Summary of Conservation Tillage Effects on Grain Yield in the Blackland Prairie

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Introduction

Conservation tillage received renewed interest with the passage of the 1985 and 1990 Food Security Act. This is especially true for the Blackland Prairie area, a land resource of approximately 2 million acres. The soils of this region are predominately heavy, expanding clays and are highly erodible when tilled. The soils are underlain by soft limestone or chalk as the main soil-forming parent material with topography ranging from level to sloping. This formation, coupled with a relatively high cropping intensity, causes this land resource region to be one of the nation's most susceptible to productivity losses from soil erosion (USDA, 1989; U. S. Army Corps of Engineers, USDA-SCS, 1990). Research (Hairston et al., 1984; Hairston et al., 1987) in the Blackland Prairie has shown that a positive correlation exists for higher yields on soils with a greater soil depth. Continued loss of top soil to erosion will eventually expose the unproductive chalk subsoil and render the region unsuitable for row crops.

Conservation tillage, such as stale seedbed systems (ridge-tillage and no-tillage) and rotation systems, have the potential to minimize production costs, enhance productivity, and meet conservation compliance. The objectives of this study were to evaluate crop yield response to selected tillage and crop rotation/tillage systems on several soils in the Blackland Prairie Region.

Materialsand Methods

Studies were initiated in the fall of 1991 at the Mississippi Agricultural and Forestry Experiment Station's Prairie Research Unit, Prairie, and the Northeast Branch Station, Verona. The Prairie site was a Vaiden silty clay (very-fine, montmorillonitc, thermic, Vertic Hapladalfs) with generally acidic topsoil and with a 1 to 2% slope. The Verona site was a Leeper silty clay (fine, montmorillonitic, nonacid, thermic, Vertic Haplaquepts) with alkaline top-soil and 0.15 to 0.3% slope. The experimental design was a randomized complete block design with four plot replications of 20 feet x 60 feet each. Annual surface broadcast fertilizer applications of P_2O_5 and K,O and nitrogen for soybean, corn and wheat were made according to soil test recommendations.

The following continuous cropping tillage treatments were evaluated on both sites: (I) no-tillage (NT) corn: (2) ridge-tillage (RTl) corn, planted no-till and cultivated once with a high-clearance cultivator equipped with ridgers; (3) turf aerator (TA) corn, with turf aerator knives operated one month prior to planting at 10° angle from vertical and at a 4- to 6-inch depth (Prairie site); (4) conventional raised-bed tillage (CTB) corn chiseled, disked, bedded, and do-alled before planting, and cultivated once; (5) NT soybeans; (6) ridge-tillage (RT2) soybeans planted no-till and cultivated twice with a high-clearance cultivator equipped with ridgers; (7) TA soybeans; and (8) conventional smooth seedbed tillage (CT) soybeans chiseled, disked, and do-alled before planting, and cultivated twice during the growing season.

The following tillage/crop rotation treatments were evaluated on both sites: (1) RTI corn followed by RT2 soybeans; (2) RT2 soybeans followed by RTI corn, (3) NT corn followed by minimum tillage MT wheat (diskedtwice after corn harvest and do-alled before planting wheat) with NT doublecropped soybeans followed by NT corn; (5) NT corn followed by MT bed wheat and NT doublecrop soybeans (Verona site); (6) MT bed wheat with NT doublecrop soybeans followed by NT corn (Veronasite); (7) fall paratill bed (FPTB) soybeans followed by FPTB corn; and (8) FPTB corn followed by FPTB soybeans.

Corn plots were planted in 30-inch rows with 1.5 seeds/foot of row. Burndown and preemergence herbicides were applied to RTI, TA, and NT corn. Preemergence herbicides were applied to CTB corn plots. A post-directed herbicide was applied broadcast to NT and TA, and in a 15-inch band to RTl corn. Nitrogen (N) as ammonium nitrate was applied broadcast over the top of all corn plots at 160 lb N/A (split application).

The herbicide 2,4-D was applied as an early (mid-February to mid-March) spring broadleaf weed control method on all monocrop soybean stale seedbed (RT2, NT, TA) and wheat-doublecrop soybean treatments. Two weeks prior to planting soybeans, a bumdown herbicide was applied to NT, TA, and RT2 soybean plots. Soybeans were planted in 30-inch rows with 9 seeds/ft of row in May-June on monocrop treatments and in June on doublecrop treatments. A preemergence herbicide was applied to all monocrop soybean plots. Soybean weed control during the cropping season involved the use of broadcast over-the-top postemergence herbicides and/or post-directed herbicides applied on TA and NT treatments. Postemergence over the top and/or post-directed herbicides in a 15-inch band with two cultivations were applied to RT2 and CT soybean treatments.

The center 6-foot wide swath of wheat was harvested for grain yield in both studies and the center two rows of corn and soybean plots, at both studies, were harvested for grain yield. Soybean and corn yields were adjusted to bushels per acre at 13.5 and 15.5% seed moisture, respectively. Data were subjected to statistical analysis (SAS, Cary, NC, 1991) and means were separated by Least Significant Difference (LSD) at the 0.05 probability level.

Results and Discussion

The first year data (1992) was an establishment year for crop rotation and tillage systems. This data is not being reported. The data being reported is for both locations for 1993-1995 growing season. Rainfall for the growing seasons of May-October (1993-95) is presented in Table 1. Rainfall for 1993 ranged from normal for the Prairie site to above nomal for the Verona site. The rainfall for 1994 was above normal for both sites, ranging from 150% to 170% of normal. Sufficient early rainfall in 1995 was good for corn production but less than needed in August and September for optimum soybean yield.

Wheat

Wheat yields for 1993-1995 for both sites are presented in Table 2. Low yields for I993 resulted from a late spring freeze which caused cold injury to seed heads. 1994 yields were higher on the Vaiden soil than the Leeper soil, possibly because of better surface drainage on the Vaiden site. Wheat yields for 1995 were low on the Vaiden site. Environmental conditions were not favorable to high wheat yields due to a cool wet spring. Wet soil conditions in the fall of 1995 caused no wheat to be planted on the Leeper site.

Corn

Continuous CTB and RTI corn, and rotation of RT2 soybeans followed by RT1 corn on the Vaiden soil on raised-bed systems in I993 showed no corn yield difference, but produced higher yield than the flat systems of continuous TA and NT corn and a rotation of MT wheat NT double cropped soybeans followed by NT corn. The higher yields for the raised bed treatments are attributed to better surface drainage than the smooth surface system of NT and TA. Crop rotation had no effect on yield. The 1994 yield on the Vaiden soil was lower than 1993, and neither tillage nor crop rotation had any effect on yield. The lack of yield difference and the lower yield may have been due to plant injury caused by post emergence herbicide applications. Environmental conditions for corn for 1995 were exceptional. The raised-bed systems (continuous CTB and RTI corn and FPTB Bn; Fb RPTB corn) on the Vaiden soil in I995 were no different in yield, but were higher than the flat systems of continuous NT, and TA corn and NT corn following MT wheat with NT double cropped soybeans in a rotation. Crop rotation nor tillage system had no effect on yields in 1995.

Corn yield on the Leeper soil in 1993 was no different between tillage and crop rotation systems (Table 3). Corn yields for 1994 were similar to results on Vaiden soil in 1993, which showed higher yields for the raised-bed systems. The Leeper site in 1994 indicated an interaction between raised-bed systems and smooth tillage systems. The raised-bed rotation treatments, RTI corn following RT2 soybeans, FPTB soybeans followed by FPTB corn and MT bed-wheat-double cropped NT soybeans followed by NT corn produced higher yield than smooth tillage systems continuous NT corn, NT corn following MT wheat-double crop soybeans, but were not different from continuous CTB and RTI corn treatments. Continuous RTI and CTB corn yields, however, were no different from MT wheat-doublecrop NT soybeans followed by NT corn.

In 1995 no corn yield showed any significant difference between tillage and crop rotation systems and these results could be attributed to a warm dry spring and good soil moisture growing conditions.

Soybeans

1993 soybean grain yields, on the Vaiden site, were not different between continuous CT, NT, and TA and rotations of RTI corn followed by RT2 soybeans, and NT double cropped soybeans produced higher yield than continuous R R soybeans (Table 4). The lower continuous RT2 soybean yield in I993 is attributed to a severe infestation of stem canker, which caused plant death in that treatment but did not affect other treatments. In 1994, all tillage and crop rotation, except NT soybeans doublecropped following MT wheat, produced similar yields. NT doublecrop soybeans were replanted on July 5,1994, because of poor stands caused by excessive rainfall in June, followed by a dry August, which resulted in no harvestable yields. All tillage and crop rotation treatments except NT doublecrop soybeans following MT wheat and RT2 soybean following RTI corn in 1995 produced similar yields. The lower double crop yields can be attributed to late plantings, dry conditions and higher temperatures in August and September. RT2 soybeans following RTI corn, produced higher yield than FPTB corn followed by FPTB soybean.

Soybean yield on the Leeper site for 1993 varied with tillage and crop rotation (Table 4). Continuous CT and NT soybeans, and rotations of RTI corn followed by RT2 soybean and NT corn followed by MT Wheat-NT doublecropped soybeans drilled into wheat stubble were not different in yield, but all produced higher yields than RT2 continuous soybeans. Lower yields for RT2 continuous soybeans were due to stem canker disease, which caused plant death in this treatment but did not effect other treatments. Continuous CT, NT, RT and RT2 soybeans following RTI corn produced similar yields, but were higher than NT double crop soybeans in **30**-inch rows and drilled rows (7.5 inch). FPTB soybeans following FPTB corn produced higher yield than other treatment.

Table 1. 1993-1995 rainfall at Prairie Research Unit, Prairie, MS and Northeast Mississippi Branch Station, Verona, MS

Month	Prairie[1] 1993	1994	1995	Verona[2] 1993	1994	1995
		inches			inches	
May	4.40	3.27	4.00	5.54	4.39	2.94
June	2.92	12.92	4.26	4.36	7.57	4.15
July	4.60	11.10	4.26	2.04	9.57	3.13
August	5.03	1.14	1.89	5.51	2.91	4.46
September	4.80	5.56	.80	6.83	5.09	2.01
October	2.45	5.72	4.28	2.70	6.22	3.93
Six-month total	24.20	39.71	19.62	26.98	35.75	20.62

[1]Prairie average rainfall totals for May, June, July, August, September, and October: 4.72, 5.04, 3.78, 2.58, 3.44, and 3.08; a 6-month total of 25.97 inches.

[2]Verona average rainfall totals for May, June, July, August, September, and October: 4.04, 3.50, 4.49, 3.08, 3.39, and 2.61, a 6-month total of 21.11 inches.

Table 2. Effect of tillage and rotation on wheat yield in a soybean-wheat double croppping system in 1993-1995, at the Northeast Branch Station, Verona, MS, and at the Prairie Research Unit, Prairie, MS

	Wheat 1993	1994	1995	Avg.
	---------bu/acre--------			
1. Corn-Wheat/Soybean Rotation				
A. Leeper silty clay - Verona[1]				
1. NT Corn; fb[2] MT - Wheat NT Beans	17.1	37.0	----	27.0
2. NT Corn; fb MTBd - Wheat NT Beans	16.4	38.2	----	27.2
B. Vaiden silty clay - Prairie[3]				
1. NT Corn: fb MT - Wheat NT Bean	26.2	70.0	22.8	39.6

[1]Previous crop (1991) was conventional tillage soybeans.
[2]fb = followed by.
[3]Previous crop (1982-91) was native grasses cut for hay. Since 1992 was first year of the study, data for rotation effects are not available.

Table 3. Tillage and crop rotation effect on corn yield on Vaiden silty clay and Leeper silty clay soils, Prairie and Verona, MS. 1993-1995.

Crop Rotation/ Tillage System	Vaiden Silty Clay[1] 1993	1994	1995	Mean	Leeper Silty Clay[2] 1993	1994	1995	Mean
	---bu/acre---				---bu/acre---			
I. CONVENTIONAL TILLAGE								
Continuous Corn (CTB)	92.1	89.3	156.7	112.9	86.6	126.9	133.5	115.6
II. STALE SEEDBED SYSTEMS								
A. Continuous Corn								
1. No Tillage (NT)	72.0	76.8	131.6	93.4	80.1	113.4	137.1	108.3
2. Ridge Tillage (RT1)	100.4	76.3	151.3	109.3	100.4	121.9	136.6	120.9
3. Turf Aerator-Renovator (TA)	62.1	84.4	138.2	94.9	-----	-----	-----	-----
B. Corn-Soybean(Bn) Rotation (2-year)								
4. RT2 Bn; fb[3] RT1 Corn	109.2	82.4	132.7	108.1	89.7	136.6	136.6	119.5
5. FPTB Bn; fb FPTB Corn	-----	-----	168.5	-----	-----	141.5	135.6	-----
C. Corn-Wheat/Soybean Doublecrop Rotation (2 year)								
6. MT Wheat NT Bn; fb NT Corn	56.2	76.8	139.7	86.7	90.9	109.6	139.3	114.9
7. NT Corn; fb MT Bed Wheat NT Bn	----	-----	-----	-----	93.8	138.1	151.5	129.9
LSD (0.05)	17.7	NS	22.9	13.9	NS	20.2	NS	11.5
CV%	14.4	26.8	10.3	13.4	15.9	11.4	10.1	12.4

[1]Previous crop was native grass for hay production 1982-91. Prior to initiation of study, the site was disked twice and harrowed

[2]Previous crop (1991) was conventionally tilled soybeans.

[3]fb = Followed by

Table 4. Tillage and crop rotation effect on soybean yield on Vaiden silty clay and Leeper silty clay soils, Prairie and Verona, MS. 1993-1995.

Crop Rotation1	Vaiden Silty Clay				Leeper Silty Clay			
Tillage System	1993	1994	1995	Mean	1993	1994	1995	Mean
	bu/acre				bu/acre			
I. CONVENTIONAL TILLAGE								
Continuous Soybean (CT)	41.5	34.5	30.5	35.5	31.2	41.7	39.4	37.4
II. STALE SEEDBED SYSTEMS								
A. Continuous Soybean (Bn)								
1. No Tillage (NT)	40.7	33.7	34.3	36.2	38.6	41.7	44.3	41.9
2. Ridge Tillage (RT2)	29.2[1]	37.4	33.8	33.5	21.5	40.5	45.5	35.3
3. Turf Aerator-Renovator (TA)	40.7	37.8	30.2	36.2	----	----	----	----
B. Corn-Soybean Rotation (2-year)								
4. RTI Corn; fb RT2 Bn	41.2	36.4	39.4	39.0	37.7	41.5	48.7	42.6
5. FPTB Corn; fb FPTB Bn	----	35.5	32.7	33.8	----	49.7	50.0	49.8
C. Corn-Wheat/Soybean Doublecrop Rotation (2-year)								
6. NT Corn; fb MT Wheat NT Bn	42.7	---[2]	13.3	----	35.5[3]	23.9[1]	47.1	35.5
7. NT Corn; fb MT Bd Wheat NT Bn	----	----	----	----	28.1	26.0	45.7	33.3
LSD (0.05)	6.8	NS	6.6	NS	7.5	5.7	5.8	3.9
CV%	11.9	13.4	13.9	14.2	18.4	11.1	9.3	13.1

[1]Low yield is due to plant death caused by stem canker disease.
[2]No yield data due to stand failure and an extremely late replanting date.
[3]Drilled soybeans

1995 growing conditions were good in early and mid-growing season, but little rainfall and high temperatures were recorded in late August and early September. Yields were not different between NT, RT, RT2 soybean following RT corn, FPTB soybean following FPTB corn, NT corn followed by MT wheat NT soybean and NT corn followed by MT bed wheat NT soybean. Although CT was lower in yield than other treatments it was not different from NT. Soybeans showed no yield response in the 2 yr corn rotation system. These yields resulted in no difference between CT and NT soybeans yield and is in contrast to previous tillage research on Prairie soils which showed lower yield for NT. (Buehring et al., 1981; Buehring et al., 1988; Hariston et al. 1984; and Hariston et al., 1990). The similar yields for NT and CT soybeans is possibly due to the early March 2,4-D application followed by a burndown herbicide application 2 weeks prior to planting which removes weed competition and reduces soil water loss. These results are contrary to results from previous research (Buehring et al, 1981; and Buehring et al, 1988) where NT burndown treatments were applied at planting.

Summary

Summary of data for 1993-1995 indicated that corn and soybean tillage systems showed differences in yield response. Corn yields were generally higher on raised beds than on the non-raised treatments with tillage having no effect on yield in either system. Raised beds can enhance yield and increase stands and is especially beneficial for corn emergence and development during periods of above normal rainfall. Neither corn nor soybeans in a two year rotation, showed any yield response to rotation. Unfavorable growing conditions were the limiting factors for wheat-soybean yield in the two year double crop rotation treatments.

Yields at both sites for double crop soybeans following wheat were reduced due to wet soil conditions at planting, followed by below average rainfall which resulted in low yields or no harvestable soybeans. Soybean response to tillage differed by year and by location. Environmental conditions determined the yield response to the different tillage systems. Both corn and soybean yields can be maintained with NT, RT and PTB. PTB soybean treatment, on the bottomland Leeper site, has the potential to increase yield above CT. However, PTB soybean on the Vaiden site showed no added yield response over CT. These studies will be continued in order to determine the long-term effects oftillage and rotation systems on both corn and soybean yield.

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