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Long-Term No-Till and Conventional-Till Soybean Yields

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This publication summarizes collaborative soil conservation research data from 1983 through 1999 at Holly Springs, Mississippi, about the effect of long-term no-till and conventional-till on soybean productivity. The study was conducted by scientists of the USDA-ARS National Sedimentation Laboratory in Oxford, Mississippi, and the North Mississippi Branch of the Mississippi Agricultural and Forestry Experiment Station in Holly Springs, Mississippi. It was published by the Office of Agricultural Communications, a unit of the Division of Agriculture, Forestry, and Veterinary Medicine at Mississippi State University.

Long-Term No-Till and Conventional-Till Soybean Yields (1983-1999)

INTRODUCTION

This report summarizes the effect of erosion on soil productivity as represented by annual crop yields of long-term no-till soybean *Glycine max* (L.) Merrill at Holly Springs, Mississippi from 1984 to 1999. The National Sedimentation Laboratory (NSL) and the North Mississippi Branch of the Mississippi Agricultural and Forestry Experiment Station (MAFES) cooperated in this research. The NSL, located at Oxford, and the North Mississippi Branch of MAFES, located 30 miles north of Oxford at Holly Springs, are in the north central region of Mississippi. The Brown Loam soils at the station are representative of the severely eroded loess soils of the southeastern United States.

McGregor et al. (1992) reported probable trends for increasing soil losses with time under conventional-till history, and decreasing soil losses with time for no-till history. More data were needed to definitely establish trends. That initial report contained crop yields over an eight-year period (1984-1991). McGregor et al. (1999) published crop yield data from the plots that were collected from 1983 to 1997. No-till annual crop yields varied widely due to weather but appeared to slightly decrease with time. A definitive trend line was derived for declining conventional-till soybean yields with time. In the first several years after establishment of no-till, conventional-till yields exceeded no-till yields. However, no-till yields exceeded those from conventional-till by about 800 kg/ha after 14 years.

Cullum et al. (2000) extended the work of McGregor et al. (1999) to include the evaluation of cumulative erosion due to the effects of slope length on crop yield, and to evaluate the effect of fragipan depth on long-term no-till and conventional-till soybean yield. All the data relative to both the Cullum and McGregor studies were taken from the same soybean plots, but McGregor presented whole-plot data whereas Cullum's data set included subplot yields for different subplot slope lengths.

Significant new information could be gained by changing rather than continuing this long-term project as originally conceived beyond 1999. Thus changes in the methodology of the plots were made in the year 2000 to include a soybean-winter wheat treatment, and to test the effect of conventional-till after no-till soybean as well as no-till after conventional-till soybean.

This bulletin has three objectives: (1) summarize the research findings relative to the long-term crop yields of no-till and conventional-till soybean; (2) present the complete crop yield data sets for the soybean studies from 1983 through 1999, which also includes two more years of data since the last publication about this soybean study; and (3) give the results of a recent topographic survey indicating dramatic differences in elevation between no-till and conventional-till plots after 17 years of soil erosion. Rainfall simulator measurements of erosion from no-till and conventional-till were a part of this project but the results are given separately (McGregor et al. 1999).

PROCEDURE

The study was located on the North Mississippi Branch of the Mississippi Agricultural and Forestry Experiment Station at Holly Springs, Mississippi. Appendix Table 1 gives the soybean varieties, fertilization, herbicide, and harvest dates from 1984 to 1999. Appendix Table 2 gives the cultivation dates on the conventional-till plots during this same period of time.

Procedures used in this long-term soybean crop yield study from 1984 through 1997 (Cullum et al. 2000; McGregor et al. 1999) are repeated in some detail here. The study area was arranged in a randomized block design having 12 blocks with two treatments of no-till and conventional-till on a Loring silt loam soil (*Typic Fragiudalfs*) on slopes ranging from about 3% to 4% (Figure 1). This arrangement results in paired plots (no-till on one plot and conventional-till in the other). A fragipan layer was about 0.30 to 0.45 m below the soil surface. Each of the 24 plots in the study was 46 m in length and 5.5 m in width with 0.9-m-wide rows in an uphill and downhill direction. The two middle rows of each plot were harvested with a "plot-sample" combine to provide soybean yields. From 1983 until 1998 the soybean rows in the plots generally extended down slope below the end of the plots about 18 m. In April of 1998, fescue grass was established below each of the plots to help alleviate problems with sedimentation in the ditch at the bottom of the slopes.

Six sequential 7.6-m-long slope subplots within each plot were designated as A through F with subplot A at the top of the plot (Cullum et al. 2000). Simulated rainfall was applied with a rainulator in the lower one-third of the plots, subplots E and F, during some years. Thus only the upper two-thirds (31 m) of all plots (subplots A, B, C, and D) were used to evaluate yields.

The rainulator subplots received simulated rainfall after light cultivation. Although reported in the appendix, crop yields from these subplots were excluded from crop yield analyses. Soybean yields from continuous no-till and conventional-till systems have now been measured for 16 years (1984-1999) on 12 pairs of plots oriented uphill and downhill.

Depth to the fragipan layer was determined by probing in the early spring of 1985. Each subplot was probed to obtain a single depth value for each subplot. Appendix Table 3 gives the representative depth of fragipan for each subplot. The average fragipan depths in the spring of 1985 were 42, 38, 37, and 30 cm in the conventional-till and 46, 44, 35, and 30 cm for the no-till for subplots A, B, C, and D, respectively. The effective slope lengths for runoff travel distance on subplots A through D were 7.6, 15.2, 22.8, and 30.5 m, respectively. Effective slope length for a designated subplot is the distance runoff travels from the top of the plot (top of subplot A) to the end of the designated subplot.

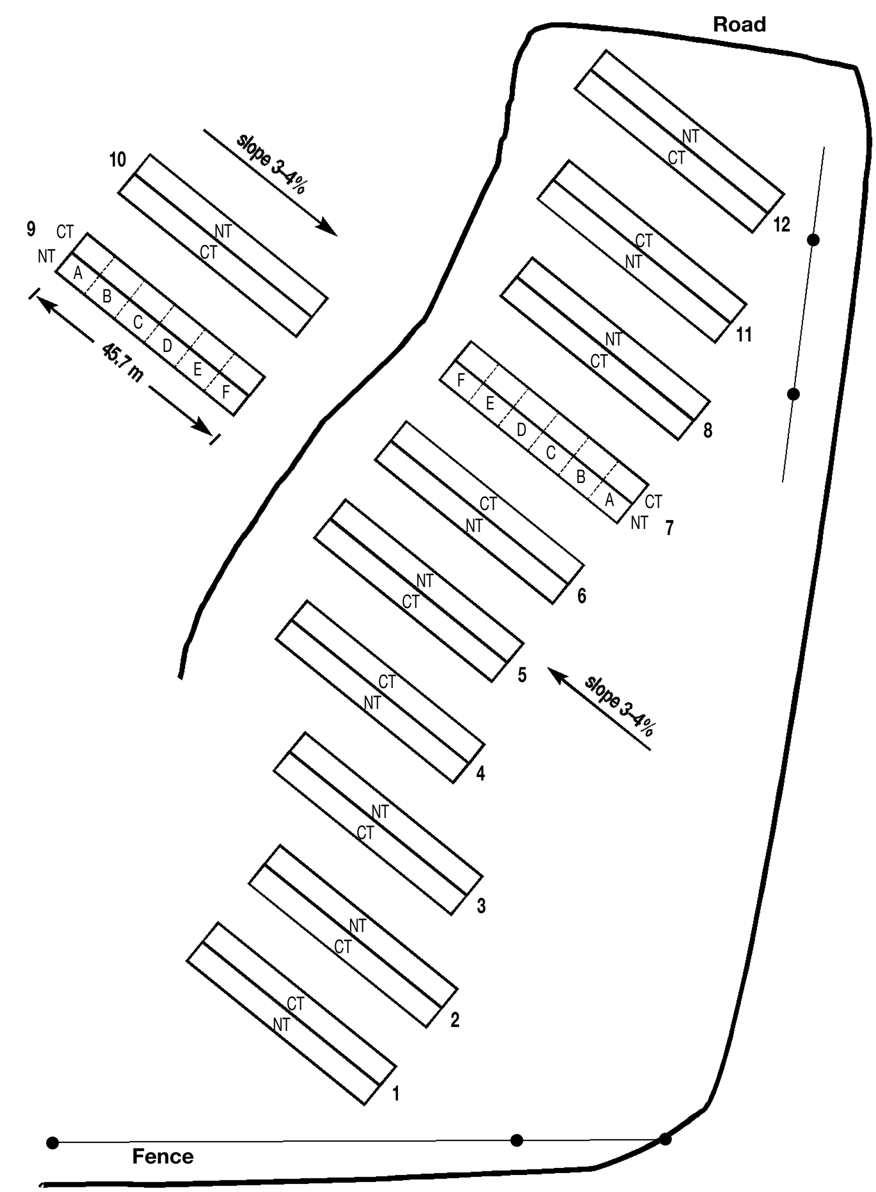

Figure 1. Layout of long-term conventional-till (CT) and no-till (NT) soybean plots showing tillage type and 7.6-m-long subplots A, B, C, D, E, and F (Figure taken from Cullum et al., 2000).

Corn silage had been grown on the site for the twenty years prior to plot establishment in 1983. All plots received extensive tillage preceding planting in 1983 that consisted of disking, do-all cultivation, moldboard plowing, disking, and do-all cultivation to smooth out any soil and topographical differences left over from previous farming and erosion. Thus normal cultural practices for no-till or for conventional-till were not used for the plots in 1983. However, effects of no-till began in the growing season of 1983 when the plots designated for no-till received no tillage during the growing season while those designated for conventional-till received two cultivations for weed control. For purposes of statistical analyses of conventional-till versus no-till, 1984 was considered to be the first year of complete no-till.

Conventional-till plots received tillage after 1983 that consisted of disking, chiseling, disking, and do-all cultivation preceding planting. These plots were then cultivated twice during each growing season for weed control. Lime at 5.6 t/ha was applied to the entire plot area in May of 1983. From 1984 through 1989, fertilizer was incorporated with a double-disk opener on both no-till and conventional-till plots at planting time at rates recommended by the Mississippi Agricultural and Forestry Experiment Station. Starting in 1990, the fertilizer was broadcast at planting time on the soil surface on both no-till and conventional-till plots.

RESULTS

An analysis of variance (SAS 1989) showed that the effects of tillage, pair, and year were significant at the 1% level during the 1984-1997 period (McGregor et al. 1999). These results supported earlier conclusions for the 1984-1991 period (McGregor et al. 1992).

An exponential equation fitted to the differences of no-till and conventional-till average yield (McGregor et al. 1999) reflected that no-till soybean yield exceeded conventional-till soybean yield by about 70% after 14 years:

$$NT - CT = 830 - 1442\, e^{-226\, t} \quad (1)$$

where NT - CT equals differences between no-till and conventional-till crop yields in kg/ha, and t equals the number of years starting with year one in 1984. The r^2 value was 0.60 for the 14-year period. Using values of no-till minus conventional-till yields in the equation partially eliminated the variable effect of years. The equation reflected that no-till soybean yields exceeded conventional-till soybean yields by about 800 kg/ha after 14 years. Extending the trend for yield differences beyond the limits of the data illustrated how yield differences may approach an average no-till yield minus a very low average conventional-till yield. Conventional-till yields will be minimized because continuation of conventional-till eventually allows the shallow topsoil to be nearly eliminated by soil erosion. Conversely, good management of no-till soybean land will allow improvement of the soil structure over time and will increase surface cover, particularly in the first several years of no-till. Even under no-till, soil erosion occurs; thus over a very long period of time average no-till yields may decline slightly reflecting this loss of soil above the fragipan. Figure 2 shows the relationship in Equation 1, derived from data from 1984 through 1997.

Average annual soybean yields and annual rainfall amounts are presented in Table 1. McGregor et al. (1999) reported that no-till soybean yields exceeded those from conventional-till by about 800 kg/ha after 14 years (1984-1997) without tillage. Differences in crop yields between no-till and conventional-till during the next two years (1998-1999) should not be considered as being part of an overall trend because of severe drought in the summers of both years that adversely affected both no-till and conventional-till yields. Occurrences of extremes of drought or excessive rainfall in the growing season appeared to affect soybean yields in some years, but not in others. Unfortunately, yields from both no-till and conventional-till soybean were low in 1998 and 1999 because of dry conditions during most of these two growing seasons. Conventional-till soybean yields ranged from about 180 kg/ha in 1999 to 700 kg/ha in 1985. No-till yields ranged from about 430 to 2,640 kg/ha during these same years. Average annual rainfall of 1,413 mm was only 11 mm less than the 30-year (1961-1990) norm (NOAA, 1993), while the average growing-season (June through August) rainfall of 349 mm was 48 mm greater than normal.

Table 1. Average soybean yields from no-till and conventional-till productivity plots, yield differences, and annual and growing-season rainfall.

Year	Crop Yields			Annual
	No-till Average	Conv.-till Average	Difference NT - CT	Rainfall
	kg/ha	*kg/ha*	*kg/ha*	*mm*
1983 [1]	816	1036	-210	1462
1984	2298	2648	-341	1402
1985	2642	2699	-54	1221
1986	1222	1303	-91	1245
1987	2075	1731	332	1297
1988	2235	1321	922	1351
1989	1308	1154	156	1654
1990	710	403	291	1685
1991	2273	1642	631	2111
1992	2173	1448	711	1429
1993	1751	1490	266	1251
1994	2334	1146	1193	1505
1995	1480	1024	461	1268
1996	1769	940	827	1225
1997	2137	1276	864	1369
1998	928	502	426	1354
1999	427	181	246	1241
Averages[1]				
1984-99	1735	1305	430	1424
St. Dev.	655	684	411	235

[1]All plots were extensively cultivated in the spring of 1983 (the first year), but after that no tillage was done in the plots designated as no-till. Thus the 1983 data do not represent either no-till or conventional-till.

Although poor soybean yields from both no-till and conventional-till were produced during several years, the sustained trend for lower yields from conventional-till as compared to no-till indicated an adverse effect of excessive erosion and tillage on soil productivity. Continued erosion of the soil overlying a fragipan soil creates an environment where crop yields cannot be maintained even under optimum climatic growing conditions.

Conventional-till soybean yields exceeded no-till soybean yields in early years of no-till while no-till was being established. During 1983, the initial year of establishment of plots, all plots received extensive tillage before planting. Plots designated for conventional-till were cultivated twice during that growing season, but plots designated for no-till were not cultivated during the growing season. Greater soybean yields in 1983 were obtained from plots that received tillage during the growing season. Thus cultivation during this period may have resulted in a benefit to yield during that year. Rainfall of 150 mm for the period June through August in 1983 was lower than during these months in the next 16 years. Normally, evaporation of soil water under established no-till with accumulated surface residues would be less than under conventional-till, thus providing more water for crop growth. Also, the cultivation broke a surface crust, enhancing infiltration under conventional-till while the surface crust remained on the plots designated for no-till during this establishment year.

No-till soybean yields averaged 13% less than conventional-till soybean yields in 1984 (Table 1). During 1985 and 1986, no-till yields averaged only 4% less than conventional-till yields. Over the next thirteen years (1987-1999), yield of no-till soybean averaged 62% greater than conventional-till soybean. These results imply that benefits of no-till as compared to conventional-till require time for accumulation of surface cover and perhaps for improvement of surface structure. The increased surface cover should have reduced soil water evaporation losses. Runoff measurements from rainfall simulation experiments (McGregor et al. 1999) showed that infiltration was greater on plots with a history of no-till even following cultivation as compared to other cultivated plots with a conventional-till history.

Figure 3 illustrates the large yield differences in different years, which were partially due to variation in weather. Figure 3 also shows how differences between no-till and conventional-till generally increased and favored no-till more and more with time. These data suggest that the productive potential of no-till as compared to conventional-till may not be recognized in short-term studies. The abnormal summer rainfall in 1998 and 1999 confuses interpretation of the long-term trends in no-till and conventional-till crop yields with time. McGregor et al. (1999) reported that an exponential equation derived for slightly declining no-till soybean yields from 1984 through 1997 had a very poor fit, with an r^2 of only 0.11. But McGregor et al. (1999) reported a definitive trend line (exponential relationship) with an r^2 of 0.65 for declining conventional-till soybean yields from 1984 through 1997. These equations represent conditions over a 14-year period at Holly Springs, Mississippi, but illustrate what may happen on many shallow soils. Although there will be annual variation in crop yields, including that caused by climatic conditions, conventional-till crop yields will eventually approach a minimum value. Where very severe erosion takes place, this minimum value may be unacceptable for economic crop production. Long-term no-till crop yields theoretically can be expected to have slight declines with time, finally approaching a minimum value that will be significantly greater than conventional-till crop yields. The Holly Springs no-till data suggest that no-till yields will vary from year to year, but not suffer sustained declines in yields like conventional-till.

Table 2 shows the average no-till and conventional-till soybean crop yields for subplots A, B, C, and D during each year from 1984 through 1999. The table also shows the average differences in yields between no-till and conventional-till for each of these subplots from 1984 through 1999. The table generally shows a decrease in conventional-till crop yields in the lower subplots (C and D) as compared to those in the upper subplots (A and B). Likewise, the 16-year average crop yields for both no-till and conven-

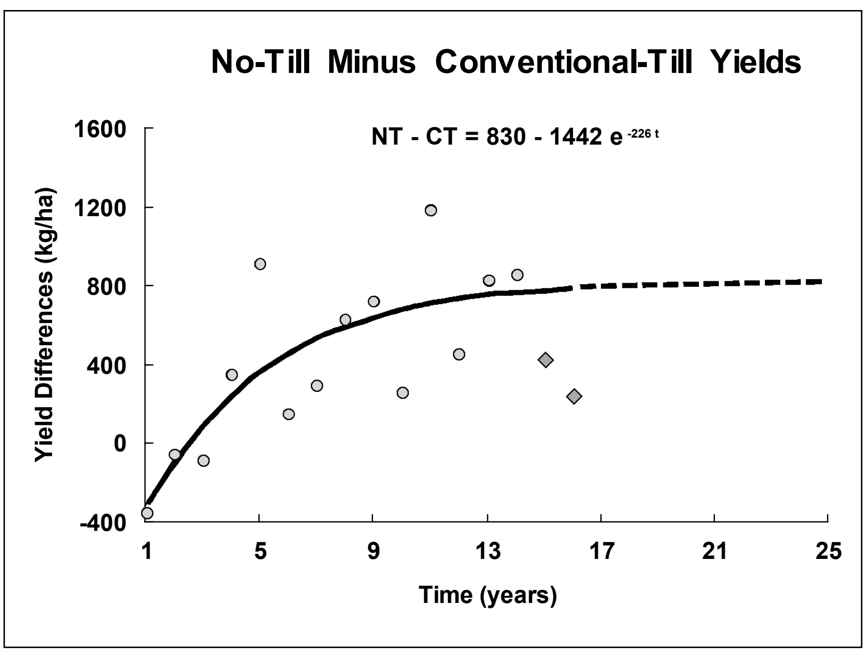

Figure 2. Average annual yield differences (NT - CT) between no-till and conventional-till soybean versus time (1984-1997). The curvilinear relationship is conceptually extended beyond the range of data to show the expected trend for long-time results. Data points for 1998 and 1999 have been added to Figure 7 published by McGregor et al. (1999).

tional-till decline with distance downslope, although this decrease for conventional-till is much more pronounced. The difference in yields (no-till crop yield minus the conventional-till crop yield) for the two tillage systems increased with distance downslope.

Appendix Tables 4 and 5 give the no-till and conventional-till soybean yields, respectively, during each year for each subplot, including subplots E and F, where simulated rainfall experiments were sometimes conducted. The data for subplots A through D are provided for further study and analysis. Data in subplots E and F provide a record of how crop yields were affected by tillage used in the simulated rainfall experiments and also are available here for further study.

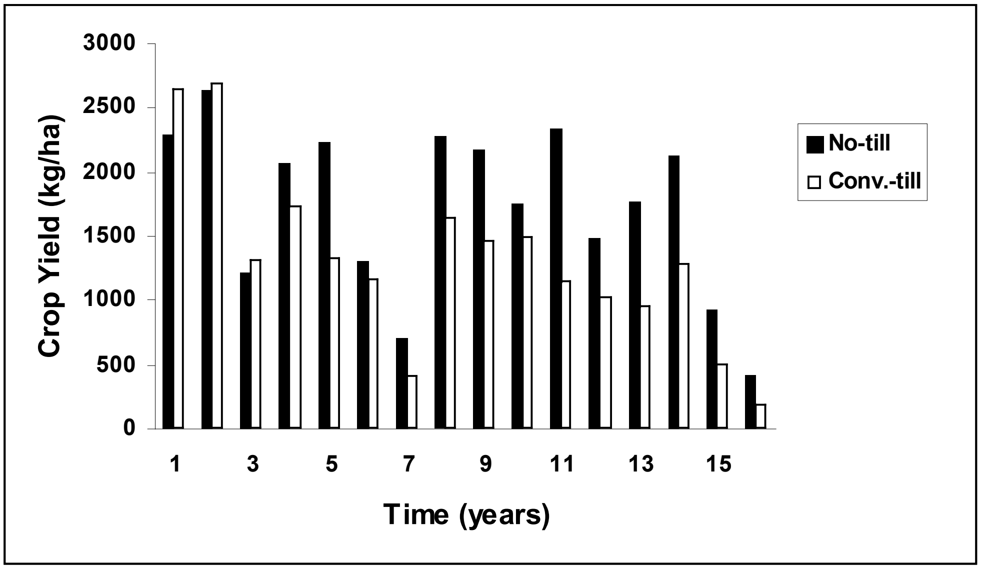

Figure 3. Soybean yields from no-till and conventional-till plots from 1984 to 1999.

Variables Affecting Yield

The effectiveness of no-till in maintaining yield over years was shown in Equation 1 using the difference of no-till and conventional-till crop yields. The following two regressions illustrate the effect of slope length on no-till and conventional-till yield, respectively. The number of years was included in the regressions to account for the variation of slope length over years. The log of years was used to keep the equation form similar to Equation 1. Also, no-till and conventional-till data were examined separately.

The regression of conventional-till crop yield in kg/ha as a function of number of years (t) starting with year one in 1984 and effective slope length (L) in meters was:

$$\text{Conventional-till crop yield} = 2959 - 589.1 (\ln t) - 24.0 (L) \quad (2)$$

The r^2 for Equation 2 was 0.57. The equation reasonably re-creates the conventional-till crop yield data set from 1984-1997. Likewise, a similar equation:

$$\text{No-till crop yield} = 2395 - 148.9 (\ln t) - 12.7 (L) \quad (3)$$

reasonably re-creates the no-till crop yield data set for the same period, but the r^2 for this equation was only 0.08. The reason for this low r^2 value was that the three-dimensional response surface for the variables in this equation was generally nearly flat. Just as in two-dimensional equations, a fit with a flat line gives an r^2 of zero. Theoretically, no-till yields over time generally should vary up or down according to whether the growing season soil moisture levels are acceptable or not. These levels primarily depend upon the weather.

Cullum et al. (2000) reported that tillage, year, effective slope length, and fragipan depth significantly affected crop yield during the 1984 to 1997 study period. Both increase in slope length and decrease in fragipan depth produced lower yields in both tillage systems with greater yield reduction from the conventional-till practice. Improved fits for regressions of declining conventional-till crop yield with time occurred for the lower slope segments (subplots C and D, compared to A and B) because the lower segments had greater erosion rates.

Predicted Soil Erosion with RUSLE

Researchers often use variation in crop yield with depth to a fragipan horizon to explain the effects of soil erosion on soil productivity (Frye et al. 1983; Rhoton 1990). An initial assumption of this study on these fragipan plots was that erosion of the conventional-till soybean areas would progress at a rate rapid enough to affect soybean crop productivity. Eroded soil would cause fragipan areas to be closer to the surface. Less moisture would be available to the crop. Conversely, no-till was thought to be a practice that could maintain crop yields with very little loss of topsoil.

Cullum et al. (2000) predicted erosion per unit area with the revised universal soil loss equation (RUSLE, version 1.06) in each of the A, B, C, and D subplots. The predicted erosion within subplots B, C, and D for conventional-till increased 54%, 85%, and 108%, respectively, as compared to that within subplot A. The increase was only 12.5% for no-till subplots B, C, and D, as compared to that within subplot A. The estimated accumulated depth of soil loss from each subplot A, B, C, and D for conventional-till represented a net decrease in fragipan depth of about 2%, 5%, 8%, and 10%, respectively, from 1984 to 1997. No-till produced no estimated significant changes to depth of fragipan during the study period. Greater erosion from conventional-till on the lower subplots apparently contributed to a decrease in soil productivity on the shallow Loring silt loam soil that was underlain by a restrictive fragipan.

Measured Soil Erosion with Rainfall Simulators

Simulated rainfall experiments were conducted in the E and F subplots in 10 pairs of plots by 1996. Both no-till and conventional-till subplots in these areas were disked lightly before application of rainfall in 1986, 1987, 1990, and 1996. Soil loss amounts from subplots with a no-till history were 42%, 23%, 77%, and 58% less than those with a conventional-till history, as determined from 60-minute initial runs in 1986, 1987, 1990, and 1996, respectively (McGregor et al. 1999). These data suggest that no-till reduces soil erodibility. Except for 1990, soil losses changed little with time for plots with conventional-till history. Conventional-till soil losses were about 1.7 times greater in 1990, the seventh year, as compared to conventional-till soil losses in any of the other years. Most of the rainfall simulation results failed to detect the significant conventional-till soil losses that were taking place. Topographical surveys, however, revealed the severity of the conventional-till soil losses.

Topographic Survey Reveals Soil Erosion

A topographic survey was made in the spring of 2000 of all plots. Appendix Table 6 shows surface gradients in percent for each of the no-till and conventional-till subplots. The slope length from the top of the first subplot through the fourth subplot downslope (A, B, C, and D) was 30.5 m. The average surface gradient of the 30.5-m-long slope length ranged from 2.7% to 5.2% for no-till plots in pairs 1 through 12, and from 2.9% to 5.5% for the conventional-till plots in these pairs. The overall average slope gradient for these 30.5-m slope lengths was 3.8% for the no-till plots and 4.1% for the conventional-till plots. No-till slopes for combined EF lengths averaged 4%, but deposition in the conventional-till EF subplots reduced conventional-till slopes to 2.7% in the EF subplots. McGregor et al. (1999) reported the original slopes for all paired plots were estimated to range from 3% to 4%; however, some original field notes for existing slopes in areas where 10 of the paired plots would be located had slopes that ranged from about 3.7% to 4.8%. Very little erosion on no-till plots would be expected to cause little change in percent slope. Increasing erosion in the conventional-till plots with distance downslope would be expected to cause the overland slope to increase unless a slope reach was encountered where there was significant deposition.

The initial assumption of rapid erosion under continued conventional-till was verified with the topographical surveys. The surveys revealed differences in elevation representative of much more erosion under conventional-till practices than predicted with RUSLE. This survey was taken in the spring of 2000 on all plots. The survey revealed some dramatic differences in elevation after 17 years between no-till and conventional-till plots (Appendix Table 7). Elevations in each of the conventional-till subplots in A, B, C, D, E, and F averaged 14, 19, 24, 23, 12, and 1 cm less than those measured for the no-till subplots. The loss for the 30.5-m-long ABCD reach averaged 20 cm from the conventional-till plots as compared to the no-till plots. The differences in elevation in the lower (E and F) subplots as compared to those in the C and D subplots reflect observed deposition occurring in the E and F subplots.

Table 2. Average soybean crop yields for subplots A, B, C, and D during each year.[1]

Year	No-Till Yields				Conventional-Till Yields				Average (NT-CT) Yields			
	A	B	C	D	A	B	C	D	A	B	C	D
	kg/ha	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*	*kg/ha*
1984	2843	2440	2239	1670	3087	2784	2588	2107	-244	-344	-349	-437
1985	2676	2623	2595	2673	2844	2632	2696	2593	-168	-9	-101	80
1986	1288	1274	1116	1208	1413	1411	1185	1190	-125	-137	-69	18
1987	2245	1976	2070	2010	1856	1669	1708	1650	389	307	362	360
1988	2359	2262	2243	2074	1611	1392	1231	1036	748	870	1012	1038
1989	1219	1381	1310	1322	1256	1078	1142	1126	-37	303	168	196
1990	706	742	711	679	441	391	409	384	265	351	302	295
1991	2670	2230	2079	2113	2252	1828	1420	1056	418	402	659	1057
1992	2434	2153	2077	2026	1912	1683	1234	962	522	470	843	1064
1993	1779	1720	1781	1723	1731	1719	1402	1109	48	1	379	614
1994	2614	2283	2296	2141	1713	1259	806	805	901	1024	1490	1336
1995	1588	1544	1455	1332	1197	1163	890	844	391	381	565	488
1996	1890	1856	1842	1488	1211	855	829	863	679	1001	1013	625
1997	2304	2265	2035	1945	1754	1438	984	927	550	827	1051	1018
1998	1070	1105	907	631	567	628	402	410	503	477	505	221
1999	483	473	420	331	253	262	113	94	230	211	307	237
Avg.	1886	1770	1699	1585	1569	1387	1190	1072	317	383	509	513
St. Dev.	750	631	638	639	778	695	702	622	343	399	489	483

[1]Each value in the table is the average of soybean yields from 12 subplots, except in cases of missing data, where the average is then estimated by using the average of the remaining subplots. (See Appendix Tables 4 and 5 to see occurrences of missing data.)

Summary

Annual crop yields of long-term no-till soybean (*Glycine max*) and conventional-till soybean at Holly Springs, Mississippi were summarized for a 16-year period, 1984 through 1999. This research report also provides a complete data set of crop yields, cultural practices, and chemical applications used for weed control. The Brown Loam soils at North Mississippi Branch Experiment Station, located 30 miles north of Oxford at Holly Springs, are representative of the severely eroded loess soils of the southeastern United States. The soybean plots were located on shallow Loring *(Typic Fragiudalfs*) silt loam soil that was underlain by a restrictive fragipan. The no-till practices provided minimal erosion and the conventional-till provided excessive erosion.

McGregor et al. (1992), McGregor et al. (1999), and Cullum et al. (2000) indicated probable trends for increasing soil losses with time under conventional-till history, and minimal soil losses with time for no-till history. The latter study indicated that greater erosion from conventional-till occurred on slope segments from 15 to 30 m (subplots C through D) as compared to those from 0 to 15 m (subplots A through B). This greater erosion apparently contributed to a decrease in soil productivity on the shallow Loring silt loam soil.

Differences and trends in crop yields between no-till and conventional-till soybean on a soil overlaying a fragipan were recorded over the 16-year period. Crop yield results and computations with the revised universal soil loss equation indicate that soil loss from conventional-till soybean on fragipan soils reduces long-term crop productivity, while the soil resource base is maintained on these soils under no-till soybean. No-till crop productivity under no-till also is maintained at a higher level than under conventional-till.

A recent topographic survey revealed dramatic differences in elevation between no-till and conventional-till plots after 17 years that represent much more erosion under conventional-till than predicted with RUSLE. Elevations in each of the conventional-till consecutive A, B, C, D, E, and F downslope subplots averaged 14, 19, 24, 23, 12, and 1 cm less than those measured for the respective no-till subplots. The loss for the 30.5-m-long ABCD reach averaged 20 cm from the conventional-till plots as compared to the no-till plots.

Although poor soybean yields from both no-till and conventional-till were produced during several years, the sustained trend for lower yields from conventional-till as compared to no-till indicated an adverse effect of excessive erosion and tillage on soil productivity. Continued erosion of the soil overlying a fragipan soil creates an environment where crop yields cannot be maintained even under optimum climatic growing conditions.

References

Cullum, R.F., K.C. McGregor, C.K. Mutchler, J.R. Johnson, and D.L. Boykin. 2000. Soybean yield response to tillage, fragipan depth, and slope length. *Trans. of ASAE* 43(3):563-571.

Frye, W.W., L.W. Murdock, and R.L. Blevins. 1983. Corn yield – fragipan depth relations on a Zanesville soil. *Soil Sci. Soc. Am. J.* 47(5):1043-1045.

McGregor, K.C., C.K. Mutchler, and R.F. Cullum. 1992. Soil erosion effects on soybean yields. *Trans. of ASAE* 35(5): 1521-1525.

McGregor, K.C., C.K. Mutchler, and R.F. Cullum. 1999. Long-term management effects on runoff, erosion, and crop production. *Trans. of ASAE* 42(1): 99-105.

National Oceanic and Atmospheric Administration (NOAA). 1993. *Climatological Data Annual Summary Mississippi 1993*, Vol. 98(13): 2-3. Asheville, NC: National Climatic Data Center.

Rhoton, F.E. 1990. Soybean yield response to various depths of erosion on a fragipan soil. *Soil Sci. Soc. Am. J.* 54(4):1073-1079.

SAS Institute, Inc. 1998. *The SAS System for Windows*, PC Release Ver. 6.08. Cary, NC.

Appendix Table 1. Soybean variety, fertilization, herbicide, and harvest data from 1984 to 1999.

Year	Soybean Variety	Fertilization (lb/A)	Preplant Herbicide Application (Burndown)	Preemergence Herbicide Application	Postemergence Herbicide Application	Date of Harvest
1984	Essex	N - 0 P - 60 K - 60	4/25 - 2,4-D 4/25 - Banvel	5/17 - Roundup 5/17 - Dual	6/21 - Basagran 6/25 - Blazer 7/10 - Poast	9/30
1985	Forrest	N - 0 P - 60 K - 60	5/14 - Roundup	5/24 -Gramoxone 5/24 - Dual	6/10 - Blazer 6/24 - Poast 7/3 - Basagran	10/10
1986	Epps	N - 0 P - 60 K - 60	3/28 - 2,4-D 4/28 - Gramoxone	5/14 - Dual 5/14 - Gramoxone 5/14 - Scepter	None	9/30
1987	Tracy M	N - 0 P - 50 K - 50	4/21 - Gramoxone	5/19 - Roundup 5/19 - Scepter 5/19 - Dual	None	10/16
1988	Forrest	N - 0 P - 58 K - 58	4/8 - Roundup 4/28 - Gramoxone	5/24 - Dual 5/24 - Roundup 5/24 - Scepter	7/6 - Assure 7/6 - Blazer 7/18 - Poast	11/25
1989	Bedford	N - 0 P - 60 K - 60	4/13 - Gramoxone	5/11 - Dual 5/11 - Scepter 5/11 - Roundup	6/26 - Poast 6/26 - Blazer	10/11
1990	Essex	N - 0 P - 78 K - 78	4/24 - Roundup	5/29 - Roundup 5/29 - Scepter 5/29 - Dual	6/28 - Fusilade 6/28 - Blazer 6/28 - Basagran	10/31
1991	Hutcheson	N - 0 P - 65 K - 65	3/25 - Gramoxone 5/2 - Gramoxone	6/4 - Gramoxone 6/4 - Dual 6/4 - Scepter	6/19 - Fusilade 6/19 - Classic 7/5 - Fusilade	10/10
1992	Agra Tech 550	N - 0 P - 50 K - 50	4/3 - Gramoxone 4/24 - Gramoxone	6/1 - Dual 6/1 - Scepter 6/1 - Gramoxone	6/29 - Classic 7/8 - Fusilade 7/20 - Poast	10/22
1993	Hartz 5164	N - 0 P - 60 K - 60	3/30 - Gramoxone 5/10 - Gramoxone	5/31 - Dual 5/31 - Scepter 5/31 - Gramoxone	6/23 - Fusilade 6/28 - Classic	10/27
1994	Hutcheson	N - 0 P - 50 K - 50	4/19 - Gramoxone 5/10 - Gramoxone 5/18 - Roundup	5/23 - Dual 5/23 - Scepter 5/23 - Gramoxone	6/22 - Classic 7/7 - Classic 7/7 - Fusilade	10/24
1995	Hartz 5088	N - 0 P - 50 K - 50	3/23 - Roundup	5/23 - Gramoxone 5/23 - Dual 5/23 - Scepter	6/22 - Classic 6/23 - Poast	10/18
1996	Hutcheson	N - 0 P - 45 K - 45	4/17 - Gramoxone 5/24 - Gramoxone	5/31 - Scepter 5/31 - Dual 5/31 - Gramoxone	6/28 - Poast 7/10 - Classic 7/16 - Scepter	10/31
1997	Asgrow 5601 Roundup Ready	N - 0 P - 60 K - 60	4/2 - Roundup	5/22 - Gramoxone 5/22 - Squadron	6/29 - Roundup 7/17 - Roundup	10/16
1998	Asgrow 5801 Roundup Ready	N - 0 P - 50 K - 50	4/24 - Gramoxone	6/2 - Dual 6/2 - Scepter 6/2 - Gramoxone	6/29 - Roundup 8/4 - Roundup	10/28
1999	Asgrow 5401 Roundup Ready	N - 0 P - 60 K - 60	4/20 - Gramoxone	5/28 - Dual 5/28 - Scepter 5/28 - Gramoxone 6/16 - Roundup	7/21 - Roundup	10/27

Appendix Table 2. Cultivation dates during soybean study (1984-1999).

Year	Seedbed Preparation			Dates of
	Chisel	Disk	Disk & Do-all	Cultivation
1984	4/17	4/17	5/17	6/12, 6/26
1985	5/13	5/14	5/23	6/4, 6/26
1986 [1]	4/17	4/25	5/8	6/16, 6/25
1987 [2]	4/22	4/22	5/19	6/10, 6/29
1988	4/14	4/14	5/24	6/22, 7/7
1989	4/20	4/20	5/11	5/30, 6/22
1990 [3]	5/10	4/24	5/29	6/11, 6/25
1991	4/26	4/26	6/3	7/1, 7/17
1992	5/4	5/4	6/1	7/2, 7/13
1993	5/18	5/18	5/28	6/23, 7/6
1994	4/25	4/25	5/23	6/16, 7/1
1995	4/25	4/25	5/22	6/21, 7/13
1996 [4]	5/3	5/3	5/31	6/27, 7/11
1997	4/30	4/30	5/21	6/24, 7/8
1998	5/5	5/5	6/2	8/3, 8/9
1999	5/10	5/10	6/16	7/30, 8/9

Note — In E and F sections:
[1]Plots 1 & 2 and 3 & 4 were disked twice and harrowed in preparation for rainulator (simulated rainfall) runs on 7/1 and 7/15, respectively.
[2]Plots 5 & 6 and 7 & 8 were disked twice and harrowed in preparation for rainulator runs on 6/17 and 7/7, respectively.
[3]Plots 13 & 14, 15 & 16, and 21 & 22 were disked twice and harrowed in preparation for rainulator runs on 6/19, 6/26 and 7/10, respectively.
[4]Plots 9 & 10, 11 & 12, and 23 & 24 were disked twice and harrowed in preparation for rainulator runs on 6/13, 6/19 and 6/26, respectively.

Appendix Table 3. Depth of fragipan measured at the center of A, B, C, and D subplots.

Plot	Subplots[1]				Average[2]	Standard
Number	A	B	C	D		Deviation[2]
	cm	*cm*	*cm*	*cm*	*cm*	
			No-till			
1	41	38	30	23	33	8
4	38	38	30	25	33	6
6	48	38	28	28	36	10
7	53	46	33	28	40	12
10	43	28	36	23	32	9
11	36	33	28	25	30	5
13	43	36	28	33	35	6
16	41	51	64	33	47	13
17	38	41	36	30	36	4
20	41	33	33	30	34	4
21	28	28	53	43	38	12
24	51	46	43	33	43	7
Average[3]	42	38	37	30	37	
St. Dev.[3]	7	7	11	6	5	
			Conventional-till			
2	36	43	30	25	34	8
3	46	41	33	30	37	7
5	46	46	28	20	35	13
8	53	51	30	25	40	14
9	41	36	33	25	34	6
12	36	43	28	23	32	9
14	51	61	36	28	44	15
15	46	56	46	30	44	10
18	43	43	41	30	39	6
19	41	33	38	41	38	4
22	66	33	43	41	46	14
23	46	43	38	36	41	5
Average[3]	46	44	35	30	39	
St. Dev.[3]	8	9	6	7	4	

[1]Each subplot has a length of 7.6 m.
[2]Averages and standard deviations of fragipan depths are included for subplots within each plot.
[3]Averages and standard deviations of subplot fragipan depths across all plots.

Appendix Table 4. No-till (NT) soybean yield (kg/ha) for each subplot from 1984 to 1999, and yields on each subplot during 1983 when all plots received intensive tillage.[1]

Subplot[2]	Pair# 1	2	3	4	5	6	7	8	9	10	11	12	Avg.[3]	Avg.	Avg.
	Plot# 1	4	6	7	10	11	13	16	17	20	21	24		abcd	abcdef
							1983								
A	–	1089	968	926	807	795	628	806	480	743	–	1061	**830**		
B	897	919	904	910	890	740	530	1034	475	313	1158	1479	**854**		
C	877	830	787	551	763	713	864	1046	423	516	998	1184	**796**		
D	851	914	692	422	551	585	802	–	676	734	1248	1122	**782**	**816**	
E	973	758	1276	1039	567	649	816	914	1113	882	1213	781	**915**		
F	1462	1112	1336	1387	851	989	1026	940	1189	803	1229	1358	**1140**		**886**
							1984								
A	–	2327	3119	2823	2280	2508	2327	2616	3273	2347	3561	4091	**2843**		
B	2260	2381	2153	2153	2240	2260	1817	2575	2756	2683	2998	2998	**2440**		
C	3045	2441	1737	1375	1496	2341	2240	2133	2441	2180	2937	2502	**2239**		
D	1361	2421	1147	1422	724	1415	1885	2052	1891	1127	2562	2032	**1670**	**2298**	
E	1402	2240	2616	2294	1415	1254	2200	1549	2240	1147	2763	2502	**1969**		
F	3682	2428	2716	2864	2119	2555	3058	2186	2984	3092	2535	3199	**2785**		**2324**
							1985								
A	–	2394	2495	2287	2823	2890	3192	2763	2495	2569	2602	2924	**2676**		
B	2394	2508	2555	2790	2683	2723	2756	2508	2562	2495	2810	2696	**2623**		
C	2166	2689	2575	2388	2602	2461	2830	2535	2790	2461	2783	2864	**2595**		
D	2434	2636	2763	2884	2736	2622	2850	2669	2649	2314	2676	2844	**2673**	**2642**	
E	2441	2334	2488	2978	2515	2770	2870	2783	2273	2414	2515	2837	**2602**		
F	2622	2327	2622	3065	2562	2562	3092	2944	2488	1898	1992	2548	**2560**		**2622**
							1986								
A	–	1368	925	1462	1750	1375	771	1690	704	–	1368	1469	**1288**		
B	1247	1670	1469	1274	1368	1060	1174	1066	1019	818	1355	1764	**1274**		
C	1221	1080	879	1093	1268	879	1200	1066	1147	879	1194	1489	**1116**		
D	885	1368	1549	1650	1113	1408	1308	879	1073	785	1187	1294	**1208**	**1222**	
E	–	–	1214	1207	1274	1268	785	899	1301	644	1154	979	**1073**		
F	–	–	1187	1127	1140	959	1080	899	1194	1180	765	1006	**1054**		**1169**
							1987								
A	–	2609	1730	2072	1757	2086	2247	2441	2213	–	2676	2622	**2245**		
B	1496	1925	1576	2233	1563	1898	2227	2206	1958	1536	2186	2904	**1976**		
C	2019	2072	1797	2260	2072	1744	2213	2555	1657	1556	2341	2555	**2070**		
D	1858	1851	2072	2367	1690	1978	2153	2629	1589	1475	2347	2113	**2010**	**2075**	
E	1268	1616	–	–	1502	1972	2260	2300	1757	1556	2320	2300	**1885**		
F	2025	1710	–	–	1757	2032	2434	2361	1965	2113	2555	2394	**2135**		
							1988								
A	–	2200	2273	2307	2267	2113	2079	2481	2159	2508	2897	2669	**2359**		
B	2066	1958	2240	1891	2374	2280	2173	2683	2186	2072	2783	2441	**2262**		
C	2548	1918	2032	2045	2327	2213	2086	2616	2414	1864	2374	2481	**2243**		
D	2146	1630	1885	1710	1898	2180	2045	2616	1878	2019	2703	2173	**2074**	**2235**	
E	1744	1643	1871	1200	1985	2005	2508	2569	2032	1992	2649	2233	**2036**		
F	2005	1831	1844	1764	2408	2408	2159	2455	2401	1992	2434	2240	**2162**		
							1989								
A	–	1542	1509	1200	818	1046	905	1261	999	993	1301	1831	**1219**		
B	1569	1026	1462	1549	1388	1200	1227	1408	1314	946	1368	2119	**1381**		
C	1053	1080	1697	1180	1563	1911	1107	1013	1013	905	1415	1784	**1310**		
D	1066	1113	1321	1221	1341	1589	1556	1569	1261	1234	1294	1301	**1322**	**1308**	
E	912	1623	1576	1341	1489	939	1247	1435	1395	1080	2099	1683	**1402**		
F	852	1268	1281	2092	2139	2025	1831	1435	1093	1073	1221	1663	**1498**		
							1990								
A	–	731	731	550	–	483	677	456	999	597	738	1100	**706**		
B	1080	630	604	684	–	570	570	483	570	785	1093	1093	**742**		
C	852	597	724	456	–	449	530	892	577	610	1033	1100	**711**		
D	785	684	765	510	362	523	610	892	456	590	972	999	**679**	**710**	
E	738	758	610	637	342	537	–	–	758	731	–	999	**679**		
F	979	577	704	724	617	744	–	–	791	778	–	1093	**779**		
							1991								
A	–	2548	3286	2683	1341	2079	2347	2347	3622	3152	2884	3085	**2670**		
B	1677	1677	2616	2347	1140	2146	2280	2347	2481	2146	2616	3286	**2230**		
C	2146	1408	2213	1744	1140	2280	2213	2750	2079	1542	2616	2817	**2079**		
D	2146	1408	2079	2012	872	2548	1744	3353	2616	1677	2683	2213	**2113**	**2273**	
E	1878	1542	2548	1140	1610	2280	1341	1677	2817	2213	2280	2012	**1945**		
F	2414	1677	2347	2012	2347	2884	2012	2012	2817	–	1610	2414	**2231**		

Continued.

Appendix Table 4 (cont.). No-till (NT) soybean yield (kg/ha) for each subplot from 1984 to 1999, and yields on each subplot during 1983 when all plots received intensive tillage.[1]

Subplot[2]	Pair# 1 Plot# 1	2 4	3 6	4 7	5 10	6 11	7 13	8 16	9 17	10 20	11 21	12 24	Avg.[3]	Avg. abcd
1992														
A	–	2082	3425	2781	2259	2202	2706	2317	2642	1944	2095	2320	**2434**	
B	1106	1981	2622	2355	2273	2048	2284	2077	2950	1464	2395	2278	**2153**	
C	1573	2004	1915	2083	1957	2100	2524	2029	2423	1450	2214	2653	**2077**	
D	1785	1630	2484	1852	2243	2087	2020	2449	2136	1240	2309	2079	**2026**	**2173**
E	1508	2648	2055	793	2406	2026	1905	2864	2003	1856	2067	2126	**2021**	
F	2201	2514	1831	2187	2014	2346	2330	2460	2883	1986	2213	2034	**2250**	
1993														
A	–	1555	1411	1939	1503	1443	2119	1775	1855	1841	2138	1991	**1779**	
B	1638	1436	1510	1796	1489	2007	1861	1356	1721	1760	2113	1952	**1720**	
C	2617	1792	1714	1368	1685	1855	1755	2140	1304	1328	2041	1768	**1781**	
D	1642	1592	1575	1637	1716	2226	1740	2115	1700	1143	1550	2038	**1723**	**1751**
E	2395	1588	1516	912	1926	1833	1394	1288	1542	1430	1773	1688	**1607**	
F	2746	1747	1970	1578	1896	1992	1541	1520	2058	1553	1683	1811	**1841**	
1994														
A	–	2186	3216	2858	1996	2217	2203	2037	3201	2084	2675	4084	**2614**	
B	3313	1688	2575	2118	1721	1688	2113	1287	3100	1873	2723	3201	**2283**	
C	2244	2649	2653	2469	2043	1875	1959	2121	2780	1263	2619	2879	**2296**	
D	1762	2099	2389	2579	1707	1970	1435	1890	2933	2170	2821	1937	**2141**	**2334**
E	2484	2135	2761	2375	2478	2086	1693	1085	3297	3188	2612	2091	**2357**	
F	3240	2583	2926	2567	2620	2364	2260	1474	3829	3709	2443	2693	**2726**	
1995														
A	–	1494	1564	1178	1105	1114	1537	1579	2101	1468	2209	2117	**1588**	
B	1710	1228	1609	920	1227	1383	1388	1692	1671	880	2589	2225	**1544**	
C	1960	1204	1554	625	943	1153	1424	1804	1540	806	2351	2093	**1455**	
D	1333	1343	1392	772	1236	1300	1089	1848	1308	940	2023	1400	**1332**	**1480**
E	1719	1631	1395	1134	1187	–	825	1210	1472	1942	2284	1170	**1452**	
F	2039	1377	1988	1204	1483	–	1224	1056	1316	2720	1868	1489	**1615**	
1996														
A	–	2009	1518	1352	1656	1258	1337	1360	1746	2102	3526	2926	**1890**	
B	1800	1404	1898	1183	1152	1566	1417	2735	1815	1653	2649	2997	**1856**	
C	1979	1582	1316	878	–	–	1251	2198	2685	1532	2372	2628	**1842**	
D	1174	1008	1029	751	–	–	1215	2451	2085	1605	2077	–	**1488**	**1769**
E	1498	1371	1260	1144	–	–	1751	1667	1866	1715	2197	–	**1608**	
F	2220	1075	934	1607	–	–	1419	1274	1628	3474	1569	–	**1689**	
1997														
A	–	2349	2541	2577	1852	2033	2484	2364	2157	2200	1849	2933	**2304**	
B	1976	2187	2262	2109	2260	2189	2245	2718	2055	1769	2492	2919	**2265**	
C	2550	2130	2235	1680	2195	1664	2377	2010	1851	1141	2561	2025	**2035**	
D	2071	1512	2092	1727	1001	1582	2073	2527	2246	1570	2792	2144	**1945**	**2137**
E	1740	2027	2188	1591	1208	1385	2037	1484	2313	2383	2631	2043	**1919**	
F	2342	1902	2366	2774	1360	2100	2236	1908	3263	3646	2220	2564	**2390**	
1998														
A	–	1452	853	1368	898	81	808	789	1696	884	2048	889	**1070**	
B	681	1053	482	818	1145	936	1083	1241	1213	775	1756	2079	**1105**	
C	473	910	484	484	809	903	1062	1574	859	670	1517	1139	**907**	
D	313	592	770	421	176	331	830	871	998	714	1205	355	**631**	**928**
E	974	679	1039	553	317	739	704	993	1082	913	839	691	**794**	
F	1429	627	1115	1125	523	510	428	918	1490	83	847	460	**796**	
1999														
A	–	259	327	342	284	392	496	264	851	–	713	897	**483**	
B	341	244	192	522	443	358	562	417	636	286	994	684	**473**	
C	419	255	425	351	178	289	561	302	551	302	851	551	**420**	
D	285	340	190	250	65	325	506	493	479	423	560	58	**331**	**427**
E	241	359	168	289	173	382	464	180	443	235	532	133	**300**	
F	719	273	361	516	347	571	571	248	626	354	449	284	**443**	

[1]First year of conventional-till (CT) and NT comparisons was 1984.

[2]Soybean rows in subplots E and F of no-till plots 1 & 4 in 1986; plots 6 & 7 in 1987; plots 13, 16, & 21 in 1990; and plots 10, 11, & 24 in 1996 were disked twice and harrowed in preparation for rainulator (simulated rainfall) runs in 1986, 1987, 1990, and 1996, respectively. Also, subplots A, B, and C of plot 10 in 1990; subplots C and D of plot 10 and 11 in 1996; and subplot D of plot 24 in 1996 were inadvertently lightly cultivated in preparation for simulated rainfall, which should not have been and was not applied in these designated areas.

[3]The first **AVG** column gives the average of like subplots (either A, B, C, or D) for the number of entries of crop yields listed (12 subplots where there were no missing values). The second **AVG** column contains the average “whole” plot values for A, B, C, and D subplots, or averages of averages for these subplots.

Appendix Table 5. Soybean yield (kg/ha) for each conventional-till plot from 1983 to 1999, and yields on each plot during 1983 when all plots received intensive tillage.[1]

Subplot[2]	Pair# 1 Plot# 1	2 4	3 6	4 7	5 10	6 11	7 13	8 16	9 17	10 20	11 21	12 24	Avg.[3]	Avg. abcd
							1983							
A	1262	1158	1102	1143	1061	1032	783	872	830	1004	—	1466	**1065**	
B	1522	1057	1086	1144	1039	1118	1075	1021	726	890	1795	1395	**1156**	
C	1251	1047	1061	383	976	803	972	1417	788	803	1233	1014	**979**	
D	1006	759	1137	536	950	597	918	1189	925	866	1067	1029	**915**	**1029**
E	918	1084	1367	1118	891	539	768	869	1010	1076	1625	1329	**1050**	
F	1431	983	1744	1292	1004	1084	1223	941	979	1098	1406	1650	**1236**	
							1984							
A	2206	2984	3286	3119	3105	2508	2830	3259	3145	3058	3943	3595	**3087**	
B	3789	2528	2294	2964	2515	2294	2884	2488	2864	2428	3642	2716	**2784**	
C	3051	2267	2548	2428	2012	2213	2696	3313	2669	1999	3098	2763	**2588**	
D	1978	2341	2193	1670	2206	1817	2320	2502	2099	1730	2119	2314	**2107**	**2642**
E	3058	2320	2428	2502	2059	2113	2515	2240	2233	2045	2616	2602	**2394**	
F	3829	2032	3159	3105	2394	2743	2924	3132	2595	2756	2964	2817	**2871**	
							1985							
A	2515	2555	2602	2468	3125	3065	2817	2924	3038	2656	3259	3105	**2844**	
B	2703	2683	2629	2917	2716	2461	2642	2334	2602	2515	2837	2548	**2632**	
C	2575	2884	2341	2629	2917	2984	2958	2542	2864	2461	2837	2354	**2696**	
D	2347	2803	2327	2488	2709	2763	2797	2850	2575	2468	2314	2676	**2593**	**2691**
E	2495	2495	3031	2897	2857	2723	2924	3105	3038	2575	2086	2770	**2750**	
F	2709	2495	2810	2937	2850	2884	2508	3206	2984	2468	2005	2502	**2697**	
							1986							
A	1777	1677	1234	939	1589	1603	1395	1120	986	818	2153	1663	**1413**	
B	1898	1777	1140	1382	1677	724	1348	1864	1033	818	2045	1221	**1411**	
C	1643	1335	1107	1321	1335	724	905	1764	1019	1053	899	1120	**1185**	
D	1288	1563	1127	1053	1428	899	1227	1187	959	979	1301	1274	**1190**	**1300**
E	—	—	972	1294	1281	972	912	845	845	979	1060	946	**1011**	
F	—	—	—	1576	1019	959	771	1918	1502	1107	1100	1274	**1247**	
							1987							
A	2113	1838	2005	1697	1589	1489	1549	1717	2408	1831	2159	1871	**1856**	
B	1817	1690	1750	1563	1382	1469	1596	1442	2220	1643	1858	1603	**1669**	
C	—	1717	2052	1462	1777	1194	1281	—	2092	1690	1925	1885	**1708**	
D	1683	1898	1388	1428	1355	1623	1496	2206	1905	1321	1683	1811	**1650**	**1721**
E	1542	1623	—	—	1482	1663	1382	2059	1623	1683	1697	1623	**1638**	
F	1710	1200	—	—	1361	1757	1683	1972	1824	1972	1864	2126	**1747**	
							1988							
A	1797	1898	1663	1355	885	1066	1529	1174	1811	1388	2300	2468	**1611**	
B	1462	1221	1355	1489	986	1449	1482	1194	1569	999	1978	1516	**1392**	
C	1180	1395	1382	1154	852	1268	704	1422	1402	892	1496	1623	**1231**	
D	825	1147	925	677	798	805	1147	1542	1207	1160	1013	1187	**1036**	**1318**
E	778	711	1200	939	838	885	684	1180	1650	1650	1180	1066	**1063**	
F	1435	946	1241	912	1107	1120	1019	1174	1643	1891	1911	1415	**1318**	
							1989							
A	1348	1207	1247	1241	1140	966	1335	1086	1214	1207	1616	1462	**1256**	
B	456	1093	1019	999	1395	939	1247	1113	899	986	1382	1402	**1078**	
C	630	1522	1133	1428	1583	610	1174	1019	583	946	1824	1254	**1142**	
D	1174	1502	825	905	1174	1288	885	865	1207	852	1442	1388	**1126**	**1151**
E	718	993	1147	1086	892	537	1107	1328	1449	1764	724	858	**1050**	
F	865	1120	858	1703	1321	1086	751	925	1167	1522	805	905	**1086**	
							1990							
A	724	510	443	376	—	308	241	174	355	389	879	456	**441**	
B	604	389	248	315	—	194	443	235	268	174	925	503	**391**	
C	972	302	577	168	—	262	409	295	376	215	563	355	**409**	
D	275	308	691	141	315	241	342	563	322	322	496	597	**384**	**406**
E	315	322	664	537	221	215	—	—	342	644	—	389	**405**	
F	577	342	651	617	409	429	—	—	765	610	—	738	**571**	
							1991							
A	2012	2079	2079	2079	1408	2012	1610	2414	2347	3219	3085	2683	**2252**	
B	1408	1073	1744	1542	1140	2012	1945	2079	2012	2079	3018	1878	**1828**	
C	1408	1677	1677	1207	805	1744	1274	1811	1610	1140	1610	1073	**1420**	
D	671	1811	1073	671	872	1073	1542	1073	1408	872	1073	537	**1056**	**1639**
E	134	1006	2012	1475	939	1408	1475	805	1811	1006	1610	1006	**1224**	
F	2079	1475	2213	1878	1677	2012	2012	1274	1610	1878	2750	2012	**1906**	

Continued.

Appendix Table 5 (cont.). Soybean yield (kg/ha) for each conventional-till plot from 1983 to 1999, and yields on each plot during 1983 when all plots received intensive tillage.[1]

Subplot[2]	Pair# 1 Plot# 1	2 4	3 6	4 7	5 10	6 11	7 13	8 16	9 17	10 20	11 21	12 24	Avg.[3]	Avg. abcd
1992														
A	1500	1878	1757	2246	1819	1529	1773	1469	2249	1862	2298	2561	**1912**	
B	1339	1012	1837	1671	1962	2070	2023	1580	1680	1030	2276	1721	**1683**	
C	741	1509	717	1093	1329	1602	1403	1677	1452	390	1855	1036	**1234**	
D	309	1167	522	937	1013	799	1257	1180	1354	1086	1059	865	**962**	**1448**
E	1655	541	1664	1665	1713	1215	1243	615	1702	1873	1005	1443	**1361**	
F	1954	1548	2121	1681	1788	2030	2257	1211	1847	2005	1910	1619	**1831**	
1993														
A	1855	1716	1753	1647	1323	1364	1360	1433	1902	2519	1848	2049	**1731**	
B	1975	1301	1606	1449	1335	1773	1749	1403	2030	2217	2304	1482	**1719**	
C	1365	1416	1267	1104	1220	1243	1479	1739	1601	1551	1672	1171	**1402**	
D	1168	1130	810	996	1123	803	1397	1203	1450	626	1149	1449	**1109**	**1490**
E	1750	674	1475	1458	1240	1490	1460	1076	1801	894	1651	1660	**1386**	
F	2372	1045	2061	1977	1777	1929	2164	1855	2558	1700	2196	2037	**1973**	
1994														
A	1548	870	1858	898	876	1619	1203	1515	2183	1751	3383	2848	**1713**	
B	704	706	986	635	603	1734	1617	928	1773	810	2732	1881	**1259**	
C	348	728	395	770	462	814	1037	1362	1271	850	818	820	**806**	
D	369	805	338	1127	267	130	852	395	2351	1812	403	811	**805**	**1146**
E	1704	364	857	2514	953	685	847	801	3063	2350	1305	1116	**1380**	
F	2229	2178	909	2659	1889	1356	1776	1492	3506	2807	2488	1728	**2085**	
1995														
A	1063	1459	1186	1336	975	825	973	1218	1286	1045	1384	1611	**1197**	
B	1009	1351	1024	1315	487	1192	1402	1047	1048	698	2129	1255	**1163**	
C	593	1363	492	849	456	884	1020	897	795	680	1903	748	**890**	
D	431	1485	539	672	372	557	679	941	958	1054	1610	835	**844**	**1024**
E	1189	967	1112	1009	567	—	700	456	1124	1314	1840	871	**1014**	
F	1381	1205	1331	1320	924	—	1348	1053	1490	2050	1763	1573	**1403**	
1996														
A	1151	1373	1142	1155	418	768	756	1249	923	1021	2466	2109	**1211**	
B	718	938	577	886	227	728	1037	759	464	443	2795	690	**855**	
C	497	1682	192	585	—	785	506	674	381	498	2499	821	**829**	
D	611	1166	172	402	—	—	430	756	1046	1225	1963	—	**863**	**940**
E	917	746	754	893	—	—	371	110	2689	2709	2701	—	**1321**	
F	1268	831	1075	1664	—	—	731	537	1859	3060	2171	—	**1466**	
1997														
A	1103	2220	1636	1868	1157	1844	1744	917	3450	1534	1533	2047	**1754**	
B	1180	1706	1005	1327	414	1867	1902	1061	1668	634	3026	1467	**1438**	
C	522	1676	255	939	113	1217	1199	995	1481	713	1878	819	**984**	
D	949	1334	430	446	292	590	957	608	1807	1426	1326	963	**927**	**1276**
E	826	985	819	829	300	551	542	896	662	733	1770	1513	**869**	
F	515	673	414	636	163	522	744	545	333	318	2006	495	**614**	
1998														
A	136	679	510	879	571	311	257	359	873	661	895	677	**567**	
B	307	682	441	864	421	576	800	474	504	448	1164	854	**628**	
C	100	536	89	484	53	476	325	575	577	472	714	427	**402**	
D	69	649	77	109	166	236	87	989	795	513	752	478	**410**	**502**
E	791	1593	1174	1340	830	1323	1251	658	2476	1101	1100	1469	**1259**	
F	847	1224	721	952	297	1340	1365	761	1197	455	2171	1053	**1032**	
1999														
A	50	182	372	353	100	50	188	53	552	368	392	378	**253**	
B	104	147	99	533	123	141	118	359	292	222	595	407	**262**	
C	48	110	15	180	29	38	37	159	142	14	489	91	**113**	
D	24	80	34	34	58	42	11	145	140	22	303	237	**94**	**181**
E	98	487	366	631	410	223	184	258	626	474	642	486	**407**	
F	220	489	316	620	302	413	574	340	362	321	835	613	**450**	

[1]More intensive tillage than normal was used in 1983 on all plots. First year of conventional-till (CT) and NT comparisons was 1984.
[2]Soybean rows in subplots E and F of conventional-till plots 2 and 3 in 1986; 5 and 8 in 1987; 14, 15, & 22 in 1990; and 10, 12, & 23 in 1996 were disked twice and harrowed in preparation for rainulator (simulated rainfall) runs in 1986, 1987, 1990, and 1996, respectively. Also soybean rows in subplots C and D of plot 9 in 1996, and subplot D of plots 12 and 23 in 1996 were inadvertently lightly cultivated in preparation for simulated rainfall, but should not have been cultivated since the rainfall was conducted in subplots E and F of plots 12 and 24 instead. Data for affected years are treated as missing and the light cultivation affect was assumed minimal for ensuing years.
[3]The first **AVG** column gives the average of like subplots (either A, B, C, or D) for the number of entries of crop yields listed (12 subplots where there were no missing values). The second **AVG** column lists the average "whole" plot values for A, B, C, and D subplots, or averages of averages for these subplots.

Appendix Table 6. Percent surface slope of each subplot (A, B, C, D, or E) after 17 years of no-till and conventional-till.

Subplot	Pair Number												Avg.
	1	2	3	4	5	6	7	8	9	10	11	12	
	No-till plot numbers												
	nt1	**nt4**	**nt6**	**nt7**	**nt10**	**nt11**	**nt13**	**nt16**	**nt17**	**nt20**	**nt21**	**nt24**	**nt**
	%	%	%	%	%	%	%	%	%	%	%	%	%
A	—	5.5	3.7	4.7	4.9	4.9	3.1	1.6	0.1	0.3	2.7	2.1	3.1
B	4.7	5.5	3.9	4.4	4.6	4.6	2.9	2.1	1.8	1.6	2.1	2.9	3.4
C	4.9	3.8	5.1	5.0	4.9	4.5	3.5	2.5	3.7	3.5	2.5	4.2	4.0
D	5.9	3.7	5.5	4.9	4.5	3.7	3.8	4.5	5.1	6.1	3.3	3.0	4.5
E	4.7	5.6	4.8	4.1	3.5	3.5	4.6	5.8	4.8	5.3	5.7	3.4	4.6
F	2.6	4.7	3.7	2.7	2.6	3.8	3.3	3.6	2.9	3.4	4.0	2.8	3.3
	Conventional-till plot numbers												
	ct2	**ct3**	**ct5**	**ct8**	**ct9**	**ct12**	**ct14**	**ct15**	**ct18**	**ct19**	**ct22**	**ct23**	**ct**
	%	%	%	%	%	%	%	%	%	%	%	%	%
A	5.6	5.5	5.4	5.3	5.3	4.9	3.5	4.1	0.7	1.1	3.0	3.1	4.0
B	5.5	5.8	5.6	5.1	5.1	4.0	4.0	2.7	3.3	3.1	2.8	3.3	4.2
C	5.2	5.6	4.8	4.1	4.1	4.4	4.1	4.3	4.2	4.9	3.2	3.2	4.3
D	4.1	5.0	3.5	3.3	3.3	3.8	4.0	5.3	3.5	3.6	4.1	2.6	3.8
E	3.4	3.7	2.9	2.5	2.5	2.6	2.9	3.0	2.7	3.0	3.9	2.0	2.9
F	2.7	2.6	2.6	2.1	2.1	2.6	2.9	2.3	2.1	2.1	2.7	1.7	2.4

Appendix Table 7. Soil surface elevation differences (no-till minus conventional-till) after 17 years for each subplot (A, B, C, D, or E).

Subplot	Pair Number												Avg.	S.D.
	1	2	3	4	5	6	7	8	9	10	11	12		
	cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
A	14	14	21	21	15	23	9	12	8	5	12	13	**14**	**5**
B	20	14	34	25	18	20	15	22	15	13	14	20	**19**	**6**
C	24	21	41	26	18	18	21	28	23	25	20	20	**24**	**6**
D	19	35	30	16	11	18	24	37	19	22	26	14	**23**	**8**
E	4	29	15	5	4	15	18	17	5	2	20	9	**12**	**8**
F	-1	13	5	-5	-3	5	10	3	-7	-12	9	0	**1**	**7**

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