from cotton fields during winter and spring rains.

The amount of biologically fixed N contributed by a vetch cover crop generally exceeded the amount of N removed by the subsequent cotton crop. Conservatively estimating the amount of biologically fixed N as the difference between N contents of vetch and wheat covers (Table 2), the annual contributions of a vetch cover to soil N reserves averaged 73.8 lbs N/Ac under conventional tillage and 79.9 Ibs N/Ac under no-till. Maximum cotton yields resulted in removal of about 63 Ibs N/Ac in harvested seedcotton (Fig. 3). If N losses from this soil are minimal, our findings indicate that the use of a vetch cover can provide sufficient N for optimum yields without depleting soil N reserves in fields used for continuous cotton production.

Summary

No-till management enhanced N status of cotton grown on Gigger silt loam after a winter cover of wheat or volunteer native vegetation, but led to a slight reduction in N status following a vetch cover crop. Regardless of the tillage system employed, N availability following a vetch cover was sufficient to produce maximum cotton yields without the addition of supplemental inorganic N fertilizers. Assuming losses of N from this soil are not great, the biologically fixed N contributed by the vetch cover crop is adequate to sustain soil N reserves under continuous cotton production. Wheat cover crops were highly effective in recovering residual soil N and in preventing its accumulation as NO_3 during early spring. The influence of wheat covers

on N availability to the subsequent cotton crop does not adequately account for the need for greater amounts of inorganic N fertilizers to obtain maximum yields of cotton grown after a wheat cover than after a fallow of native vegetation.

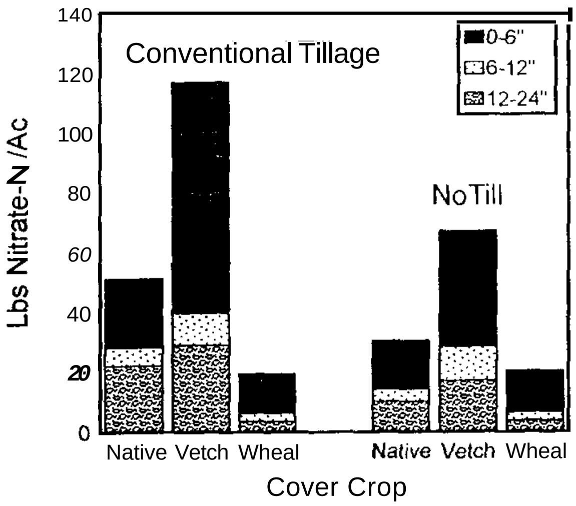

Fig. 2. Effects of tillage and winter cover crops on the average amounts of soil nitrate present in the surface 0-24" prior to planting cotton in 1991, 1992 and 1993.

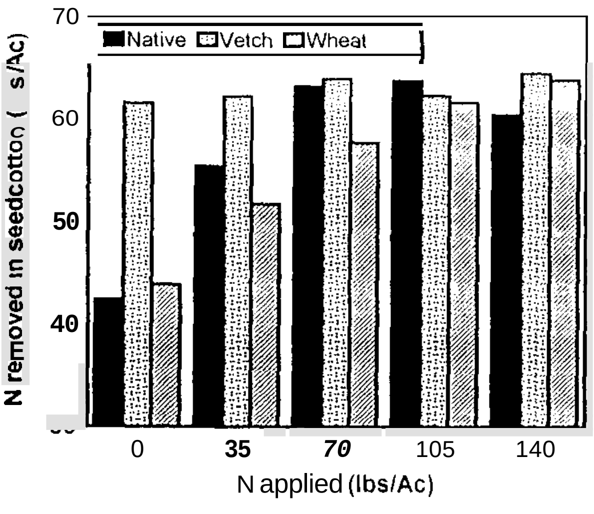

Fig. 3. Average amount of N removed annually in harvested seedcotton.

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