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# Tillage Effects on Crop Yield in Coastal Plain Soils

C. R. Camp, G. D. Christenbury, C. W. Doty
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## ABSTRACT

CORN (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] were grown on an 18-ha site of Coastal Plain soils under nonirrigated and irrigated conditions for the three-year period, 1979-81. The five tillage treatments were double disking and minimum tillage, both with and without in-row subsoiling at planting; and disking with uniform chisel plowing. Rainfall during the growing season was near normal in 1979, below normal in 1981, and much below normal in 1980. There were significant yield differences due to tillage and irrigation for both corn and soybean. Corn yield increases due to deep tillage were greater in magnitude and were more consistent than those for soybean. Minimum tillage without subsoiling produced the lowest yields for both corn and soybean; however, this treatment had the poorest stand and the most severe weed competition of all treatments. Deep tillage and irrigation produced additive yield increases for corn, but not for soybean, indicating the possible need to use both management practices for corn in some soil conditions. Irrigation increased yields for both corn and soybean across all tillage treatments with mean yield increases of 3.37 t/ha (86%) and 0.73 t/ha (51%) for corn and soybean, respectively. The choice of management practices will depend upon their cost relative to their respective yield increase potential.

## INTRODUCTION

Drought-induced water stress is the factor most limiting crop production in the Coastal Plain region of the Southeast. Most of the soils are coarse textured and have very low water-holding capacities, and many have compacted horizons that confine plant roots to the surface layer. Although annual rainfall exceeds evapotranspiration, rainfall distribution during the growing season is often poor, resulting in drought periods varying in length from several days to several weeks.

Management practices to reduce the effects of drought include the addition of water to the surface layer by irrigation; removal or disruption of compacted soil layers by deep tillage to allow extraction of water stored in the subsoil; or a combination of irrigation and deep tillage. With increasing energy costs, the most efficient and economical practice must be determined since both deep tillage and irrigation require high energy inputs.

Reported benefits of deep tillage on these soils include reduced soil impedance to root growth, increased rooting depth, increased water infiltration, reduced oxygen stress during wet periods, and increased yields for corn, millet, and soybean. Campbell et al. (1974) reported that chiseling to a 38-cm depth fractured the E horizon and increased rooting depth. Also, they concluded that the effectiveness of chiseling on layered soils depended upon the duration of drought. Consequently, chiseling may only partially relieve drought stress. Similarly, Doty and Reicosky (1978) reported as much as 12 cm more water was used by plants during the growing season on chiseled treatments than on nonchiseled treatment. They estimated that the additional water extracted by roots from the larger soil volume could sustain sweet corn and millet from 8 to 24 days longer under drought conditions. Kamprath et al. (1979) reported higher soybean yields for chiseled and subsoiled treatments than for conventional plowing and disking treatments on three coarse-textured Coastal Plain soils. They attributed the increased yield to increased root proliferation below the compacted horizon and greater utilization of subsoil water because rainfall was below normal during late flowering and early pod fill for the years this study was conducted.

The combination of deep tillage and irrigation has generally not resulted in an economical benefit. Reicosky et al. (1976) reported increased sweet corn yield with chiseling on a soil with a water table at a depth of 80 cm, but there was no additional yield increase with irrigation. Slightly higher (less negative) daily minimum leaf water potential, lower stomatal resistance, and smaller fluctuations in stem diameter were measured on chiseled treatments and were similar to those measured on furrow-irrigated treatments. Doty et al. (1975) reported that corn and millet yields for chiseled, nonirrigated treatments were comparable to yields for nonchiseled, irrigated treatments. Doty and Reicosky (1978) reported a greater net return with corn and millet for chiseling than for conventional tillage with irrigation even with droughts of 26 and 31 days, suggesting that chiseling may be as effective in supplying water to a crop as irrigation alone would be.

Langdale et al. (1981) reported corn grain yield increases due to in-row subsoiling of 1.4 to 3.6 t/ha for a range of N fertilizer rates under irrigation. Yield increases were attributed to increased soil rooting volume and available water in the subsoil below the compacted soil layer found at a depth of 20 to 30 cm.

Management of the surface or plow layer has been suggested as an alternative to deep tillage. In this management system, the necessary water and nutrients

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The authors are: C. R. CAMP, Agricultural Engineer, USDA-ARS, Florence, SC; G. D. CHRISTENBURY, Associate Professor, Agricultural Engineering Dept., Clemson University, Clemson, SC; and C. W. DOTY, Agricultural Engineer, USDA-ARS, Florence, SC.

are provided at the appropriate time throughout the growing season to produce good crop growth and yield. Corn yields of 12.5 t/ha or greater were reported for three coarse-textured soils using this concept (Rhoads and Stanley, 1973, 1974).

Deep tillage does not always result in increased crop yield and plant root development, particularly in soils where a compacted layer does not exist. Subsoiling to 40-and 60-cm depths in medium-to-fine textured soils did not signficantly increase yields in Iowa and significantly increased yield in only 2 of 14 experiments in Illinois (Larson et al., 1960). Jamison and Thornton (1960) reported that subsoiling depressed crop yields in a Missouri claypan soil.

In addition to its primary advantage of reducing soil loss, conservation tillage offers economically sound tillage methods for the southeastern Coastal Plain. Conservation tillage improves water infiltration and soil profile recharge during the growing season, reduces evaporation, and improves the water use efficiency of stored water during short drought periods (Reicosky et al., 1977).

The objective of this research was to determine the optimum combination of tillage and irrigation for the efficient production of corn and soybean in southeastern Coastal Plain soils. Preliminary results (one year) for this study were reported by Camp et al. (1980).

## MATERIALS AND METHODS

Corn (*Zea mays* L. cv. Pioneer 3369-A) and soybean [*Glycine max* (L.) Merr. cv. Bragg] were grown on an 18-ha site near Florence, South Carolina, where the predominant soils are Bonneau loamy sand (Arenic Paleudult) and Norfolk loamy sand (Typic Paleudult). These soils had a compacted E horizon 2 to 6 cm thick at a depth of 20 to 30 cm. The irrigated corn and soybean treatments were located in separate quadrants of a high pressure center pivot irrigation system and were rotated between quadrants each year. The nonirrigated treatments were located immediately adjacent to the center pivot system (Fig. 1). Three irrigation scheduling treatments were located in separate sectors within each quadrant for each crop. The results for the irrigation scheduling portion of this study will be reported in a later paper and will not be discussed in detail here. The results for irrigated treatments discussed in this paper are means of the three separate irrigation scheduling treatments because the amount of irrigation water applied to each irrigation treatment was similar, and

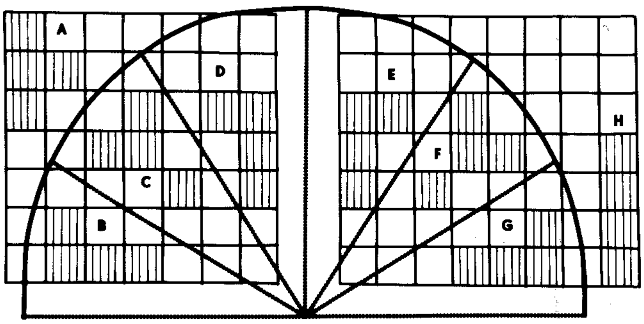


**Fig. 1—Tillage treatments are shown schematically as strips within squares with nonirrigated treatments (A,H) located outside center pivot areas and irrigated treatments located within sectors of center pivot area (B,C,D,E,F,G) which could be irrigated independently.**

there were no significant yield differences among the irrigated treatments.

Five tillage treatments were included for both irrigated and nonirrigated treatments in a randomized complete block design with four replications. Each square within a sector in Fig. 1 was considered a replication. The tillage treatments were as follows:

1. DD — Double-disking, spring tooth harrowing with drag and planting
2. DDSS — Double-disking, spring tooth harrowing with drag and in-row subsoiling at time of planting
3. MT — Minimum tillage — planting directly into residue without prior tillage
4. MTSS — Minimum tillage — planting directly into residue with in-row subsoiling, but without prior tillage
5. CP — Chisel plowing — disking, chiseling, spring tooth harrowing with drag and planting.

Subsoiling (Treatments DDSS and MTSS) was performed in the row only with a subsoiler-planter operated at its maximum depth (40 cm). Chiseling (Treatment CP) to a depth of about 35 cm was accomplished using a chisel plow with tines spaced 25 cm apart. All plots were planted using a six-row, in-row subsoiler-planter unit (Brown-Harden Super Seeder with John Deere-71 Flexi-planters*). The subsoiler unit included a 50-mm wide fluted (waffle) coulter immediately in front of each subsoiler shank which had a 65-mm wide chisel point. A spider wheel tine was attached immediately behind the subsoiler shank to firm the soil for planting. Treatments that were not subsoiled (DD, MT, and CP) were planted using the same equipment except that the subsoiler shanks were removed. Each tillage plot was 30 m long and six rows (5.8 m) wide.

Corn was planted on 3 April 1979, 24 April 1980, and 30 March 1981 in rows spaced 98 cm apart. Soybean was planted on 17 May 1979, 16 May 1980, and 20 May 1981 in 98-cm rows. Fertilizer was applied in a band in 1980 and broadcast in 1979 and 1981 to both crops. Sidedress nitrogen was applied through the irrigation system for the irrigated treatment except in 1979 when it was applied broadcast in liquid form by ground equipment. Sidedress N for the nonirrigated treatment was also applied broadcast as a liquid with ground equipment. The annual application of N, P, and K fertilizer was based on soil test recommendations and averaged 240, 62, and 174 kg/ha for corn and 16, 35, and 107 kg/ha for soybean, respectively. Mean plant populations were 72,900 and 57,500 plants/ha for irrigated and nonirrigated corn, respectively, and 237,600 plants/ha for soybean. Pesticides were applied in accordance with South Carolina Cooperative Extension Service recommendations.

Tensiometers were installed at depths of 30, 45, and 60 cm in the row of each tillage treatment in one randomly selected replication. Tensiometer measurements were recorded three times each week during the growing season. Irrigation water was applied when soil water

*Mention of trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agriculture or the S.C. Agr. Exp. Sta. and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

TABLE 1. GROWING SEASON RAINFALL AND IRRIGATION FOR CORN AND SOYBEAN DURING 1979-81 ON COASTAL PLAIN SOILS

| Year | Rainfall* | Irrigation† | Total‡ |
|---|---|---|---|
| | ------------- mm ------------- | | |
| | Corn | | |
| 1979 | 429 | 149 | 578 |
| 1980 | 217 | 280 | 497 |
| 1981 | 370 | 220 | 590 |
| Mean | 339 | 216 | 555 |
| | Soybean | | |
| 1979 | 644 | 173 | 817 |
| 1980 | 449 | 319 | 768 |
| 1981 | 503 | 159 | 662 |
| Mean | 532 | 217 | 749 |

*Total water received by nonirrigated treatments.
†Mean of three irrigation scheduling treatments.
‡Total water received by irrigated treatments.

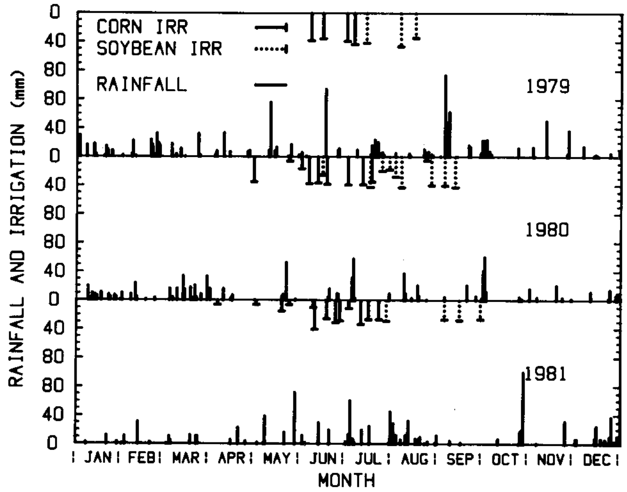


**Fig. 2—Rainfall and irrigation received by corn and soybean on Coastal Plain soils during the three-year period, 1979-81.**

suction at the 30- or 45-cm depth in any tillage treatment was in the 25-50 kPa range. Rainfall and pan evaporation were measured on site. All tillage treatments within a sector were irrigated at the same time because irrigation was provided by a center pivot system. The four center rows of each plot were harvested and weighed for yield determination. A 20-m row segment of corn was harvested 10 September 1979, 4 September 1980, and 24 August 1981 using a two-row combine. A 30-m row segment of soybean was harvested 20 November 1979, 13 November 1980, and 3 November 1981 using a four-row combine.

## RESULTS AND DISCUSSION

Annual rainfall and irrigation received during the three years (1979-81) of this study are included in Table 1. Rainfall and irrigation distributions for each year are shown in Fig. 2. Rainfall during the corn-growing season in 1979 was adequate to satisfy evapotranspiration until early June when irrigation was initiated. Although rainfall occurred, irrigation was required for the remainder of the corn-growing season. Soybean required frequent irrigation in August because little rainfall occurred. Most of the rainfall in September occurred during a 4-day period in association with Hurricane David. Irrigation was required later in the month because of a 12-day period without rainfall. In 1980 total rainfall during the corn- and soybean-growing seasons was much less. Irrigation was required every month for corn and every month during the period June through September for soybean.

In 1981 adequate rainfall occurred during the early portion of the corn-growing season, but significant irrigation was required during June and July, a critical period for corn. Adequate rainfall also occurred during much of the soybean-growing season, but irrigation was required during July and September. August was a fairly wet month (74 mm rainfall), but September was very dry (9 mm rainfall).

### Corn

Mean corn grain yields for the deep tillage (DDSS, MTSS, CP) treatments were significantly higher than other tillage treatments during the three years of this study for both irrigated and nonirrigated conditions (Table 2). Subsoiled treatments (DDSS and MTSS) produced the highest yields, and the nonsubsoiled treatments (DD and MT) produced the lowest yields with the CP treatment producing yields intermediate between the other treatments. There were no significant differences in yield between the two subsoiled tillage treatments (DDSS and MTSS). Tensiometer data show that more water was extracted at the 60-cm depth on a deep tillage treatment (Fig. 3) indicating that rooting was deeper in this treatment. Root observations in pits excavated near the end of the 1979 season also indicated rooting was deeper in the deep tillage treaments (40-45 cm) than in the shallow tillage treatments (18-20 cm).

TABLE 2. CORN GRAIN YIELD FOR FIVE TILLAGE TREATMENTS WITH AND WITHOUT IRRIGATION DURING 1979-81 ON COASTAL PLAIN SOILS

| Tillage treatment | Corn, t/ha* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1979 | | 1980 | | 1981 | | Mean | |
| | Irr. | N-irr. | Irr. | N-irr. | Irr. | N-irr. | Irr. | N-irr. |
| DDSS | 9.81a † | 6.47a | 7.18a | 2.99a | 9.04a | 4.90a | 8.68a | 4.79a |
| MTSS | 9.33ab | 6.82a | 7.33a | 3.06a | 8.67a | 4.31ab | 8.44ab | 4.73a |
| CP | 9.00ab | 6.74a | 5.56b | 2.03ab | 7.52b | 4.17ab | 7.36bc | 4.31a |
| DD | 8.24bc | 5.27a | 4.45b | 1.44b | 6.72c | 2.47bc | 6.47cd | 3.06b |
| MT | 7.24c | 4.95a | 5.12b | 1.72b | 4.51d | 1.79c | 5.62d | 2.82b |
| Mean | 8.72 | 6.05 | 5.93 | 2.24 | 7.29 | 3.53 | 7.31 | 3.94 |

*Yield for each irrigated treatment is mean of three irrigation scheduling treatments.
†Means within a column followed by the same letter are not significantly different at P = 0.05 as determined by the Duncan's multiple range test.

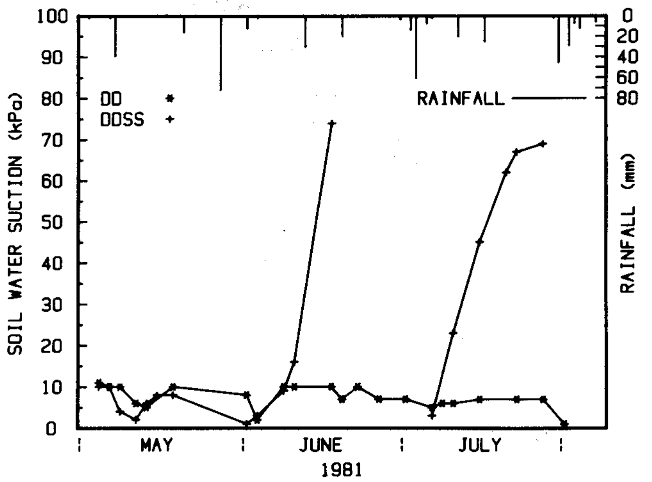


**Fig. 3—Rainfall and soil water suction at 60-cm depth for two tillage treatments in corn without irrigation.**

The irrigated corn grain yields were consistently higher than nonirrigated yields for all tillage treatments. Yield increases due to irrigation were similar for all tillage treatments with mean increases of 3.80 t/ha for the subsoiled treatments, 3.05 t/ha for the CP treatment, and 3.10 t/ha for the non-subsoiled treatments. The overall mean irrigated corn grain yield was 3.37 t/ha (86%) higher than the yield for nonirrigated treatments. The greatest yield increase due to irrigation (165%) occurred in 1980, the year with lowest rainfall during the growing season.

The magnitude of yield differences among tillage treatments varied with year and with irrigation treatment, but the yield ranking of tillage treatments was consistent across time and irrigation treatment with few exceptions. With irrigation, subsoiling increased mean corn grain yield 2.21 t/ha for the double disked treatment, and 2.82 t/ha for the minimum tilled treatment while chisel plowing increased yields 0.89 t/ha when each was compared with the DD treatment. Without irrigation, the yield increases were 1.73, 1.91, and 1.25 t/ha, respectively, for the same comparisons. In both cases, the greatest yield increase due to subsoiling was produced on the minimum tillage treatment. This may be partly due to the consistently low yield for the MT treatment. Although no measurements were made, observations indicated that plant emergence and seedling growth and vigor were poorer and weed competition caused by lack of canopy shading was greater for the MT treatment than in other tillage treatments.

Although irrigation should have provided adequate water in the soil profile, deep tillage further increased corn yield over the shallow tillage treatments. For example, a 3-year mean corn yield increase of 2.21 t/ha was obtained due to subsoiling for the double disked treatment with irrigation (Table 2). The yield increase due to subsoiling for the same treatment without irrigation was 1.73 t/ha. The yield increase due to irrigation was 3.41 and 3.89 t/ha for the DD and DDSS treatments, respectively. Therefore, both subsoiling and irrigation increased corn yields, and the benefits of these two practices appear to be additive for these soils. This probably is due to better nutrient recovery from the deeper soil layers by deeper penetrating roots in the deep tillage treatments. In these soils, most nutrients are very mobile and easily leach from the surface soil layer to the subsoil following rainfall where they may be unavailable to plants with restricted root systems. This is especially true when rainfall occurs shortly after irrigation or rainfall when the upper soil profile is near maximum storage. Although fertilizer can be applied to replace nutrient losses due to leaching, it may not be feasible because of economic, environmental, or equipment considerations. On the other hand, if plant roots were restricted to a soil depth shallower than that used to estimate soil water storage or to schedule irrigation, plant water stresses may have become high enough to reduce yields even under irrigation. Therefore, the soil water regime in the deep tillage treatments might have been more nearly optimal than the shallow tillage treatments, but no observations, including soil water suction measurements, indicated that this was the case. Langdale et al. (1981) suggested that water and nutrient recovery from the deeper depths of a similar Coastal Plain soil was responsible for increased corn grain yield and better N utilization on subsoiled treatments under irrigated conditions.

**Soybean**

Soybean yield differences due to both irrigation and tillage treatments were significant within individual years over the period of the study (Table 3). The yield increase due to deep tillage was not as great nor as consistent as it was with corn. The only significant soybean yield difference due to tillage was for the MT treatment with irrigation which yielded less than the two deep-tilled treatments (DDSS and MTSS), but was not significantly different from the DD or CP treatments. The low soybean yield for the MT treatment may have been due to poor stand establishment and weed competition, as was the case with corn. Poor soil-seed contact and non-uniform depth of seed placement when planting into residue were the primary factors contributing to the poor stand establishment in the MT treatment. There were no significant differences in the three-year mean yields due to tillage for the nonirrigated treatment.

Although not statistically significant, the MTSS treatment without irrigation produced slightly higher yields than the DDSS treatment in two of three years. This was probably due to a larger volume of available water in the soil profile which resulted from improved infiltration of rainfall and profile recharge. Residue on the soil surface may have also reduced evaporative losses from the soil surface. Soybean extracted water deep in the soil profile in deep tillage treatments in a manner similar to corn (Fig. 3). When planting rooting depth is increased from 30 to 90 cm, about 8 cm more water is available to plants provided surface conditions allow infiltration and recharge of the soil profile. This increased volume of stored water sustains plants over longer drought periods without incurring stress.

The mean soybean yield for all tillage treatments with irrigation was 0.73 t/ha (51%) higher than the same treatments without irrigation. The greatest yield increase due to irrigation occurred in 1980 (105%), a dry year, while the smallest increase occurred in 1979 (38%), a year with near normal rainfall. Yield increases due to irrigation did not vary much among the various tillage treatments. Mean yield increases due to irrigation were 0.70, 0.68, and 0.86 t/ha for the subsoiled,

TABLE 3. SOYBEAN YIELD FOR FIVE TILLAGE TREATMENTS WITH AND WITHOUT IRRIGATION DURING 1979-81 ON COASTAL PLAIN SOILS

| Tillage treatment | Corn, t/ha* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1979 | | 1980 | | 1981 | | Mean | |
| | Irr. | N-irr. | Irr. | N-irr.† | Irr. | N-irr. | Irr. | N-irr. |
| DDSS | 2.09a‡ | 1.50a | 2.41a | 1.38a | 2.26a | 1.59a | 2.25a | 1.49a |
| MTSS | 2.18a | 1.95a | 2.43a | 1.13ab | 2.07ab | 1.66a | 2.22a | 1.58a |
| CP | 1.98a | 1.29a | 2.48a | 1.19ab | 2.00ab | 1.43a | 2.16ab | 1.30a |
| DD | 1.94a | 1.36a | 2.37a | 1.08ab | 2.02ab | 1.80a | 2.11ab | 1.41a |
| MT | 2.09a | 1.32a | 2.01b | 0.93b | 1.70b | 1.56a | 1.93b | 1.27a |
| Mean | 2.06 | 1.49 | 2.34 | 1.14 | 2.01 | 1.61 | 2.14 | 1.41 |

*Yield for each irrigated treatment is mean of three irrigation scheduling treatments.
†Treatment means were different only at P = 0.08 by ANOV procedure.
‡Means within a column followed by the same letter are not significantly different at P = 0.05 as determined by the Duncan's multiple range test.

nonsubsoiled, and chisel plowed treatments, respectively.

Soybean yield rankings for the various tillage treatments were about the same for irrigated conditions as for nonirrigated conditions, but yields fluctuated more across the three years of the study than they did for corn. Soybean yield increases due to deep tillage with irrigation were greatest for the minimum tillage treatment (0.29 t/ha) and least for the chisel plowed treatment (0.05 t/ha), while the yield increase for the double disked treatment was intermediate (0.14 t/ha). Without irrigation, soybean yield increases were also greatest for the minimum tillage treatment (0.30 t/ha). Yields increased slightly for the double disked treatment (0.08 t/ha), but decreased (0.11 t/ha) for the CP treatment when compared to the DD treatment. As with corn, the much greater yield increase due to subsoiling for the minimum tillage treatment was probably the result of the consistently low yield for the MT treatment.

The additive yield increase due to deep tillage and irrigation observed for corn was not evident for soybean. If the yield increase observed for corn was caused by the recovery of leached nutrients, particularly N and K, from the subsoil by deep root activity, a similar yield response for soybean probably would not be expected since soybean is not dependent upon fertilizer N.

## CONCLUSIONS

Deep tillage increased corn grain yields for both irrigated and nonirrigated conditions over a three-year period. Yield increases due to deep tillage were greater with irrigation than without. The yield increase due to irrigation was similar for all tillage treatments and the mean yield was 86% higher with irrigation.

Soybean yield differences due to tillage and irrigation were both significant, but the yield increase due to tillage was not as great nor as consistent as it was with corn. The greatest soybean yield increase due to deep tillage was obtained for the MTSS treatment. Irrigation provided a 51% mean yield increase for all tillage treatments.

Deep tillage and irrigation produced an additive yield increase for corn, but not for soybean. The corn grain yield increase due to deep tillage without irrigation was 1.74 t/ha while the yield increase due to the combined effects of irrigation and deep tillage was 5.62 t/ha.

Since irrigation and deep tillage both provided yield increases for corn, the selection of the best combination of management practices will depend upon energy costs for the respective operation in relation to the yield increases provided. Deep tillage may be required with irrigation in order to obtain maximum corn yield. Conservation tillage may offer yield increase under nonirrigated conditions due to improved soil water infiltration and storage and reduced evaporation.

## References


1. Camp, C. R., G. D. Christenbury, and C. W. Doty. 1980. Conservation tillage and irrigation for Coastal Plains soils: A progress report. Proc. ASAE Conf. on Crop Production with Conservation in the 80's. Dec. 1-2, pp. 111-120.
2. Campbell, R. B., D. C. Reicosky, and C. W. Doty. 1974. Physical properties and tillage of Paleudults in the Southeastern Coastal Plains. J. Soil Water Conserv. 29:220-224.
3. Doty, C. W., R. B. Campbell, and D. C. Reicosky. 1975. Crop response to chiseling and irrigation in soils with a compact $A_2$ horizon. TRANSACTIONS of the ASAE 18(4):668-672.
4. Doty, C. W., and D. C. Reicosky. 1978. Chiseling to minimize the effects of drought. TRANSACTIONS of the ASAE 21(3):495-499.
5. Jamison, V. C., and J. F. Thornton. 1960. Results of deep fertilization and subsoiling on a claypan soil. Agron. J. 52:193-195.
6. Kamprath, E. J., D. K. Cassel, H. D. Gross, and D. W. Dibb. 1979. Tillage effects of biomass production and moisture utilization by soybeans on Coastal Plain soils. Agron. J. 71:1001-1005.
7. Langdale, G. W., J. E. Box, Jr., C. O. Plank, and W. G. Fleming. 1981. Nitrogen requirements associated with improved conservation tillage for corn production. Comm. Soil Sci. Plant Anal. 12(11):1133-1149.
8. Larson, W. E., W. G. Lovely, J. T. Pesek, and R. F. Burwell. 1960. Effect of subsoiling and deep fertilization placement on yields of corn in Iowa and Illinois. Agron. J. 52:185-189.
9. Reicosky, D. C., R. B. Campbell, and C. W. Doty. 1976. Corn plant water stress as influenced by chiseling, irrigation, and water table depth. Agron. J. 68:449-503.
10. Reicosky, D. C., D. K. Cassel, R. L. Blevins, W. R. Gill, and G. C. Naderman. 1977. Conservation tillage in the southeast. J. Soil Water Conserv. 32:13-19.
11. Rhoads, F. M., and R. L. Stanley, Jr. 1973. Response of three corn hybrids to low levels of soil moisture tension in the plow layer. Agron. J. 65:315-318.
12. Rhoads, F. M., and R. L. Stanley, Jr. 1974. Response of corn (Zea Mays L.) grown on soils of three textural classes to plow layer water management. Soil Crop. Soc. of Florida Proc. 34:1-3.