Tillage, Cover Crops, and Nitrogen Fertilization Effects on Cotton and Sorghum Yields and Nitrogen Uptake

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Introduction

Sustainable management practices, such as conservation tillage and cover cropping, that reduce soil erosion and N leaching and increase soil organic matter, still remain a challenge for cotton and sorghum production in southeastern USA (*Doran and Smith, 1987*). While no-till or reduced till can reduce soil erosion and increase organic matter compared with conventional till, cover crops can reduce N leaching, improve soil organic matter and N supply, and increase succeeding crop yields compared with no cover crops. In contrast, increased rate of N fertilization can increase N leaching. Use of conservation tillage in cotton production system lagged behind corn and soybean in USA due to limited information (*CTIC, 1994; Triplett et al., 1996*).

Objectives

1. Examine the effects of tillage, cover crops, and N fertilization rates on cotton and sorghum yields and N uptake.
2. Determine best management practices consisting of tillage, cover crops, and N rates that sustain cotton and sorghum yields and N uptake and reduce potentials for soil erosion and N leaching.

Materials and Methods

Treatments and experimental design:

- Tillage (no-till, strip till, and chisel till) as main plot,
- Cover crops [hairy vetch (legume), rye (nonlegume), hairy vetch/rye mixture, and winter weeds] as split plot, and
- N fertilization rates (0, 60, and 120 kg ha^{-1} for cotton and 0, 65, and 130 kg N ha^{-1}) as split-split plot.
- Replications: 3
- Cover crop planting: October-November 1998, 1999, and 2000.
- Cover crop biomass incorporation: April 1999, 2000, and 2001.
- Fertilization: 36 kg P ha^{-1} and 75 kg K ha^{-1} for cotton in 2000 and 2002, and 40 kg P ha^{-1} and 80 kg ha^{-1} K for sorghum in 2001 applied at planting. N fertilizer applied one-third at planting and two-third after 6 wk for cotton and two-third at planting and one-third after 6 wk for sorghum.
- Cotton planting and seeding rate: May 2000 and 2002 at 8 kg ha^{-1}.
- Sorghum planting and seeding rate: June 2001 at 12 kg ha^{-1}.
- Cotton biomass (lint + seeds + leaves + stems) and lint harvest: October-November 2000 and 2002.
- Sorghum biomass (grains + stems + leaves) and grain harvest: October 2001.

Cotton growth at 2 months after planting in conventional till with winter weeds (no cover crop) (left) and in strip till with hairy vetch/rye cover crop.

Results and Discussion

Application of greater levels of N from hairy vetch or a mixture of hairy vetch/rye cover crops (Table 1) and higher N fertilization rates decreased cotton lint yield at the expense of biomass yield and N uptake compared with rye or winter weeds and or no N rate (Tables 2 and 4). High N rate can produce excessive vegetative growth that delays maturity and harvest and reduces cotton lint yield (Hutchinson et al., 1995; McConnell et al., 1995). In contrast, N application from hairy vetch or a mixture of hairy vetch and rye and increased N rate increased sorghum grain yield, biomass yield, and N uptake between hairy vetch and hairy vetch/rye mixture and between 60-65 and 120-130 kg N ha-1 suggests that hairy vetch can be replaced by hairy vetch/rye mixture and 120-130 kg N ha^{-1} by 60-65 kg N ha^{-1} to sustain cotton and sorghum yields and reduce potential for N leaching. Similarly, similar levels of cotton lint yield, sorghum grain yield, biomass yields, and N uptake between strip till and chisel till suggests that chisel till can be replaced by strip till to reduce soil erosion, improve soil organic matter, and sustain cotton and sorghum yields.

Conclusions

1. Although cover crops have greater biomass yields and N accumulation than winter weeds, hairy vetch/rye mixture had greater biomass yield and N accumulation than hairy vetch or rye alone.
2. Cotton lint yield, sorghum grain yield, biomass yields and N uptake were similar between strip till and chisel till.
3. Cotton lint yield was greater with rye than with hairy vetch or hairy vetch/rye mixture and greater with 60 than with 120 kg N ha^{-1}. In contrast, cotton biomass yield and N uptake and sorghum grain yield, biomass yield, and N uptake were greater with hairy vetch and hairy vetch/rye than with rye and greater with 60 and 120 than with 0 kg N ha^{-1}.
4. Conservation tillage, such as strip till, with a mixture of legume and nonlegume cover crops and 60-65 kg N ha^{-1} can be used to:
   - sustain cotton and sorghum yields and N uptake
   - reduce the rate of N fertilization, and...
   - has the potential to improve soil quality and reduce N leaching compared with conventional tillage, such as chisel till, with legume or nonlegume cover crops and 120 kg N ha^{-1}.

Table 1. Biomass yield and N accumulation of cover crops.

Although cover crops have greater biomass yields than winter weeds, hairy vetch and hairy vetch/rye mixture have greater N concentration and accumulation and lower C:N ratio than rye or winter weeds.

Cover Crop	Biomass yield	N conc.	N accu.	C:N ratio
	Mg ha^{-1}	g kg^{-1}	kg ha^{-1}	
Winter weeds	1.22c	18b	21c	19b
Rye	4.07b	12b	48c	33a
Hairy vetch	4.23b	34a	144b	10c
Hairy vetch/rye	6.63a	28a	186a	13b

Table 2. Effects of tillage, cover crops, and N fertilization rates on cotton lint yield, biomass yield, and N uptake in 2000.

Cotton lint yield was greater in no-till than in strip till, greater with rye than with other cover crops, and greater with 60 than with 120 kg N ha^{-1}. Biomass yield and N uptake were greater with hairy vetch and hairy vetch/rye mixture than with winter weeds, and greater with 60 and 120 than with 0 kg N ha^{-1}.

Parameter	Lint yield	Biomass yield	N uptake
	kg ha^{-1}	Mg ha^{-1}	kg ha^{-1}
Tillage			
No-till	890a	10.0a	263a
Strip till	595b	11.5a	307a
Chisel till	723ab	9.0a	219a
Cover crops			
Winter weeds	699b	7.9c	187b
Rye	879a	9.5bc	209b
Hairy vetch	660b	12.6a	362a
Hairy vetch/rye	706b	11.0ab	294a
N fertilization (kg ha^{-1})			
0	736ab	8.6b	204b
60	783a	10.5a	269a
120	689b	11.5a	316a

Ref.

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Table 3. Effects of tillage, cover crops, and N fertilization rates on sorghum grain yield, biomass yield, and N uptake in 2001.

Sorghum grain yield, biomass yield, and N uptake were greater in strip till and chisel till than in no-till, greater with hairy vetch and hairy vetch/rye mixture than with rye, and greater with 130 than with 0 kg N ha^{-1}.

Parameter	Grain yield	Biomass yield	N uptake
	--------Mg ha^{-1}----------		kg ha^{-1}
Tillage			
No-till	2.2b	8.3b	85b
Strip till	3.4a	13.8a	154a
Chisel till	3.9a	15.1a	155a
Cover crops			
Winter weeds	2.8bc	12.0ab	132ab
Rye	2.3c	9.4b	81b
Hairy vetch	3.5ab	14.1a	175a
Hairy vetch/rye	4.0a	14.2a	138a
N fertilization (kg ha^{-1})			
0	2.7b	11.6b	108b
65	3.1b	12.4ab	136a
130	3.7a	13.3a	152a

Table 4. Effects of tillage and N fertilization rates on cotton lint yield, biomass yield, and N uptake in 2002.

Cotton lint yield was greater in chisel till than in no-till and strip till and greater with 0 and 60 than with 120 kg N ha^{-1}. Biomass yield and N uptake were greater with strip-till than with chisel till and greater with 120 than with 0 kg N ha^{-1}.

Parameter	Lint yield	Biomass yield	N uptake
	kg ha^{-1}	Mg ha^{-1}	kg ha^{-1}
Tillage			
No-till	614b	3.1b	70b
Strip till	688b	4.5a	102a
Chisel till	1286a	4.1ab	91ab
N fertilization (kg ha^{-1})			
0	1021a	3.7a	80b
60	980a	3.9a	86ab
120	587b	4.0a	97a

Hairy vetch (left), rye (middle) and hairy vetch/rye cover crops (right) at the time of incorporation into the soil.