Soybean Yield Response to Tillage and Landscape Position

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INTRODUCTION

Crop productivity is slowly lost over time from soil erosion on most southeastern US. fields. Reduction of crop yields may not be recognized until the land is no longer suitable for growing crops. Difficulty of detecting crop productivity losses from soil erosion caused by water is further masked by technological innovation in agricultural research. Current research technologies may temporarily improve crop yields by employing new and innovative production practices at a rate faster than the erosion process is depleting yields. Consequently, the loss of crop productivity caused by soil erosion may be temporarily overcome with soil amendments, improved varieties, tillage practices, and annual management practices to improve seasonal water holding capacity of the soil. In soils with shallow restrictive layers, as in the fragipan soils of the Southeast Region of the U. S., the eventual loss of the shallow top soil layer should result in decreased overall crop yields. This paper reports on effects of landscape position on crop yields and compares No-Till (NT) and Conventional Till (CT) soybean *(Glycine max* [L] Merr.) yields. These results are from part of a larger ongoing study.

Various researchers (McGregor et al., 1992; Mutchler et al., 1985; Mutchler and Greer, 1984; McGregor et al., 1975) reported beneficial soil erosion control and increases in crop yields from established NT systems. Variation in crop yield with depth to a fragipan horizon also has been used to explain the effects of soil erosion on crop productivity (McGregor et al., 1992; Frye et al., 1983). Water stress became the limiting factor to satisfactory crop yields in soils with shallow restrictive layers such as fragipans.

Field slopes, another major factor in crop productivity, generally are nonuniform. Slopes, however, consist of many small uniform planes of short length along the slope. Nonuniformity of the overall slopes results in nonuniform erosion occurring along the length of the slope. Nonuniformity of the slopes results in nonuniform soil depths, organic matter, CEC, and pH across the slope due to past erosion and sediment deposits within the field. Yet, slopes are treated uniformly with the applications of soil amendments.

MATERIALS AND METHODS

This report expands the earlier study by McGregor et al. (1992) by extending the analysis of four paired plots to include slope position within the larger and ongoing study. The experimental area described by McGregor et al. (1992) was located on the North Mississippi Branch of the Mississippi Agricultural and Forestry Experiment Station near Holly Springs, Mississippi. The area consisted of paired plots (12 pairs) with the randomized treatments on a Loring silt loam (Typic Fragiudalf) on slopes ranging from 2 to 5%. Past erosion along the slope from this experimental area had caused variation in fragipan depth. Even though the site was considered unusable for crop yield studies, this area was appropriate for evaluating crop productivity from soil erosion on shallow fragipan soils. No-till soybean was grown on one plot of each pair and CT soybean was grown on the other plot from 1983 to 1996. Depth to a fragipan layer varied from about 12 to 18 in. Each of the 24 plots was 150 ft in length and 18 A in width with 3-ft-wide rows in an up-and-downhill direction. Row lengths were divided into 25-ft increments downslope (referred to position A through position F with position A at the apex of the slope, Figure 1). Soybean was harvested from the two middle rows of each plot in 25-ft segments with a plot combine to provide soybean yields. Harvested grain was moisture tested and adjusted to 14% moisture for yield weights.

Corn *(Zea mays* L.) silage had been grown on the site for the previous 20 yr prior to plot establishment in 1983. A fescue *(Festuca arundinancea)* waterway was established at the base of the plot area to trap sediments leaving the area. Due to row orientation, plot rows in the CT enhanced erosion down the slope. All plots were tilled in 1983 preceding planting of continuous soybeans; however, only the CT treatment received two more cultivations for weed control during the growing season of 1983. Tillage sequence preceding planting in 1983 consisted of disking, field cultivation, moldboard plowing, disking, and field cultivation to smooth out any soil and topographical differences left over from previous farming and erosion. After 1983, tillage for CT plots consisted of disking, chiseling, disking, and field

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cultivation preceding planting, and then followed with *two* cultivations for weed control during the growing season. During 1984 through 1989, fertilizer was incorporated with a double-disk opener on both NT and CT plots at planting time at rates recommended by the Mississippi Agricultural and Forestry Experiment Station. Starting in 1990, fertilizer was broadcast at planting time on the soil surface **on** both NT and CT plots. Preemergence herbicides in the CT were sprayed at planting. No fall plowing or tillage implements were used in the CT after the plots were harvested.

No additional tillage was done on plots designated as NT after 1983 except for some areas used for simulated rainfall experiments. During the 1987 and 1996 years, positions E and F on two of the replications in the subset of this study were tilled for these simulated rainfall experiments and thus, no yield data were obtained. One replication of yield data was missing from positions A, B, and C in 1990. These exceptions do not affect the general outcome of the study. Roundup was sprayed on the NT each year in mid-April. Fertilizers in the NT were surface broadcast after the initial burndown and before planting. Preemergence herbicides for the NT were the same as in the CT. In the NT plots, an additional application of Roundup was made at planting to bumdown any emerged weeds since the mid-April burndown. Postemergence herbicides were used if needed to control weeds and grasses. Soybean varieties were rotated annually to avoid cyst nematodes, root diseases, and other pests which could hinder the long-term aspect of the study. In all tillage systems, soybean was planted in May each year. Due to the establishment of the NT system in 1983, the yield data from 1983 did not represent NT systems and was not included with the reported 13-yr period of study.

Crop yield as affected by landscape position for 4 paired plots of a larger experiment (12 reps) were analyzed with a randomized complete block design. Trends were examined to relate the effect of slope position to soybean yield as affected by tillage system.

RESULTS AND DISCUSSION

Average soybean yields for each year are presented in Figure 2. Conventional-till soybean yields were 23 and 3% greater than NT yields during 1984 and 1985, respectively. No-till soybean yields were 5, 17, 82, 29, 50, 35, 43, 20, 119, 36, and 64% greater than CT soybean yields during 1986 through 1996, respectively. During the last 11 yr, NT soybean yields averaged 42% greater than CT soybean yields. Yields after 2 to 3 yr of continuous NT monocropping of soybean were equivalent or exceeded those of continuous CT monocropping soybean system, as was reported in the larger experiment by McGregor et al. (1992) and Johnson et al. (1995).

Significantly higher yields, as influenced by tillage, were detected in years 1988, 1990, 1991, 1992, 1994 and 1996 (Figure 2). These yield measurements showed that erosion influence on yields would gradually progress over time and measurable yield differences between NT and CT systems would increase in frequency with time.

Mutchler et al. (1985) demonstrated that a NT system for soybeans was successful in reducing runoff and soil erosion. Decreased runoff down the slope should result in more water available for the NT system thereby increasing plant growth. An increase in plant growth could mean more cover for the soils, higher yields, and more residue returned to the soil, which could reduce evaporation in future years. The process thus feeds on itself from year to year unless interrupted. This process could account for NT surpassing CT in yields during the third year. Possibly after 2 or 3 yr, increased residue levels in the NT system resulted in moisture being available at crucial times in the NT system to advance yields over the CT system.

Although poor soybean yields from both NT and CT were produced during several years, the sustained trend for lower yields from CT as compared to NT indicated an adverse effect of excessive erosion and tillage **on** crop productivity. Continued erosion of the soil overlying a fragipan soil creates an environment where crop yields cannot be maintained even under optimum growing conditions. With proper management, acceptable NT crop yields may be produced indefinitely.

A separation of means using LSD at the 0.05 probability level was conducted for tillage, slope position, and tillage and slope position interaction (Table 1). Slope position influenced soybean yields in 9 out of 13 yr (Table 1) as found by comparing differences of the average soybean yield with their LSD value for the slope position factor. Yields in the CT were severely impacted in the 75 to 125 ft range (position C and D) after 6-41 of continuous tillage. Due to the significant difference of soybean yield in the tillage and position interaction (Table 1, section of the tillage system by position interaction), an analysis was conducted that compared the average soybean yield at various slope positions along the crop row for each tillage system to the average yield at the apex or position A of the plot (Table 2). Except for position F, yields were generally less for landscape positions below the apex for both NT and CT systems

Positions A, D, and F were plotted for each tillage system (Figure 3). Soybean yields were reduced at position D and were predominantly increased at position F for each tillage system as displayed in Figure 3. Reduction of soybean yield at position D was more pronounced in the CT system, probably due to more eroding soil associated with this system as compared to the NT system. Increase in yield found at position F was probably a result of sediment deposition in both NT and CT systems At this point, differences occurring in yields due to tillage and slope position were a result of soil erosion depleting yields in the CT and yields being slightly enhanced in the NT. Possibly during tillage of the CT, fragipan clays were mixed with topsoils at the D position producing AL toxicity, reduced aeration, and increased bulk density which can reduce yields and water holding capacity.

CONCLUSIONS

Slope position influenced soybean yields in 9 out of 13 yr. After 7-yr of continuous tillage systems, yields were severely impacted in the 75 to 125 ft range of CT plots each year. Yields in the range of 125 to 175 ft down slope were not impacted in the CT plots. Apparently sedimentation was taking place in this area of the lower slope. Yields in the NT were not as pronounced as in the CT plots by slope positions which indicated the soil stability along the slope in NT plots where erosion is not taking place and affecting yields. Also, NT soybean gave higher yields in 11 out of 13 yr when compared to CT soybean.

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Table 1. Table of means for soybean yields (bu/a) as affected by tillage, location, and tillage by location interactions.

Tillage System	Position	Years 1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
CT[†]		37	41	18	24	17	17	6	23	23	21	16	14	11
NT[†]		30	40	19	28	31	22	9	31	33	25	35	19	18
LSD (0.05)		4.5	2.5	2.4	5.9	6.7	4.5	1.5	4.7	5.0	4.3	9.4	8.0	5.6
	A[‡]	42	41	20	27	26	17	8	32	34	23	29	17	17
	B[‡]	35	40	19	25	26	19	7	27	31	24	23	17	15
	C[‡]	30	39	16	27	25	21	7	24	24	21	21	13	11
	D[‡]	24	40	19	26	20	18	7	21	22	20	20	13	8
	E[‡]	31	42	18	26	21	17	7	25	25	22	27	17	14
	F[‡]	41	42	17	27	24	23	9	32	30	28	32	21	19
LSD (0.05)		5.1	3.8	3.8	3.6	3.0	5.2	2.3	5.4	5.5	3.7	6.8	2.5	5.1
CT[£]	A	45	42	20	25	19	17	6	28	27	23	20	16	13
CT[£]	B	38	40	19	23	20	16	4	24	28	23	15	15	9
CT[£]	C	34	41	17	25	18	18	6	20	18	18	9	10	7
CT[£]	D	30	38	17	22	12	16	5	14	12	14	7	8	3
CT[£]	E	34	43	17	25	15	14	6	22	24	21	19	13	11
CT[£]	F	43	43	17	24	17	19	8	29	29	29	26	19	20
NT[£]	A	40	39	21	29	34	17	9	35	40	24	39	19	22
NT[£]	B	33	40	19	27	33	21	10	31	35	26	30	19	22
NT[£]	C	26	38	15	30	32	24	9	28	30	25	34	16	15
NT[£]	D	18	41	22	30	29	21	8	28	32	27	32	18	12
NT[£]	E	28	40	19	27	27	20	8	28	27	23	36	20	17
NT[£]	F	39	40	16	29	32	28	11	36	31	28	39	24	18
LSD (0.05)		6.5	3.7	5.1	3.8	3.5	5.2	1.8	7.7	7.8	4.5	9.8	3.7	5.3
C.V. %		12.8	6.1	18.6	9.3	9.9	18.0	16.0	19.1	18.8	12.8	25.8	14.9	21.0

Notes: CT = Conventional-till NT = No-till A B C D E F are positions along slope of plot.
LSD = least significant difference (bu/A) at the 0.05 level of probability
C.V. % = coefficient of variation in percent

[†] Average yield across all positions and reps

[‡] Average yield across all tillages and reps

[£] Average yield across all reps

Table 2 Soybean yields as percent of yields from location A at various locations along the slope of the soybean row for comparison to the apex of the plot.

Tillage	Yield Ratio	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
CT	AIA	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
CT	B/A	83.8	95.3	92.5	91.1	106.8	94.2	66.7	85.0	102.8	101.1	75.6	92.3	70.6
CT	CIA	76.5	96.4	85.0	97.0	94.6	102.9	91.7	71.7	65.1	79.1	46.2	61.5	54.8
CT	DIA	65.9	90.5	83.8	85.1	64.9	91.3	87.5	48.7	45.0	61.5	35.9	49.2	26.5
CT	H A	76.0	101.8	85.0	98.3	78.4	78.3	100.0	77.0	86.2	92.3	94.9	81.5	85.3
CT	F/A	95.0	101.8	85.0	96.3	90.5	107.2	129.2	102.7	104.6	127.5	130.8	115.4	159.0
NT	AIA	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
NT	B/A	82.4	103.2	92.8	94.7	97.0	121.7	105.6	87.9	87.4	108.5	78.6	104.1	98.9
NT	CIA	65.4	96.2	73.5	103.5	96.3	137.7	94.4	78.6	75.5	105.3	87.7	85.1	70.7
NT	DIA	44.0	105.1	103.6	106.1	85.8	118.8	88.9	80.0	81.1	112.8	83.1	94.6	54.6
NT	H A	71.1	102.6	89.2	94.1	79.1	115.9	88.9	80.7	68.6	98.9	93.5	106.8	77.6
NT	F/A	96.9	103.2	77.1	102.9	94.0	162.3	116.7	102.1	78.6	118.1	101.3	128.4	82.2

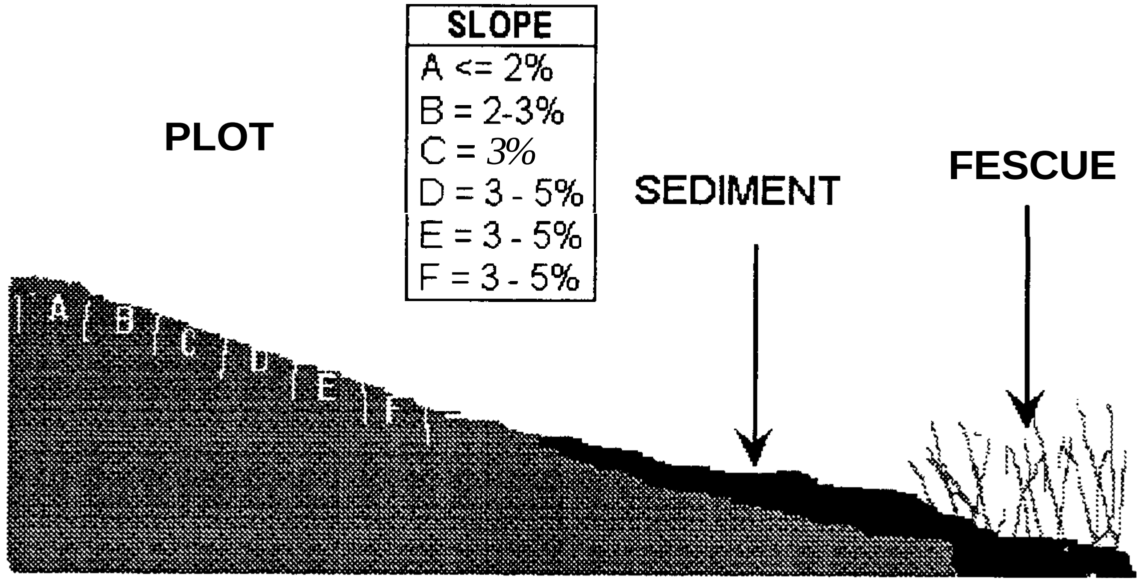


Figure 1. Topographic layout of slope and position configuration of A, B, C, D, E, and F.

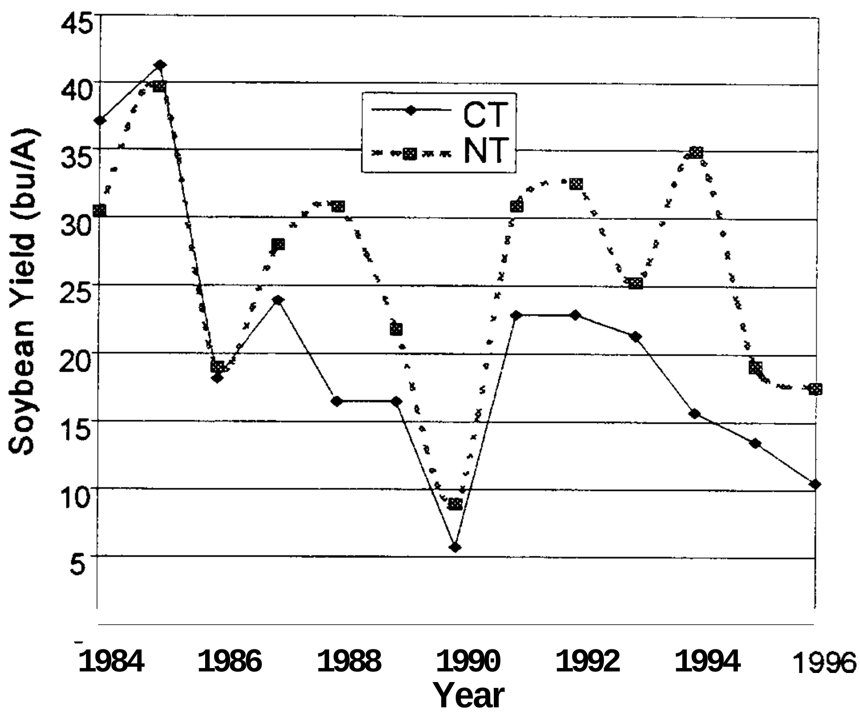
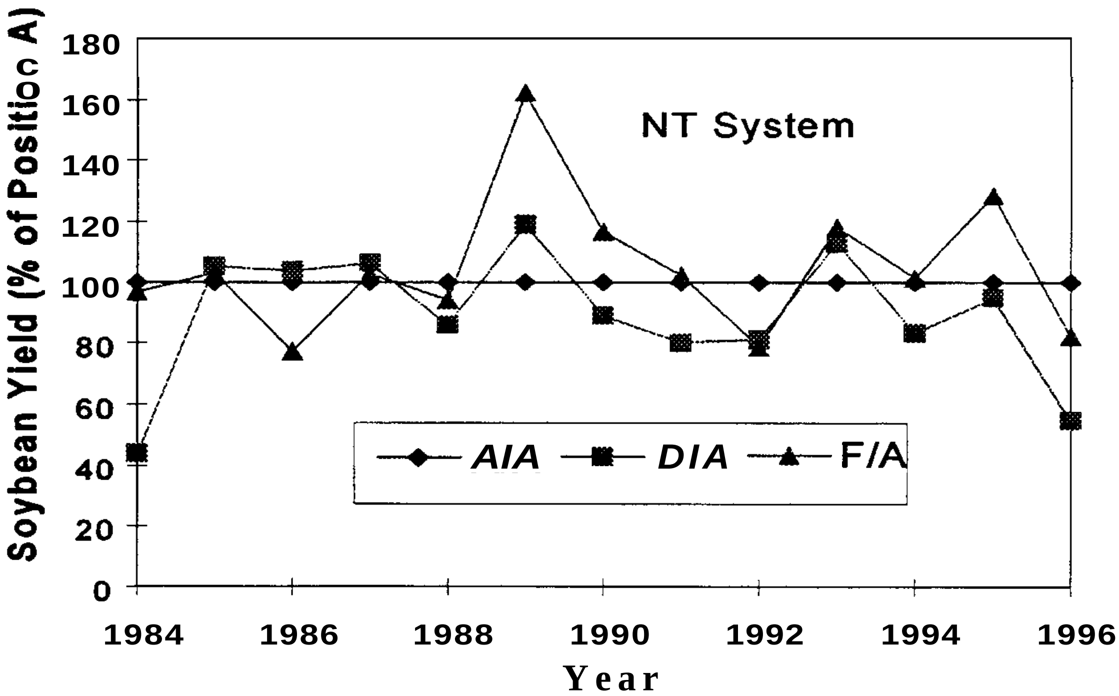


Figure 2. Average soybean yields for each year from NT and CT productivity plots



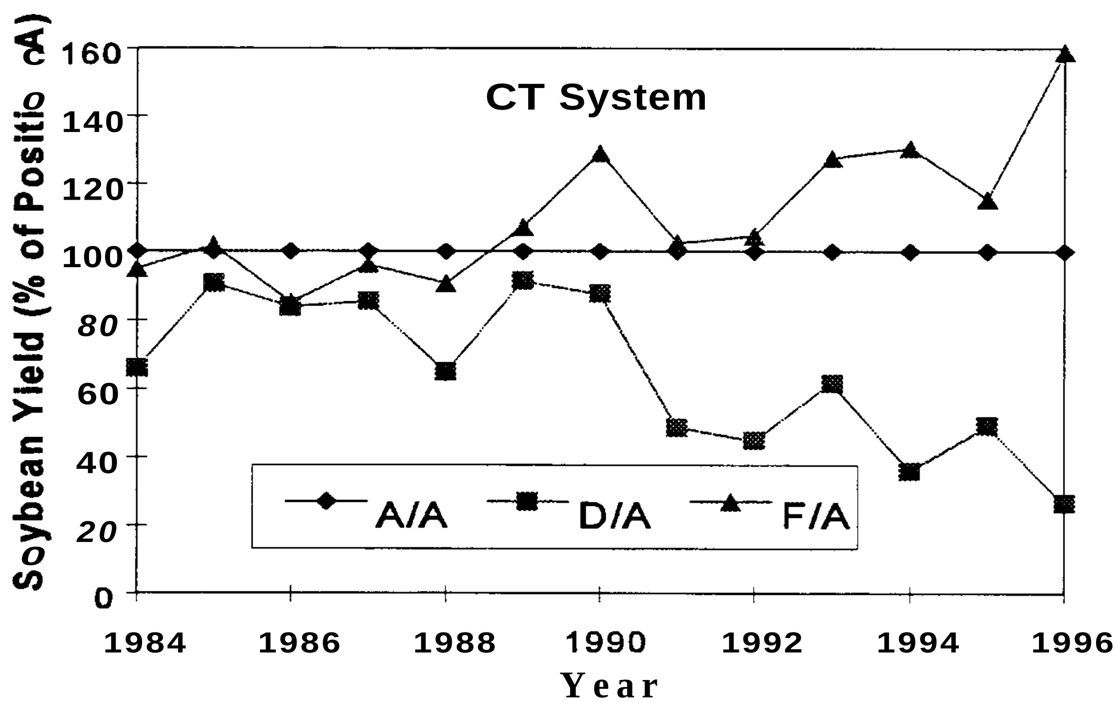


Figure 3. Average yield at various positions along slope of the soybean row compared to the average yield at position A for each tillage system.