Soybean Response to Reduced Tillage Systems on Selected Soil Resource Areas

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Introduction

It is estimated that soybeans are grown on approximately 1.25 million acres of Mississippi land where erosion potential exists using current tillage practices. Most of this erodible acreage is in central and northern Mississippi. New tillage implements such as the Paraplow® and Ro-till® have recently been introduced as reduced tillage implements. The Paraplow looks similar to a moldboard plow but differs in that the plow-shank only lifts the soil up as the shank passes through the soil profile, causing very little surface disturbance. The Ro-till is equipped with trash whippers, an in-row subsoil shank, plus two adjustable fluted coulters and a rolling basket per shank. The coulters are adjustable, and move soil over the subsoil slit as the shank moves through the soil profile. The rolling basket trails the coulters and firms the seedbed. This implement is used as a one-pass seedbed preparation system.

Soybean response to tillage systems varies widely. In the Midwest (4, 8, and 10), soybean yields are often not affected by tillage systems ranging from complete residue incorporation to no-till. Others (2 and 7) have reported that reduced tillage systems produced soybean stands, weed control, and yields comparable to those from conventional tillage. Some reported research (3 and 11) indicated no-till systems produced higher yields than a conventional tillage system. Most soybean tillage research in Mississippi has indicated a significant yield increase to tillage (1, 5, 6, and 12). A primary concern with tillage methods is their effect on soil erosion.

Studies with monocrop soybeans have confirmed a much higher soil loss with conventional tillage than with reduced tillage and no tillage. Soil loss studies on a loess soil with a 5 percent slope indicated that conventional tillage resulted in a soil loss of 8.70 tons/acre compared to 3.6 tons/acre from a reduced tillage system and 0.62 tons/acre for no-till system (6). In another study on a Blackland Prairie clay soil in Mississippi, the average soil loss from conventional tillage was 3.97 tons/acre compared to 2.90 tons/acre lost from no-till (5). In a rainfall simulator study in Mississippi on a Leeper silty clay with 0.2 percent slope, the average soil loss from one storm (2.5 inches/hour) with conventional tillage was 1.5 tons/acre compared to 0.18 ton/acre for minimum tillage (9).

This study was conducted to evaluate reduced tillage systems for soybean production that have potential to reduce soil loss. The objective was to evaluate across three major soil resource areas: (1) soybean growth and yield response to selected reduced tillage systems and depth, and (2) soybean growth and yield response to depth of P and K fertilizer placement with the Ro-till reduced tillage system.

Materials and Methods

Field plots were established for the duration of the project (1985-87) on a Catalpa silty clay at the MAFES Northeast Branch Experiment Station, Verona, MS; on a Providence silt loam at the Pontotoc Branch Experiment Station, Pontotoc, MS; and on a Loring silt loam at the Brown Loam Branch Experiment Station, Raymond, MS. The studies at each location were conducted in a randomized complete block design with four replications.

Conventional tillage, consisted of chiseling 6-8 inches deep + disking and paraplowing to depths of 4-6, 6-8, and 12-14 inches in the spring of each year. Tillage dates for Verona, Pontotoc, and Raymond are given in Tables 2, 3, and 4, respectively. Ro-till tillage treatment, at depths of 7-8, 11-12, and 14-15 inches, was done at the time of planting at all three locations. Soybeans were planted as a separate operation following the Ro-till implement. Prior to tillage in the spring of each year, dry fertilizer (0-17-34 analysis) was applied to all plots at 45 and 90 lb/acre of P_2O_5 and K_2O, respectively, except in the Ro-till fertilizer placement treatment plots. The fertilizer in the Ro-till fertilizer placement plots was applied as a liquid suspension of K_2HPO_4 and KCI, equivalent to dry fertilizer P and K rates of 45 and 90 Ib/acre P_2O_5 and K_2O, respectively. The liquid fertilizer suspension was injected to the depth of Ro-till subsoil tillage as indicated in Tables 2, 3, and 4.

Roundup@ at 1.0 lb ai/acre + X-77® surfactant at 0.5% v/v was applied as a burndown herbicide application to no-till, Paraplow, and Ro-till treatments 7 to 14 days prior to planting. The conventional tillage and Paraplow plots were smoothed with a do-all (an implement equipped with a rolling cutter bar and section harrow) prior to planting soybeans. Soybean planting dates (Table 2, 3, and 4) for 1985-87 ranged from May 31 to June 5 at both Northeast and Pontotoc

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locations and from June 5 to June 26 at the Brown Loam Station.

Centennial soybean was planted at all locations with a John Deere Max-Emerge no-till planter equipped with ripple coulters. Seeding rate was 7 seeds/linear foot of row in 30-inch rows.

Weed control management during the growing season utilized all postemergence herbicides for both Pontotoc and Raymond, and preemergence herbicides plus a post-directed spray for the Northeast Branch Experiment Station (Table 1). Plots were not cultivated during the growing season at any of the locations.

Soybean plant population data were taken about 6 weeks after planting at all three locations. Plants were counted in six randomly selected 3-foot sections of the center two rows of each plot.

Ten randomly selected mature soybean plants in the center two rows of a four-row plot were measured from the soil line to the uppermost node to determine plant height. The two center rows of each plot were harvested with a small plot combine for seed yield. The seed was weighed, then moisture was determined with a Dickey John GACII® grain analysis computer and recorded. Yield data were calculated and adjusted to 13 percent moisture. Mean separation was determined using the least significant difference (LSD) method, at the 0.05 probability level for all data.

Results and Discussion

Soybean growth and yield response to reduced tillage systems varied with year, soil resource area, and rainfall amount and distribution during the soybean growing season.

Northeast Experiment Station

Northeast Branch rainfall distribution during the soybean growing season of May through September ranged from 34 percent above normal in 1985 to about normal in 1986 and 1987. Soybean average yield ranged from 41 bu/acre in 1985 to 29 bu/acre in 1987. Stand density ranged from about 40,000 plants/acre in 1987 to 78,500 in 1986. Stand densities in the Ro-till treatments were generally lower than in the Paraplow, no-till, and conventional tillage treatments in 1985 and 1987 but not in 1986 (Table 2). The seedbed prepared by the Ro-till at planting was cloddy and rough on the surface. Sometimes the killed ,vegetation did not flow through the implement in the tillage operation, causing soil blockage.

In 1985, both Ro-till 7 to 8 and 11 to 12-inch depths with fertilizer surface-incorporated produced lower yield than conventional chisel + disk and Paraplow 6 to 8-inch depth. The Paraplow (6 to 8-inch depth) treatment, no-till, and conventional chisel + disk treatments produced the highest yields and were not different. Depth of tillage for both the Paraplow and Ro-till treatments, and fertilizer placement in the Ro-till treatment had no significant effect on yield.

Stand densities in 1986 (Table 2) were higher than those in 1985 in all tillage treatments. Plant height at maturity was less and soybean yields averaged about 10 bu/acre less than in 1985. This was possibly due to extreme dry weather in July, when rainfall was 4.2 inches below normal. Soybeans showed no response to tillage treatments. Tillage depths with Ro-till and Paraplow had no significant effect on yield.

In 1987, soybean yield ranged from 22 bu/acre for Ro-till (11 to 12-inch depth) to 38 bu/acre for the conventional chisel + disk. Both Paraplow (6 to 8-inch depth) and chisel + disk produced significantly higher yield than no-till and Ro-till (11 to 12-inch depth). In comparison to fertilizer surface applied and incorporated with the Ro-till, fertilizer P and K injected to depth of tillage with a Ro-till had no effect on yield in any of the 3 years.

Pontotoc Experiment Station

Rainfall during the July-September soybean growing season was about normal in 1985, 52 percent below normal in 1986, and 30 percent below normal for 1987. Soybean stand densities averaged 74,500 in 1985, 47,800 in 1986, and 37,700 plants/acre in 1987. Two years, 1985 and 1987, plant densities

Table 1. Herbicides and time of application for weed control in reduced tillage system studies at three MS locations, 1985-87.

Time of application*	Location: Verona — Herbicide	Location: Verona — lb ai/a	Location: Pontotoc-Raymond — Herbicide	Location: Pontotoc-Raymond — lb ai/a
Burndown	Roundup + X-77	1.0 + 0.5%	Roundup + X-77	1.0 + 0.5%
PRE-E	Dual + Scepter	2.00 + 0.125		-
POT	—	–	Poast + Blazer + Crop Oil	0.02 + 0.38 + 1 qt
P-Dir	Sencor + 2.4-DB	0.25 + 0.20		-

*Time of application code: Burndown was applied 7-14 days before planting; PRE-E = preemergence application made following soybean planting; POT = postemergence over-top application as tank mixtures, twice during soybean growing season; and P-Dir = post-directed application to soybeans 8-12 inches tall as a broadcast application.

were affected by tillage systems; in 1985 all paraplow treatments had significantly lower plant densities than both Ro-till 11 to 12-inch depth treatments (Table 3). The Paraplow 4 to 6-inch depth had the lowest plant density and was significantly lower than both Ro-till 11 to 12 and 14 to 15-inch depths fertilizer surface-incorporated; in 1987, however, the

Table 2. Effect of reduced tillage systems and fertilizer placement on soybean plant population, height at maturity and yield on a Catalpa silty clay soil in 1985-87 at the Northeast Experiment Station.

	Reduced tillage treatment	Tillage depth (in)	Fertilizer placement depth (in)	Tillage date	Plants/acre x 1,000	Plant/height (in)	Yield hu/acre
				1985			
1.	Chisel + Disk	6-8	Inc.	4/10	88.9	38	46
2.	No-till	—	Surf.	—	47.9	32	44
3.	Paraplow	4-6	Inc.	4/10	72.6	36	42
4.	Paraplow	6-8	Inc.	4/10	83.1	37	45
5.	Paraplow	12-14	Inc.	4/10	63.5	36	43
6.	Ro-till	7-8	Inc.	5/31	48.7	30	35
7.	Ro-till	11-12	Inc.	5131	46.I	31	38
8.	Ro-till	14-15	Inc.	5/31	63.9	33	41
9.	Ro-till	7-8	7-8	5/31	53.0	31	40
10.	Ro-till	11-12	11-12	5/31	53.7	30	42
11.	Ro-till	14-15	14-15	5/31	46.1	32	41
	LSD (0.05)				1.0	3	6
				1986			
1.	Chisel + Disk	6-8	Inc.	4/04	65.9	23	29
2.	No-till	—	Surf.	—	76.8	23	29
3.	Paraplow	4-6	Inc	4/04	44.1	22	30
4.	Paraplow	6-8	Inc	4/04	58.3	23	32
5.	Paraplow	12-14	Inc.	4/04	80.4	25	34
6.	Ro-till	7-8	Inc.	6/03	76.4	23	32
7.	Ro-till	11-12	Inc.	6/03	98.9	25	33
8.	Ro-till	14-15	Inc.	6/03	94.9	26	33
9.	Ro-till	7-8	7-8	6/03	84.6	25	31
10.	Ro-till	11-12	11-12	6/03	90.5	26	31
11.	Ro-till	14-15	14-15	6/03	92.9	27	34
	LSD (0.05)				33.3	4	N.S.
				1987			
I.	Chisel + Disk	6-8	Inc.	4/13	44.0	29	38
2.	No-till	—	Surf.	—	44.0	25	27
3.	Paraplow	4-6	Inc.	4/15	51.1	27	37
4.	Paraplow	6-8	Inc.	4/15	53.2	30	35
5.	Paraplow	12-14	Inc.	4/15	47.0	31	37
6.	Ro-till	7-8	Inc.	6/02	36.8	23	22
7.	Ro-till	11-12	Inc.	6/02	31.7	25	22
8.	Ro-till	14-15	Inc.	6/02	28.1	23	26
9.	Ro-till	7-8	7-8	6/02	29.0	24	20
10.	Ro-till	11-12	11-12	6/02	31.0	24	25
11.	Ro-till	14-15	14-15	6/02	33.7	27	25
	LSD (0.05)				6.5	6	7

chisel + disk treatment had a population significantly lower than the Ro-till 11 to 12-inch depth, with injected fertilizer. The Ro-till 7 to 8-inch depth, injected fertilizer treatment had the lowest plant density and was significantly lower than both Ro-till 11 to 12 and 14 to 15-inch depths with injected fertilizer treatments, no-till, and Paraplow 4 to 6 and 6 to 8-inch depth treatments.

Soybean yields were higher in 1985 than both 1986 and

Table 3. Effect of reduced tillage systems and fertilizer placement on soybean plant population, height at maturity, and yield on a Providence silt loam soil in 1985-87 at the Pontotoc Ridge-Flatwoods Experiment Station.

	Reduced tillage treatment	Tillage depth (in)	Fertilizer placement depth (in)	Tillage date	Plants/acre x 1,000	Plant/height (in)	Yield bu/acre
				1985			
1.	Chisel + Disk	6-8	Inc.	4112	71.5	35	43
2.	No-till	—	surf.	—	75.5	33	43
3.	Paraplow	4-6	Inc.	4112	67.5	33	40
4.	Paraplow	6-8	Inc.	4112	66.4	34	42
5.	Paraplow	12-14	Inc.	4112	69.0	35	41
6.	Ro-till	7-8	Inc.	6104	68.2	36	46
7.	Ro-till	11-12	Inc.	6104	84.9	35	50
8.	Ro-till	14-15	Inc.	6104	80.6	37	45
9.	Ro-till	7-8	7-8	6104	76.2	34	48
10.	Ro-till	11-12	11-12	6104	83.9	38	46
11.	Ro-till	14-15	14-15	6104	75.9	36	42
	LSD (0.05)				13.0	N.S.	7
				1986			
1.	Chisel + Disk	6-8	Inc.	4103	48.1	31	28
2.	No-till	—	Surf.	—	53.2	32	28
3.	Paraplow	4-6	Inc.	4103	42.5	29	26
4.	Paraplow	6-8	Inc.	4103	47.1	34	27
5.	Paraplow	12-14	Inc.	4103	50.5	33	31
6.	Ro-till	7-8	Inc.	6104	46.7	32	26
7.	Ro-till	11-12	Inc.	6104	48.5	33	34
8.	Ro-till	14-15	Inc.	6104	44.3	34	31
9.	Ro-till	7-8	7-8	6104	51.9	33	27
10.	Ro-till	11-12	11-12	6104	45.9	35	27
11.	Ro-till	14-15	14-15	6/04	46.3	35	25
	LSD (0.05)				N.S.	5	8
				1987			
1.	Chisel + Disk	6-8	Inc.	4122	25.7	27	28
2.	No-till	—	Surf.	—	34.4	27	28
3.	Paraplow	4-6	Inc.	4122	36.8	25	27
4.	Paraplow	6-8	Inc.	4/22	34.1	28	30
5.	Paraplow	12-14	Inc.	4/22	31.2	28	34
6.	Ro-till	7-8	Inc.	6/04	33.9	27	25
7.	Ro-till	11-12	Inc.	6/04	30.5	29	32
8.	Ro-till	14-15	Inc.	6/04	33.0	25	34
9.	Ro-till	7-8	7-8	6/04	21.8	23	26
10.	Ro-till	11-12	11-12	6/04	44.2	26	25
11.	Rotill	14-15	14-15	6/04	34.4	27	28
	LSD (0.05)				12.0	N.S.	8

1987. The Ro-till (11 to 12-inch depth) fertilizer surface-incorporated, Paraplow (6 to 8-inch depth), no-till, and chisel + disk treatment yields were not different any year. In contrast to the poor seedbed preparation by the Ro-till on the silty clay soil at the Northeast Branch Station, the Ro-till prepared a smooth, and firm seedbed in a one-pass operation all 3 years.

Although not significant, the shallow depths of tillage with

Table 4. Effect of reduced tillage systems and fertilizer placement on soybean plant population, height at maturity, and yield on a Loring silt loam soil in 1985-87 at the Brown Loam Experiment Station.

	Reduced tillage treatment	Tillage depth (in)	Fertilizer placement depth (in)	Tillage date	Plants/acre x 1,000	Plantlheight (in)	Yield bu/acre
				1985			
1.	Chisel + Disk	6-8	Inc.	4/24	66.2	21	30
2.	No-till	—	Surf.	—	69.7	21	30
3.	Paraplow	4-6	Inc.	4124	66.2	23	29
4.	Paraplow	6-8	Inc.	4/24	64.5	24	32
5.	Paraplow	12-14	Inc.	4124	61.0	22	29
6.	Ro-till	7-8	Inc.	6126	66.2	20	25
7.	Ro-till	11-12	Inc.	6126	76.1	20	26
8.	Ro-till	14-15	Inc.	6/26	57.6	20	22
9.	Ro-till	7-8	7-8	6126	83.6	20	32
10.	Ro-till	11-12	11-12	6/26	76.7	21	25
11.	Ro-till	14-15	14-15	6/26	81.9	20	23
	LSD (0.05)				N.S.	2	6
				1986			
1.	Chisel + Disk	6-8	Inc.	4124	89.9	31	35
2.	No-till	—	Surf.	—	43.9	23	13
3.	Paraplow	4-6	Inc.	4124	58.8	27	27
4.	Paraplow	6-8	Inc.	4124	47.9	26	19
5.	Paraplow	12-14	Inc.	4/24	51.7	25	22
6.	Ro-till	7-8	Inc.	6/16	85.9	31	39
7.	Ro-till	11-12	Inc.	6/16	75.0	33	41
8.	Ro-till	14-15	Inc.	6/16	74.0	30	30
9.	Ro-till	7-8	7-8	6/16	83.4	33	33
10.	Ro-till	11-12	11-12	6116	80.3	30	31
11.	Ro-till	14-15	14-15	6/16	66.9	29	28
	LSD (0.05)				22.4	4	7
				1987			
1.	Chisel + Disk	6-8	Inc.	4/29	149	43	34
2.	No-till	—	Surf.	—	118	43	35
3.	Paraplow	4-6	Inc.	4/29	126	43	36
4.	Paraplow	6-8	Inc.	4/29	I40	45	38
5.	Paraplow	12-14	Inc.	4129	126	45	36
6.	Ro-till	7-8	Inc.	6/05	126	43	35
7.	Ro-till	11-12	Inc.	6/05	144	43	38
8.	Ro-till	14-15	Inc.	6/05	142	40	35
9.	Ro-till	7-8	7-8	6/05	I27	42	35
10.	Ro-till	11-12	11-12	6/05	134	43	36
11.	Ro-till	14-15	14-15	6/05	146	41	34
	LSD (0.05)				N.S.	N.S.	N.S.

the Paraplow and Ro-till generally produced lower yields all 3 years. The Ro-till 11 to 12-inch depth fertilizer surface-incorporated treatment produced higher yield than the 7 to 8-inch depth all 3 years and had higher yield than the 14 to 15-inch depth 2 of 3 years. The Paraplow deepest depth of 12 to 14 inches produced higher yield than the shallower depths 2 of 3 years. Fertilizer P and K applied surface-broadcast and incorporated with a one-pass operation of the Ro-till, and P and Kapplied at the depth of Ro-till tillage indicated no yield difference in any year of the study.

Brown Loam Experiment Station

Rainfall during the June to September growing season was about normal in 1985, 18 percent below normal in 1986, and 29 percent above normal in 1987. In 2 (1985 and 1987) of 3 years plant densities were not significantly affected by tillage system (Table 4). In 1986, however, no-till and both Paraplow 6 to 8 and 11 to 12-inch depths had lower plant densities than chisel + disk and all Ro-till treatments.

The low yields in 1985 were probably the result of the late planting date of June 26. Both Ro-till 14 to 15-inch depth treatments produced lower yields than all Paraplow treatments, no-till, and chisel + disk. There was no significant yield response to tillage depth with either Paraplow or Ro-till. The Ro-till 7 to 8-inch depth with injected fertilizer was the only treatment which produced higher yield than fertilizer surface-incorporated with the Ro-till at the 7 to 8-inch tillage depth.

In 1986, the. no-till and Paraplow 6 to 8 and 12 to 14-inch depth treatments had significantly lower plant densities and lower yields than chisel + disk and all Ro-till fertilizer surface-incorporated treatments. The Ro-till 11 to 12-inch depth with fertilizer surface-incorporated produced more beans than no-till and all Paraplow treatments and Ro-till 14 to 15-inch depth. Fertilizer (P and K) injected at both 7 to 8 and 11 to 12-inch subsoiling depths with the Ro-till produced lower yield than where it had been surface-applied and incorporated with the Ro-till at the same tillage depth. The shallow tillage depth for Paraplow produced higher yield than the deepest tillage.

Plant densities and yields in 1987 were not affected by tillage systems (Table 4). Rainfall was 29 percent above normal and yields averaged 36 bu/acre. Tillage depth with both Paraplow and Ro-till had no effect on yield.

Summary

Soybean growth and yield response to reduced tillage systems from 1985-1987 on three soil resource areas indicated a tillage system xlocation xyear interaction. Depth of tillage with both the Paraplow and Ro-till generally produced no significant difference in yield.

Dry fertilizer P and K, that was surface-broadcast and incorporated with one pass of the Ro-till produced yields equal or greater than fertilizer P and K injected as a liquid suspension to the depth of tillage with the Ro-till at all locations and years.

No-till produced yield equal to the chisel + disk 2 of 3 years at both Verona and Raymond, and all 3 years at Pontotoc. Ro-till although not always significant, produced higher yield than chisel + disk and no-till 2 of 3 years at Raymond and all 3 years at Pontotoc. However, at Verona on a silty clay, Ro-till produced lower yield than chisel + disk 2 of 3 years. Paraplow produced yield equal to chisel + disk all 3 years at Verona and Pontotoc, and 2 of 3 years at Raymond.

Literature Cited

1. Albritton, R. C., N. W. Buehring, T. L. Watts, and W. S. Caldwell III. 1981. Progress Report for 1980. Northeast Mississippi Branch. Verona, MS. MAFES Research Highlights 44: 6 p. 4-5. Miss. Agric. and Forestry Exp. Stn. June 1981.
2. Bone, S. W., N. Rask, D. L. Forster, and B. W. Schurle. 1976. Evaluation of tillage system for corn and soybeans. Ohio Report on Research and Development. 61 (4): 60-63. Ohio Agric. Res. and Dev. Ctr., July-August 1976.
3. Edwards, J. H., D. L. Thurlow, and J.T. Eason. 1988. Influence of tillage and crop rotation on yield of corn, soybean and wheat. Agron. J. 80: 76-79.
4. Erhach, D. C. 1982. Tillage for continuous corn and corn-soybean rotation. Trans. ASAE 25: 906-911
5. Hairston, J. E., J. 0. Sanford, I. C. Hayes, and L. L. Reinschmiedt. 1984. Crop yield, soil erosion and net returns from five tillage systems in the Mississippi Blackland Prairie. J. Soil Water Conservation. 39: 391-395.
6. Mutchler, C. K., and I. D. Greer. 1984. Reduced tillage for soybean. ASAE. 27;: 1364-1369
7. Palmer, J. H. and T. H. Garner. 1980. Limited seedbed preparation schemes for planting soybeans. World Soybean Resource Conference II Abstracts.
8. Richey, C. B., D. R. Griffith, and S. D. Parsons. 1977. Yield and cultural energy requirements for corn, and soybeans with various tillage-planting systems. Adv. Agron. 29: 141-182
9. Romkens, M. J. M., J. Y. Wang, F. D. Whisler, N. W. Buehring, and J. K. Young. 1979. Runoff composition of soybean management system on Leeper clay loam soil. Proceedings Mississippi Water Resource Conference. pp. 55-59.
10. Schuler, R. T., and J. W. Bander. 1981. Reduced tillage studies on irrigation sandy loam soil in corn, and soybean production. ASAE Paper No. 81-1013. 24 pp.
11. Tyler, D. D., and J. R. Overton. 1982. No-tillage advantages for soybean seed quality during drought stress. Agron. J. 74: 344-347.
12. 1982 Summary of reduced tillage research. MAFES Research Highlights. Miss. Agric. and Forestry Exp. Stn. Special Edition. April 1982.