Conservation Tillage Systems for Corn Production on a Loessial Silt Loam and Alluvial Clay in Louisiana

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Introduction

Corn acreage has increased in recent years in Louisiana. Much of this is on mixed to heavy Mississippi River alluvial soils and to a lesser extent on loessial silt loams of the Macon Ridge. Each of these soil groups are unique in their physical and chemical characteristics and different management strategies may be required to produce optimal yield.

Research has indicated that corn performs best when planted early. Soil water within the rhizosphere may not be as plant available on clay as silt loam alluvial soils partly due to less efficient root development and physiology, making clays more drought prone. Thus, early planting dates on clay soils may be more critical than on the more coarse-textured soils. Additionally, planting in many years may be delayed because of poor seedbed conditions on clay soils, particularly if primary tillage operations are performed in early spring. Spring tillage typically produces cloddy seedbeds requiring rainfall or irrigation to produce optimal planting conditions.

According to Boquet and Coco (1993), one of the principal advantages of no-till systems is more timely planting, especially on the poorly drained, clayey soils. Herbek et al. (1986) found a trend for corn yield to increase as planting date increased from late April to mid-May for the no-till system on a poorly drained soil, while yield for the conventionally tilled plots decreased with delayed planting date.

In a Louisiana study, Hutchinson et al. (1994) found on the Macon Ridge only small differences in corn yield among conventional-till, reduced-till, and no-till treatments. Although limited tillage research on corn has been conducted in Louisiana, no-till or minimum-tillage production systems for cotton have shown promise when compared to the more traditional tillage practices on alluvial clays of the Mississippi River (Boquet and Coco, 1993; Crawford, 1992; Reynolds, 1990) and on the Macon Ridge (Hutchinson and Shelton, 1990). The inclusion of winter cover crops in combination with conservation tillage was found to be an important component of the systems.

The use of minimum-tillage systems may reduce soil erosion, especially on the sloping silt loams of the Macon Ridge (Hutchinson et al., 1991); increase soil organic matter (Boquet and Coco, 1993); reduce soil moisture evaporation (Wilhelm et al., 1986); and modify soil temperature (Wilhelm et al. 1986). The use of a leguminous cover crop, i.e. crimson clover, contributes biologically fixed N (Ebelhar et al., 1984), thus reducing need for application of N fertilizer and the potential of polluting ground water with nitrate-N.

Information is needed for corn production systems that will enhance profitability and protect the environment from unnecessary pollution of soil and water. Objectives of these experiments were to evaluate the influence of tillage systems, cover crops, and N rate on corn grain yield and yield components on two soil types.

Materials and Methods

Experiments were conducted in 1993 and 1994 to evaluate the effects of tillage systems, cover crops, and N rates on corn grown on Sharkey clay (very fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts) at the Northeast Research Station, St. Joseph , LA, and on Gigger silt loam (fine silty, mixed, thermic Typic Fragiudalf) at Winnsboro, LA. Tillage treatments were conventional tillage (CT) and no-till (NT). Cover crop treatments were native vegetation, crimson clover ('Dixie' in 1993 and 'Tibbee' in 1994) and wheat ('Florida 303'). Nitrogen rates evaluated were 50, 100, 150, and 200 lb N/A.

At Winnsboro, the experimental design was a randomized complete block with a split-split plot arrangement of treatments. Tillage treatments were main plots, cover crops split plots, and N rates split-split plots. At St. Joseph, the experimental design was a randomized complete block with a split plot arrangement of treatments. Tillage treatments were main plots and cover crops and N rates were factorially arranged as split plots. In 1993, tillage treatments were not evaluated at St. Joseph (NT management was used). In that year, the experimental design was a randomized complete block with cover crops and N rates factorially arranged. Plots were four rows wide (40-inch row width) and ranged from 28 to 40 feet long.

Conventional-till consisted of double-disking, bedding, and a bed-smoothing operation just before planting. No-till consisted of no spring primary tillage operations. At Winnsboro,

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the last cultivation of cotton helped rebuild the bed and no fall tillage was performed. At St. Joseph, beds were rehipped and smoothed (rolled) for planting in the fall.

Cover crops (crimson clover and wheat) were hand broadcast at seeding rates of 25 lb/A for crimson clover and 120 lb/A for wheat. Planting dates for cover crops were between mid-October and early November. At Winnsboro, seeds were broadcast into standing cotton stalks. After seeding, cotton stalks were cut with a rotary mower. At St. Joseph, beds were smoothed (rolled) immediately after seeding the cover crops.

Cover crops did not establish as well in 1993 as in 1994. In 1993, one burndown was applied at St. Joseph (March 9) and two applications at Winnsboro (March 9 and April 22). For each application, except April 22 at Winnsboro, 1 lb ai/A of glyphosphate was used on wheat plots, and 0.6 lb ai/A of paraquat plus 0.25% surfactant were applied on crimson clover and native vegetation plots. For the April 22 application at Winnsboro, 1 lb ai/A of 2,4-D amine was applied on NT treatments. In 1994, two burndown applications of 0.6 lb ai/A of paraquat plus 0.25% surfactant were applied in early to late March across all cover crop treatments. A similar rate of paraquat was also applied with preemerge treatments at both locations.

Preemerge treatments consisted of labelled rates of alachlor or metolachlor and atrazine at each location. Postemerge applications were 0.75 oz/A of primisulfuron at St. Joseph in 1993; 1 lb ai/A of linuron plus 0.25% surfactant at Winnsboro in 1993; and 1.5 lb ai/A of linuron and 1 lb ailA of atrazine plus 0.25% surfactant at St. Joseph in 1994. Insecticide treatments were 1 lb ai/A of carburan applied in-furrow at St. Joseph in 1993, and 1 lb ai/A of terbufos applied in-furrow in all other tests. At Winnsboro in 1993,0.03lb ai/A of cypermethrin was applied (May 6) for a cutworm infestation in the NT treatments. All plots were cultivated once in 1993 and only the CT treatment at St. Joseph was cultivated (once) in 1994.

Corn ('Pioneer Brand 3165') was planted at about 26,000 seeds/A using a John Deere 7100 or 7300 planter. Ripple coulters, if needed, were mounted on the planter for no-till planting. Planting dates were April 13 at both locations in 1993 and April 8 at Winnsboro in 1994. At St.Joseph in 1994, planting dates were different for the tillage treatments due to inclement weather affecting the CT seedbed preparation. Planting dates were March 21 for NT and April 11 for CT.

Nitrogen treatments were broadcast at about the four-leaf growth stage. Nitrogen source was ammonium nitrate. Plant samples were taken at early-silk growth stage each year. Earleaf samples were collected in 1993 and whole plant samples were collected in 1994. Plant N concentrations were determined using Kjeldahl procedures.

Corn was harvested from two center rows of each four-row plot. Grain yields were adjusted to 15.5% grain moisture. Analyses of variance of yield data were conducted using the GLM procedures of SAS. The LSD (P=0.05) was calculated for mean separation.

Results

St. Joseph

Grain yields ranged from 34 to 86 bu/acre in 1993 (Table 1) and from 83 to 178 bu/acre in 1994 (Table 2). More timely rainfall probably accounted for the higher grain yields in 1994. There were no significant interactions among treatments for grain yield either year.

In 1994, the only year tillage treatments were evaluated at St. Joseph, grain yield did not differ between tillage treatments (Table 2). As a result of delayed seedbed preparation due to wet soil conditions, the CT treatment was planted ap-

Table 1. Influence of tillage, cover crop, and N rate on corn grain yield, plants per acre (PPA), ears per acre (EPA), kernel weight, and kernels per ear at St. Joseph in 1993.

Treatment	Grain yield	PPA	EPA	Kernel weight	Kernels
	bu/A			g/l00	nolear
Cover crop					
Native vegetation	62	21,022	20,204	25.3	302
Wheat	59	20,628	19,372	25.2	304
Crimson clover	74	21,371	20,519	25.1	357
LSD (0.05)	6	N.S.	639	N.S.	27
N rate, Ib/acre					
50	34	20,715	18,899	24.2	184
100	62	21,480	20,190	25.1	308
150	79	21,081	20,888	25.4	377
200	86	20,755	20,150	26.0	417
LSD (0.05)	7	N.S.	738	0.5	31

N.S. = nonsignificant at the 0.05 probability level.

Table 2. Influence of tillage, cover crop, and N rate on corn grain yield, plants per acre (PPA), ears per acre (EPA), kernel weight, and kernels per ear on Sharkey clay at St. Joseph in 1994.

Treatment	Grain vield	PPA	EPA	Kernel weight	Kernels
	bn/A			g/loo	nolear
Tillage'					
No-ti11	136	24,405	22,689	31.8	464
Conventional	140	27,190	25,982	30.7	439
LSD(O.05)	N.S.	1052	1363	N.S.	N.S.
Cover crops					
Native	155	27,021	25,581	31.6	485
Wheat	102	23,841	22,031	30.3	382
Crimson Clover	157	26,530	25,396	32.0	487
LSD(O.05)	7	742	630	0.6	28
N rate, Ib/acre					
50	83	25,537	23,692	28.9	305
100	130	25,809	24,194	30.2	447
150	162	25,803	24,459	32.5	516
200	178	26,040	24,997	33.5	538
LSD(O.05)	8	N.S.	727	0.7	32

N.S. = Nonsignificant at the 0.05 probability level.

'No-till and conventional planted on March 21 and April 11, 1994, respectively.

proximately 3 weeks later than the NT treatment. Although tillage treatments were confounded by planting date, the delayed planting resulting from seedbed preparation is considered part of the treatment effect. Planting dates for NT (March 21) and CT (April 11) were within the recommended planting window for north Louisiana (March 15 to April 15).

Much of the research data available in Louisiana on corn planting dates is for silty soils (Mascagni et al., 1994), with little information available for clay soils. The clayey soils tend to be more drought prone than the coarser-textured alluvial soils. Thus, early planting dates may be more critical on the clay soils.

Grain yields were influenced by cover crops each year. Highest grain yields followed crimson clover in 1993 (Table 1) and crimson clover and native vegetation in 1994 (Table 2). The lack of a significant cover crop x N rate interaction suggests that crimson clover did not contribute plant-available N during the growing season. Furthermore, percent N content of corn following crimson clover was similar to native vegetation each year (Table 5). Boquet and Coco (1993) concluded that a winter legume cover crop had several beneficial effects for cotton production on a Sharkey clay soil, including a rotational effect independent of the nutritional (N) aspect.

In 1994, corn growth was severely reduced by the wheat cover crop treatments regardless of tillage treatment. Grain yield following wheat was decreased about 35% compared to the other cover crops (Table 2). Although plant populations were decreased following wheat, this would not account for the large difference in grain yield among cover crop treatments. Grain yield response per unit of applied N was similar among treatments. This is best illustated by the similarity of responses among treatments (Figure 1). Both low seed weight and low number of kernels/ear contributed to the reduced grain yield following wheat.

Grain yield increased with application of N up to 200 lb/A,

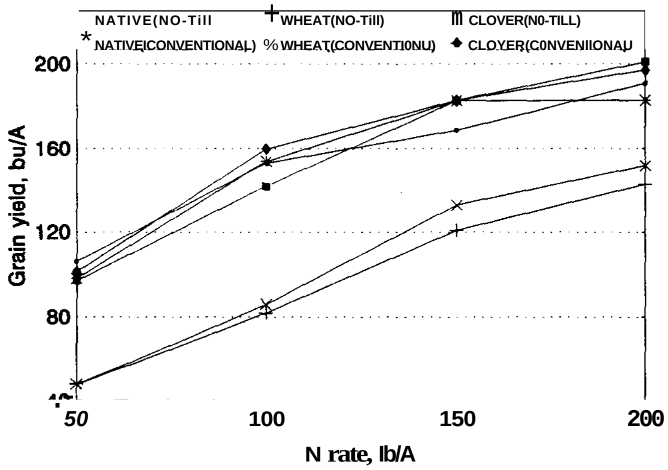

Figure 1. Influence of tillage, cover crop, and N rate on corn grain yield on Sharkey clay at St. Joseph in 1994.

regardless of cover crop treatment on this clay soil (Tables 1 and 2). Kernel weight and kernels/ear increased as N rate increased. Plant N content across N rates ranged from 1.71 to 2.42% in 1993 and 1.48 to 2.22% in 1994.

Winnsboro

Grain yields ranged from 104 to 123 bu/acre in 1993 (Table 3) and 104 to 141 bu/acre in 1994 (Table 4). Similar to St. Joseph, there were no significant interactions among treatments for grain yield.

Table 3. Influence of tillage, cover crop, and N rate on corn grain yield, plants per acre (PPA), ears per acre (EPA), kernel weight, and kernels per ear on Gigger silt loam at Winnsboro in 1993.

Treatment	Grain yield	PPA	EPA	Kernel weight	Kernels
	bu/A			g/100	no/ear
Tillage					
No-till	117	21,719	21,135	28.4	497
Conventional	115	24,201	23,773	26.4	468
LSD (0.05)	N.S.	476	606	0.8	N.S.
Cover crops					
Native	114	23,561	23,015	26.9	470
Wheat	117	23,196	22,491	27.5	481
Crimson Clover	118	22,123	21,856	27.9	496
LSD (0.05)	N.S.	851	667	0.5	N.S.
N rate, lb/acre					
50	104	22,623	21,999	27.3	441
100	117	23,762	23,090	27.6	469
150	121	22,834	22,518	27.3	503
200	123	22,621	22,209	21.4	517
LSD (0.05)	6	N.S.	N.S.	N.S.	23

N.S. =Nonsignificant at the 0.05 probability level.

Table 4. Influence of tillage, cover crop, and N rate on corn grain yield, plants per acre (PPA), ears per acre (EPA), kernel weight, and kernels per ear on Gigger silt loam at Winnsboro in 1994.

Treatment	Grain yield	PPA	EPA	Kernel weight	Kernels
	bu/A			glloo	nolear
Tillage					
No-till	129	17,622	17,306	32.3	607
Conventional	128	21,153	19,892	31.8	537
LSD(O.05)	N.S.	1095	N.S.	N.S.	N.S.
Cover crops					
Native	127	19,607	19,084	32.6	536
Wheat	124	19,130	18,144	31.8	576
Crimson Clover	134	19,432	18,586	31.8	602
LSD(O.05)	6	N.S.	N.S.	N.S.	N.S.
N **rate, lb/acre**					
50	104	19,080	18,331	30.3	490
100	129	19,448	18,596	32.0	578
150	141	19,704	18,953	33.0	611
200	141	19,317	18,517	32.9	607
LSD(O.05)	10	**N.S.**	**N.S.**	1.5	N.S

N.S. = Nonsignificant at'the 0.05 probability level.

There was no difference between tillage treatments for grain yield in either year (Tables 3 and 4). Plant populations (PPA) for NT were 10.3 and 16.7% lower than CT in 1993 and 1994, respectively. In 1993, there was a significant tillage x cover crop interaction (P=0.08). Corn stand following crimson clover in NT treatment was lower than the other two cover crops (20,351 versus 22,402 PPA), probably because of a cutworm infestation.

In 1994, cover crops significantly affected grain yield (Table 4). Grain yield following crimson clover was 10 bu/A higher than wheat and 7 bu/A higher than native vegetation. Plant N content was significantly higher following crimson clover than the other cover crops in 1994 (Table 5). However, similar to St. Joseph findings there was no significant cover crop x N rate interaction, suggesting that yield benefit from crimson clover may have been caused by some factor other than leguminous N.

On this nonirrigated loessial silt loam, optimal grain yield occurred between 100 and 150 lb N/A regardless of cover crop treatment (Tables 3 and 4). Increased kernels/ear in 1993 and increased kernel weight and kernels/ear in 1994 were the yield components contributing to the N rate yield response. Nitrogen content was increased from 2.96 to 3.12% in 1993 and 1.41 to 1.95% in 1994 by N application (Table 5).

Table 5. Influence of tillage, cover crop and N rate on corn plant N status at St. Joseph and Winnsboro in 1993 and 1994.

	1993'		1994	
Treatment	**St. Joseph**	**Winnsboro**	**St. Joseph**	**Winnsboro**
		% N		
Tillage				
No-Till	—	3.07	2.07	1.74
Conventional	—	3.14	1.74	1.69
LSD (0.05)	—	0.04	0.12	N.S.
Cover crops				
Native	2.13	3.08	1.91	1.67
Wheat	2.06	3.13	1.86	1.67
Crimson clover	2.17	3.11	1.95	1.80
LSD (0.05)	0.05	N.S.	N.S.	0.09
N rate, lb/acre				
50	1.71	2.96	1.48	1.41
100	2.07	3.04	1.88	1.67
150	2.29	3.22	2.05	1.82
200	2.42	3.21	2.22	1.95
LSD (0.05)	0.05	0.12	0.11	0.10

N.S. = Nonsignificant at the 0.05 probability level.
'Ear-leaf N in 1993 and whole plant N in 1994. Each year sampled at early silk.

Conclusions

Preliminary data suggest that minimum tillage systems may be equivalent to the traditional tillage systems on the loessial silt loam soils of the Macon Ridge. There was little agronomic benefit from cover crops in these studies. However, more research is needed to establish optimal minimum tillage production systems for corn, particularly on the clay soils.

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