5. FLORENCE, SOUTH CAROLINA

C.R. Camp[1], G.D. Christenbury[2], and
C.W. Doty[1]

INTRODUCTION

Management practices to reduce the effects of drought in Coastal Plain soils are needed. Potential practices include the addition of water to the surface layer by irrigation, 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. The most efficient and economical practice must be determined, since both deep tillage and irrigation require high energy inputs. Although conservation tillage is most often implemented to reduce soil loss, the practice also offers other advantages, including improved water infiltration and soil profile recharge, reduced evaporation, and improved water-use efficiency of stored water during short drought periods.

The objectives of this research were to determine the separate and collective effects of irrigation and tillage on corn grain yield and determine the optimum combination of irrigation and tillage for efficient corn production in Southeastern Coastal Plain soils.

METHODS

Corn (Zea mays L. cv. Pioneer 3369-A) was grown on an 18-ha site near Florence, SC, where the predominant soils are Bonneau loamy sand (Arenic Paleudult) and Norfolk loamy sand (Typic Paleudult). These soils had a compacted E horizon 20 to 60 mm thick at a depth of 0.20 to 0.30 m.

Four irrigation treatments and five tillage treatments were included in the study during the 3-year period, 1979-81. In three of the treatments, irrigation was scheduled by different methods, and in one treatment no irrigation was applied (NI). The computer-based water-balance method (CBWB) of scheduling irrigation utilized a water balance procedure adapted to a microcomputer and utilized meteorological data inputs to estimate evapotranspiration. This procedure is described in detail in chapter 2. Allowable depletion and rooting depth are two inputs which the user must estimate. The allowable depletion for all 3 years of this study was 50%. In 1979, the rooting depth was assumed to be constant at 0.60 m. In the other 2 years, it was assumed to increase stepwise to a maximum of 0.71 m.

The screened pan evaporation (SPE) method of scheduling irrigation was based on potential evapotranspiration (Campbell and Phene 1976, Doty et al. 1982). Irrigation was initiated when the water level in a screened evaporation pan dropped to a preset level below the overflow. Rainfall in excess of the simulated soil storage was wasted via an overflow. Since several soil types were present in the irrigated area (table 1), the predominant soil with the smallest available water volume in the rooting zone (58 mm) was used to calculate the allowed depletion. The active rooting zone was estimated to be 0.75 m, and irrigation was to be applied when 50% of the available water in the rooting zone was depleted. Therefore, irrigation was applied when 29 mm (50% x 58 mm) of water had evaporated from the pan. This means that the soil with the largest available water volume (87 mm) was irrigated at a depletion of 39%. At irrigation, water in the evaporation pan was replenished by a volume corresponding to the effective irrigation depth applied by the irrigation system.

[1] Agricultural engineers, U.S. Department of Agriculture, Agricultural Research Service, Coastal Plains Soil and Water Conservation Research Center, Florence, SC. 29502.
[2] Professor, Department of Agricultural Engineering, Clemson University, Clemson, SC 29634.

Table 1--Continued
Location, by sector and soil type, for irrigation treatments during the 3-year study (1979-81)*

Irrigation treatment/location		Tillage treatment	Soils
			1980 con.
NI	H	DDSS	NoA(30) BnB(65) BlA(05)
		MTSS	NoA(20) BnB(80)
		DP	BnB(100)
		DD	NoA(15) BnB(85)
		MT	NoA(10) BnB(90)
			1981
CBWB	C	DDSS	BnB(20) OcA(05) CxA(05) NoB(65) LyA(05)
		MTSS	BnB(20) OcA(05) CxA(20) NoB(50) LyA(05)
		CP	BnB(20) OcA(05) CxA(25) NoB(50)
		DD	BnB(20) OcA(05) CxA(05) NoB(50) LyA(20)
		MT	BnB(15) OcA(10) NoB(75)
SPE	B	DDSS	NoA(40) BnB(60)
		MTSS	NoA(50) BnB(50)
		CP	NoA(55) BnB(45)
		DD	NoA(50) BnB(50)
		MT	NoA(50) BnB(50)
TENS	D	DDSS	BnB(30) OcA(30) NoB(15) WgA(25)
		MTSS	BnB(30) OcA(30) NoB(15) WgA(25)
		CP	BnB(40) OcA(15) NoB(15) WgA(25)
		DD	BnB(40) OcA(20) NoB(15) WgA(25)
		MT	BnB(35) OcA(20) NoB(20) WgA(25)
NI	A	DDSS	NoA(45) BnB(30) OcA(20) RnA(05)
		MTSS	NoA(45) BnB(30) OcA(20) RnA(05)
		CP	NoA(40) GoA(05) BnB(30) CxA(25)
		DD	NoA(40) GoA(10) BnB(20) OcA(10) RnA(05) CxA(15)
		MT	NoA(50) GoA(05) BnB(20) OcA(20) RnA(05)

* Sectors are shown in figure 1 and relate to position within the center-pivot irrigation system.
**Soil and percentage contained in specified treatment:

NoA	Norfolk ls 0-2% slope	GoA	Goldsboro ls 0-2% slope
NoB	Norfolk ls 2-6% slope	LyA	Lynchburg sl 0.2% slope
BnB	Bonneau s 0-4% slope	OcA	Ocilla l 0-2 slope
BlA	Blanton s 0-2% slope	RnA	Rains sl 0-2% slope
CxA	Coxville sl 0-2% slope	WgA	Wagram s 0-2% slope

Table 1--Continued
Location, by sector and soil type, for irrigation treatments during the 3-year study (1979-81)*

Irrigation treatment/location		Tillage treatment	Soils
			1980 con.
NI	H	DDSS	NoA(30) BnB(65) BlA(05)
		MTSS	NoA(20) BnB(80)
		DP	BnB(100)
		DD	NoA(15) BnB(85)
		MT	NoA(10) BnB(90)
			1981
CBWB	C	DDSS	BnB(20) OcA(05) CxA(05) NoB(65) LyA(05)
		MTSS	BnB(20) OcA(05) CxA(20) NoB(50) LyA(05)
		CP	BnB(20) OcA(05) CxA(25) NoB(50)
		DD	BnB(20) OcA(05) CxA(05) NoB(50) LyA(20)
		MT	BnB(15) OcA(10) NoB(75)
SPE	B	DDSS	NoA(40) BnB(60)
		MTSS	NoA(50) BnB(50)
		CP	NoA(55) BnB(45)
		DD	NoA(50) BnB(50)
		MT	NoA(50) BnB(50)
TENS	D	DDSS	BnB(30) OcA(30) NoB(15) WgA(25)
		MTSS	BnB(30) OcA(30) NoB(15) WgA(25)
		CP	BnB(40) OcA(15) NoB(15) WgA(25)
		DD	BnB(40) OcA(20) NoB(15) WgA(25)
		MT	BnB(35) OcA(20) NoB(20) WgA(25)
NI	A	DDSS	NoA(45) BnB(30) OcA(20) RnA(05)
		MTSS	NoA(45) BnB(30) OcA(20) RnA(05)
		CP	NoA(40) GoA(05) BnB(30) CxA(25)
		DD	NoA(40) GoA(10) BnB(20) OcA(10) RnA(05) CxA(15)
		MT	NoA(50) GoA(05) BnB(20) OcA(20) RnA(05)

* Sectors are shown in figure 1 and relate to position within the center-pivot irrigation system.

**Soil and percentage contained in specified treatment:

NoA	Norfolk ls 0-2% slope	GoA	Goldsboro ls 0-2% slope
NoB	Norfolk ls 2-6% slope	LyA	Lynchburg sl 0.2% slope
BnB	Bonneau s 0-4% slope	OcA	Ocilla l 0-2 slope
BlA	Blanton s 0-2% slope	RnA	Rains sl 0-2% slope
CxA	Coxville sl 0-2% slope	WgA	Wagram s 0-2% slope

The third irrigation scheduling method used tensiometers (TENS). Irrigation was initiated when any two of six tensiometers in the 0.30- to 0.60-m-depth range reached a predetermined soil water pressure (SWP) value. This SWP value was -30 kPa in 1979 and -25 kPa in 1980 and 1981.

Five tillage treatments were included for both irrigated and nonirrigated treatments in a randomized complete block design with four replications. Tillage treatments were as follows:

- DD Double-disking, spring tooth harrowing with drag and planting.
- DDSS Double-disking, spring tooth harrowing with drag and in-row subsoiling at time of planting.
- MT Minimum tillage -- planting directly into residue without prior tillage.
- MTSS Minimum tillage with subsoiling -- planting directly into residue with in-row subsoiling but without prior tillage.
- 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 (0.40 m). Chiseling (treatment CP) to a depth of about 0.35 m was accomplished using a chisel plow with tines spaced 0.25 m 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) colter 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, 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.

Irrigated treatments were located within one quadrant of a high-pressure, center pivot irrigation system. Corn and soybean were grown in each of two quadrants of the center pivot system and were rotated between quadrants each year. The same tillage treatments were present in both corn and soybean and remained in the same location each year. Nonirrigated treatments (NI) were located immediately adjacent to the center pivot system (fig. 1). Three irrigation scheduling treatments were located in separate sectors within each quadrant. The location by sector for each of the irrigation scheduling treatments for each year of the study is shown in table 1. Soils within each plot are also shown in table 1. From these data it is apparent that there was considerable soil variation among and within treatments. Dates of selected crop management operations and crop development events for each year of the study are included in table 2.

Fertilizer was broadcast in 1979 and 1981 and applied in a band in 1980. Sidedress N was applied through the irrigation system for the irrigated treatments except in 1979, when it was broadcast in liquid form by ground equipment. Sidedress N for the NI treatment was broadcast every year as a liquid with ground equipment. The annual application of N, P, and K fertilizer was based on soil test recommendations and is reported in table 3. All treatments within a year received the same amount of fertilizer. Mean plant populations at harvest are also included in table 3. Pesticides were applied in accordance with South Carolina Cooperative Extension Service recommendations.

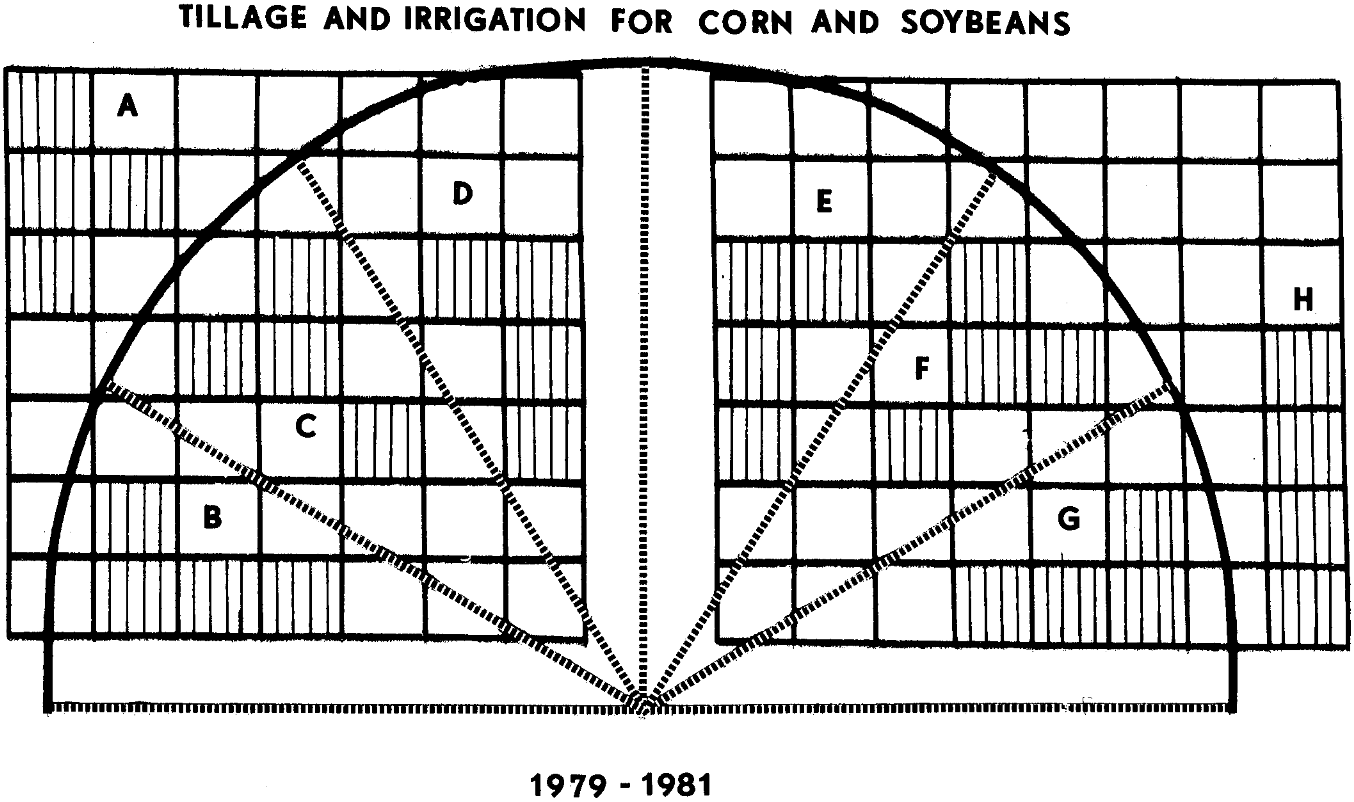

Figure 1.
Irrigation treatment areas (squares) are shown in sectors (B,C,D,E,F,G) of the center pivot system and could be irrigated independently. Nonirrigated treatment areas (A,H) are located outside the center pivot area. Tillage treatments are shown schematically as strips within the squares.

Table 2.
Dates of selected crop management operations and crop development events

Year	Dates			
	Planting	50% Emergence	Maturity	Harvest
1979	4 Apr	10 Apr	25 July	10 Sept
1980	25 Apr*	2 May	27 July	4 Sept
1981	30 Mar	7 Apr	27 July	24 Aug

*Second planting.

Table 3.
Plant population and fertilizer applied to corn during 1979-81 on Coastal Plain soils

Year	Plant Population		Fertilizer	
	Irrig.	Nonirrig.	Preplant(N-P-K)	Sidedress (N)
	----plants/ha----		----------kg/ha----------	
Corn				
1979	74,100	49,400	45-56-134	179
1980	66,700	45,200	34-67-201	34+132+67
1981	77,800	77,800	31-63-188	103+58+36

Tensiometers were installed at depths of 0.30, 0.45, and 0.60 m in the row of each tillage treatment in one randomly selected replication. Tensiometer measurements were recorded three times each week during the growing season. Rainfall and irrigation water applied were measured onsite, but other meteorological data required for the CBWB procedure were obtained at the Coastal Plains Soil and Water Conservation Research Center, which is located about 8 km from the site. Although a screen-covered, class A evaporation pan was used in the SPE irrigation scheduling treatment, daily measurements of evaporation were not obtained from this pan but from the Center's weather station. Irrigation was measured using a standard rain gauge located in the corn canopy under the center pivot system.

A 20-m segment of each of the four center rows of each plot was harvested using a two-row combine, and the samples were weighted for yield determination. All grain yields were corrected to 15.5% moisture. Corn grain yields were analyzed statistically using analysis of variance procedures and Duncan's multiple range test.

RESULTS AND DISCUSSION

Rainfall and irrigation received during the growing season for the 3 years (1979-81) of this study are shown in table 4 and figures 2, 3 and 4. Rainfall during the growing season in 1979 was adequate to satisfy evapotranspiration until early June, when irrigation was initiated. Although rainfall occurred intermittently, irrigation was required for the remainder of the growing season.

In 1980 rainfall during the growing season was much less, particularly during the vegetative stages, and irrigation was required every month of the growing season. The rainfall total for this growing season (227 mm) was the lowest in the 3 years. In 1981 rainfall was adequate during the early vegetative portion of the growing season but was deficient during the remainder of the growing season, so significant irrigation was required during June and July. This period of deficit rainfall occurred during pollination and grain fill, a very critical period for corn.

Table 4.
Irrigation and rainfall during the growing season for 1979-81

Irrigation treatment	Irrigation (mm) 1979	1980	1981	Mean
CBWB	121	333	213	222
SPE	192	297	177	222
TENS	158	325	269	238
Rainfall	427	227	365	340

Irrigation

In 1979 the SPE treatment required the greatest amount of irrigation (192 mm) while the CBWB treatment required the least amount (121 mm) (table 4). A major reason for the low irrigation requirement for the CBWB treatment was communication difficulties associated with the initiation of a new system. These difficulties caused delays in reporting data and in implementing irrigations. In 1980 the CBWB and TENS treatments required almost equal amounts of irrigation, while the SPE treatment required about 30 mm less water. This was the driest year of the study and resulted in fairly uniform irrigation intervals for all irrigation treatments. In 1981 the TENS treatment required the greatest amount of water for irrigation, and the SPE treatment required the least amount of water. Rainfall for this year was intermediate between the two previous years but was within 62 mm of the seasonal rainfall of the wettest year, 1979.

Irrigation water applied during the 3 years varied considerably, as did rainfall, but no one scheduling method consistently required the most water over the 3 years. When the mean irrigation amounts for the 3-year period are considered, the TENS treatment required more irrigation water than the other methods, but there was no difference between the other two methods.

There were some differences in soils for the irrigation treatments among the 3 years because the treatments were rotated among the six sectors of the center pivot system (table 1). Although the CBWB and SPE treatments were based on selected soil-water storage values that did not change as treatment location changed, the TENS treatment was subject to soil changes among years because tensiometers were located in the treatment areas and reflected their SWP. This could account for some of the variation in irrigation water required by the TENS treatment among the 3 years of the study.

Some variation in the irrigation water applied was due to the randomness of rainfall. For example, one method might require irrigation on a given day and another method might require irrigation the following 1 to 3 days, but rainfall after noon of the first day or the next day would preclude the need for irrigation the following days. This sequence of events occurred at least four times during the 3 years of the study but appeared to be random; nevertheless, SPE (three times) and CBWB (two times) treatments were affected more than the TENS treatment (once). Also, if more runoff should occur during high intensity storms than that estimated by the CBWB and SPE methods, these methods would overestimate the amount of stored soil water and would indicate the need for irrigation less frequently than the TENS treatment.

The water supply for the center pivot system failed about 29 June 1981. This resulted in reduced irrigation amounts for all treatments until 3 July, when rainfall replenished the water supply. Plant stress during this period was moderately high and probably reduced yield, but it was essentially equal among the three irrigation scheduling treatments.

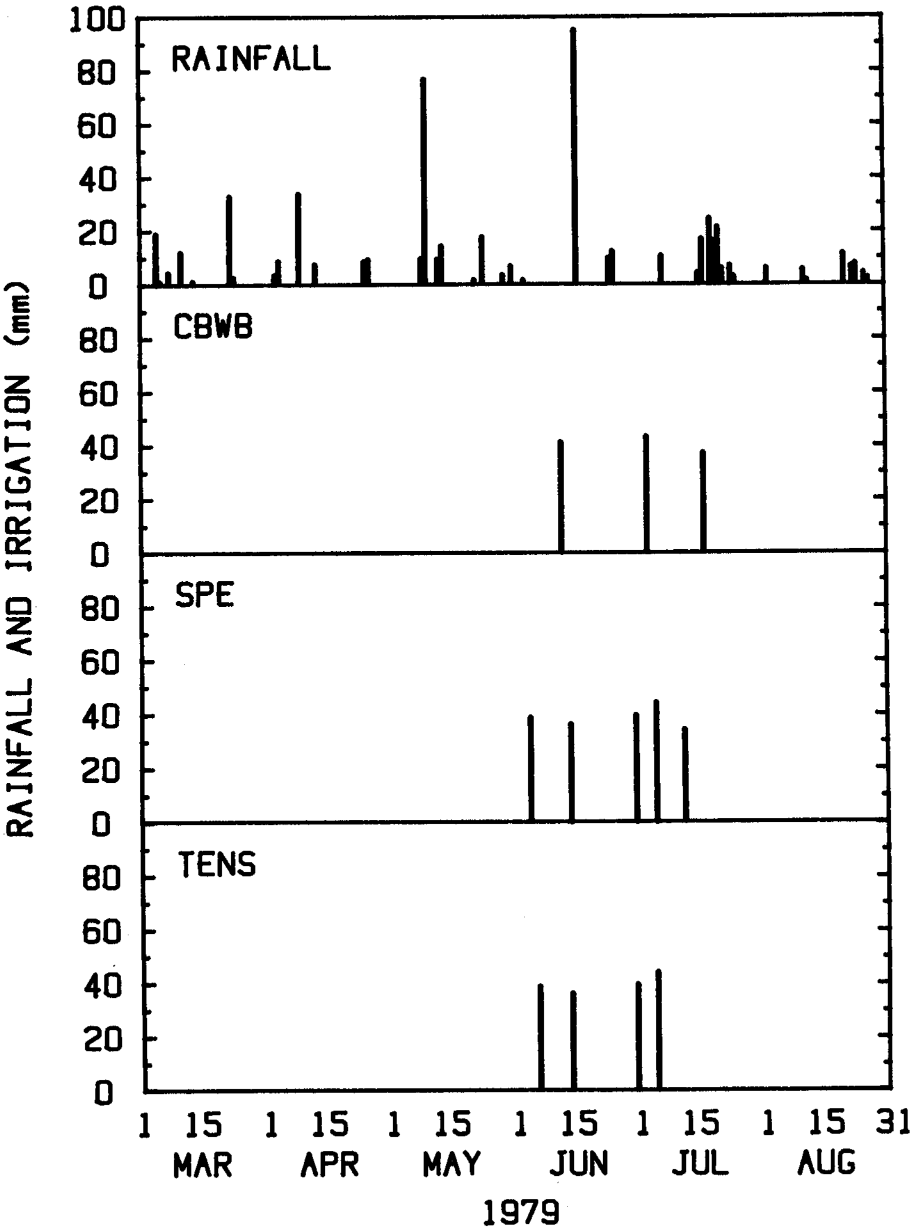

Figure 2.
Rainfall and irrigation applied to corn for three irrigation scheduling treatments in Florence, SC, during the growing seasons in 1979. CBWB = computer-based water balance; SPE = screened pan evaporation; TENS = tensiometer.

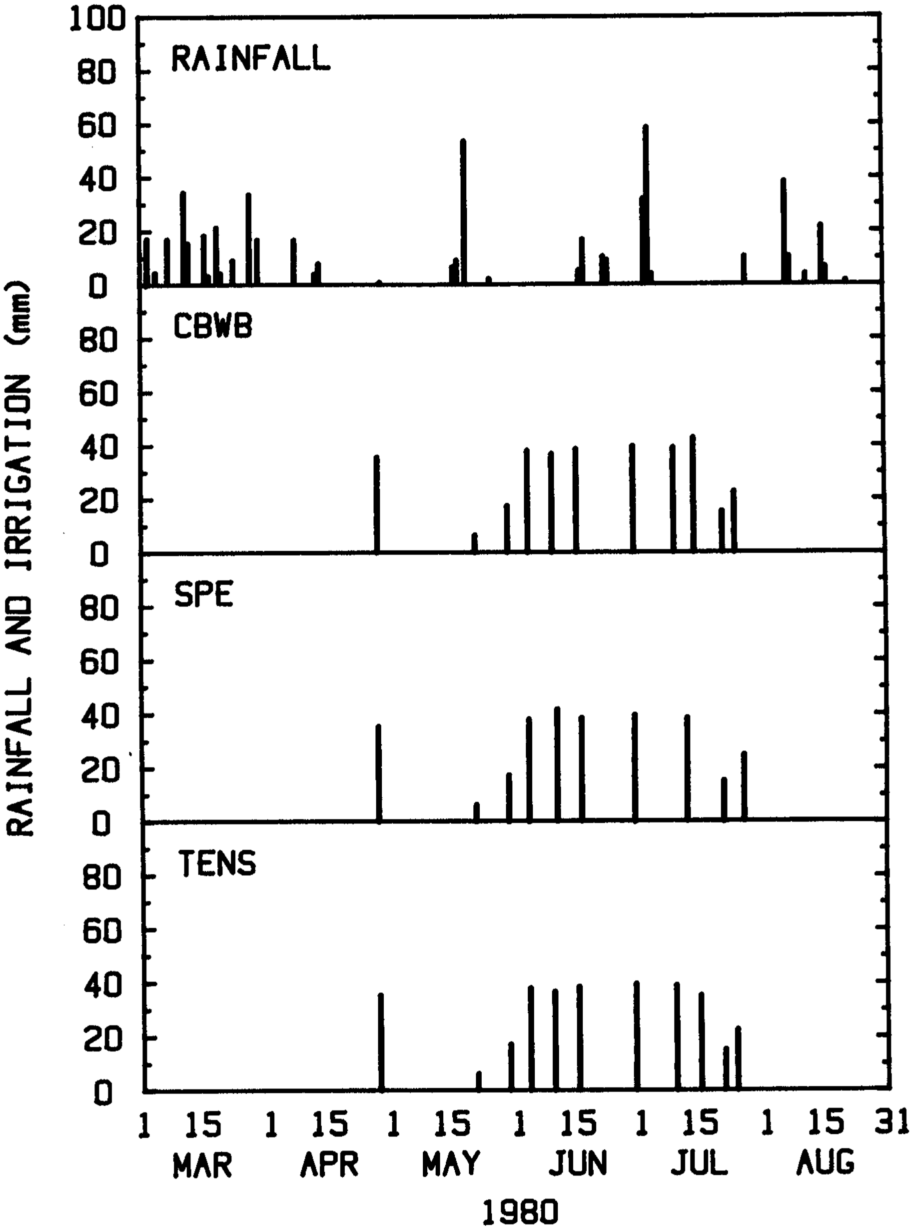

Figure 3.
Rainfall and irrigation applied to corn for three irrigation scheduling treatments in Florence, SC, during the growing season, 1980. CBWB = computer-based water balance; SPE = screened pan evaporation; TENS = tensiometer.

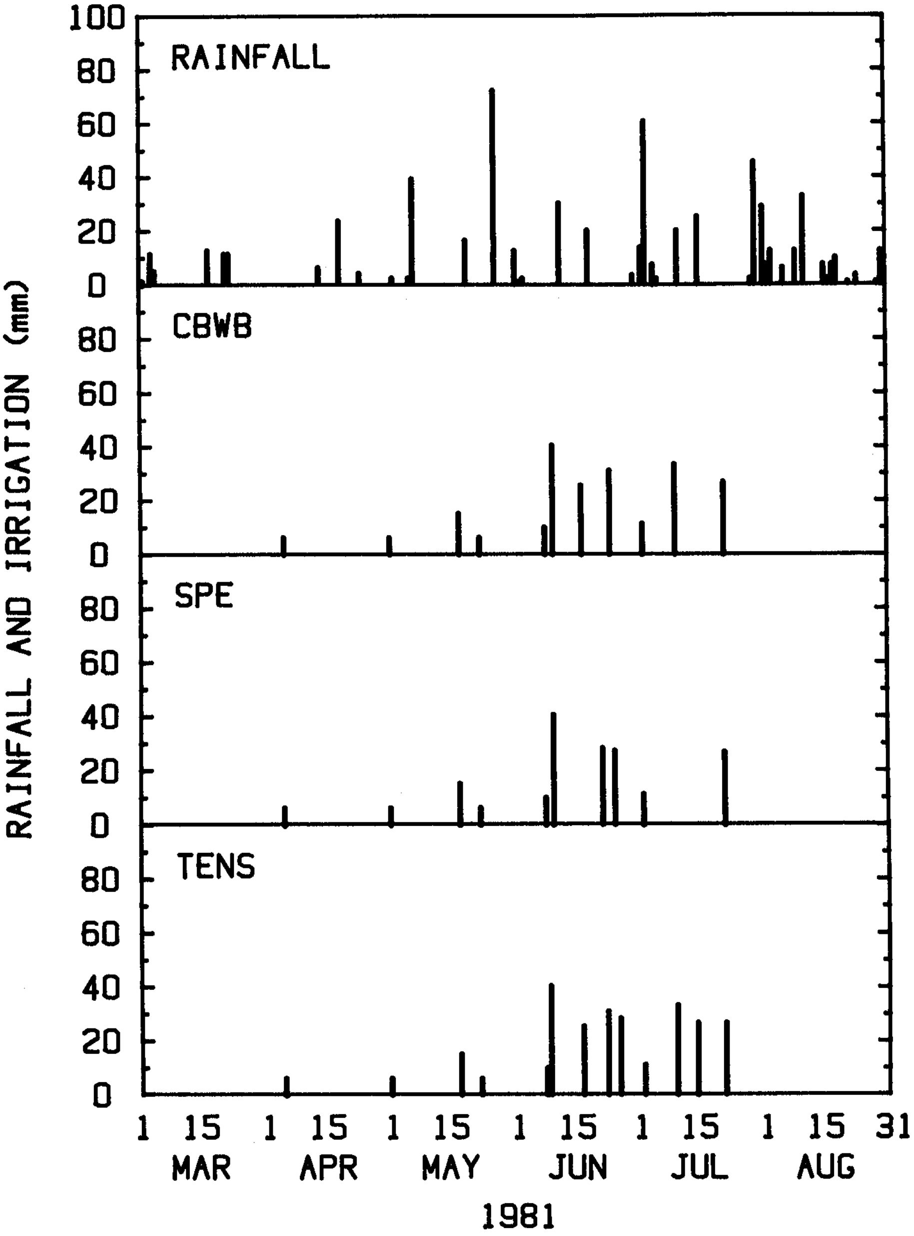

Figure 4.
Rainfall and irrigation applied to corn for three irrigation scheduling treatments in Florence, SC, during the growing season, 1981. CBWB = computer-based water balance; SPE = screened pan evaporation; TENS = tensiometer.

In 1979, corn grain yield was highest for the SPE treatment, which received the greatest amount of irrigation water (192 mm), but this yield was not significantly different from the yield for the TENS treatment, which received 158 mm of irrigation water (table 5). Additionally, the yield for the CBWB treatment was lowest of the three and received the lowest amount of irrigation water, but the yield was not significantly different from that of the TENS treatment. In 1980, corn grain yields were highest for the CBWB and TENS treatments, both of which received about 30 mm more irrigation water than the SPE treatment. In 1981 there was no statistical difference among the corn grain yields for all three irrigation scheduling treatments, although there was a maximum difference of 92 mm in irrigation water applied.

Table 5.
Mean corn grain yields for water management treatments in Coastal Plain soils for 1979-81

Year	Water management treatment*			
	CBWB**	SPE	TENS	NI
	Mg/ha			
1979	7.56 b***	9.67 a	8.94 ab	6.05 c
1980	6.69 a	4.83 b	6.28 a	2.25 c
1981	7.61 a	6.95 a	7.32 a	3.53 b
Mean	7.29 a	7.15 a	7.51 a	3.94 b

* Each yield value is mean of 5 tillage treatments.

** CBWB = Computer-based water balance; SPE = screened pan evaporation; TENS = tensiometer; NI = nonirrigated (rainfall only).

***Values followed by the same letter within a row are not statistically different at $P \leq .05$ according to Duncan's multiple range test.

None of the three scheduling methods consistently produced the highest yield. Three-year mean grain yields were not statistically different. Although it appeared that corn grain yield was related to the amount of irrigation water applied in 1980, this was not the case in 1981. In that year, the greatest amount of water was applied in the TENS treatment, but the highest yield was produced in the CBWB treatment. From these data, it appears that factors other than irrigation and rainfall substantially affected the yields produced on these treatments.

The soil variation among the sectors of the center pivot system was probably the major factor contributing to this variance. Unfortunately, it was not possible to have multiple locations for the irrigation treatments because of operational restrictions of the center pivot system and the large land area required. Although the four blocks within a sector provided spatial replication, soil variation, in some cases, was greater among sectors than it was within a sector.

Mean corn grain yields across all tillage treatments were consistently higher for the irrigated treatments than for the NI treatment (table 6). This was true for all 3 years, but the difference between irrigated and NI yields was greatest in 1980 and 1981, the 2 years when rainfall during the growing season was lowest. Yield increases due to irrigation were similar for all tillage treatments, with mean increases of 3.80 Mg/ha for the subsoiled treatments, 3.05 Mg/ha for the CP treatment, and 3.10 Mg/ha for the nonsubsoiled treatments. The overall mean corn yield for irrigated treatments was 3.37 Mg/ha (86%) higher than that for the NI treatment.

Irrigation, rainfall, upper and lower limits of available soil water, critical level (CL), and daily soil-water content (SWC) as calculated by the CBWB procedure for both the CBWB and NI treatments and for all 3 years of the study are shown in figures 5-7. The soil-water volume available for plants is a function of rooting depth; therefore, this volume increases with time from planting until it reaches a maximum for the season. The CBWB procedure was operated in a batch mode, with no reinitialization to generate these graphs. Therefore, daily SWC values do not necessarily represent the values used in actually managing irrigation for the CBWB treatment on a real time basis.

As mentioned earlier, communication problems in 1979 caused some difficulty in the timely application of irrigation to this treatment. Notwithstanding the problems associated with this irrigation management program in 1979, corn grain yields for irrigated treatments were higher for this year than for any other year of the study. In 1980, temporary periods of soil saturation caused by overirrigation or by rainfall following soon after irrigation probably occurred and caused a measured potassium deficiency in corn plants. This deficiency resulted in excessive lodging and may have reduced yields. The existence of more periods of drought stress in 1980 and 1981 reduced corn yields on NI treatments and appeared to have reduced

Table 6.
Comparison of grain yields for irrigated and nonirrigated treatments in an experiment which included 5 tillage treatments in Coastal Plain soils

Year	Nonirrigated	Irrigated*	Increase
	---------Mg/ha---------		%
1979	6.05	8.72	44
1980	2.25	5.93	164
1981	3.53	7.29	107
Mean	3.94	7.31	86

* Mean of 3 irrigation treatments.

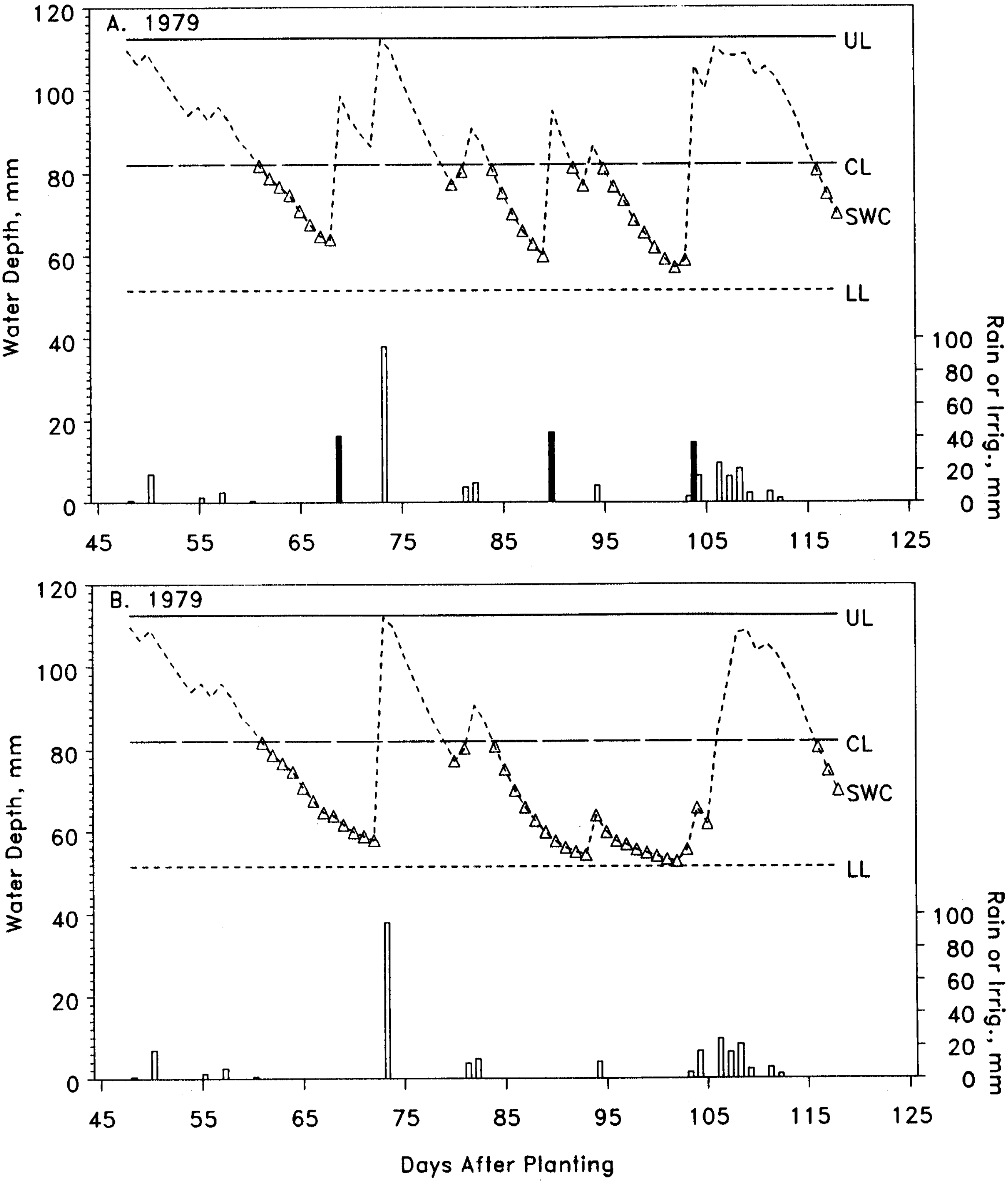

Figure 5.
Daily root-zone water content, irrigation, and rainfall data for (A) CBWB treatment and (B) NI treatment at Florence in 1979. Curves show the simulated water content (SWC) and the upper limit (UL), critical level (CL), and lower limit (LL) of available water; solid and open bars, respectively, show the amounts of irrigation (Irrig) or rain received: and triangles flag days when CBWB indicated the need for irrigation. Scale for bars shown on right vertical axis.

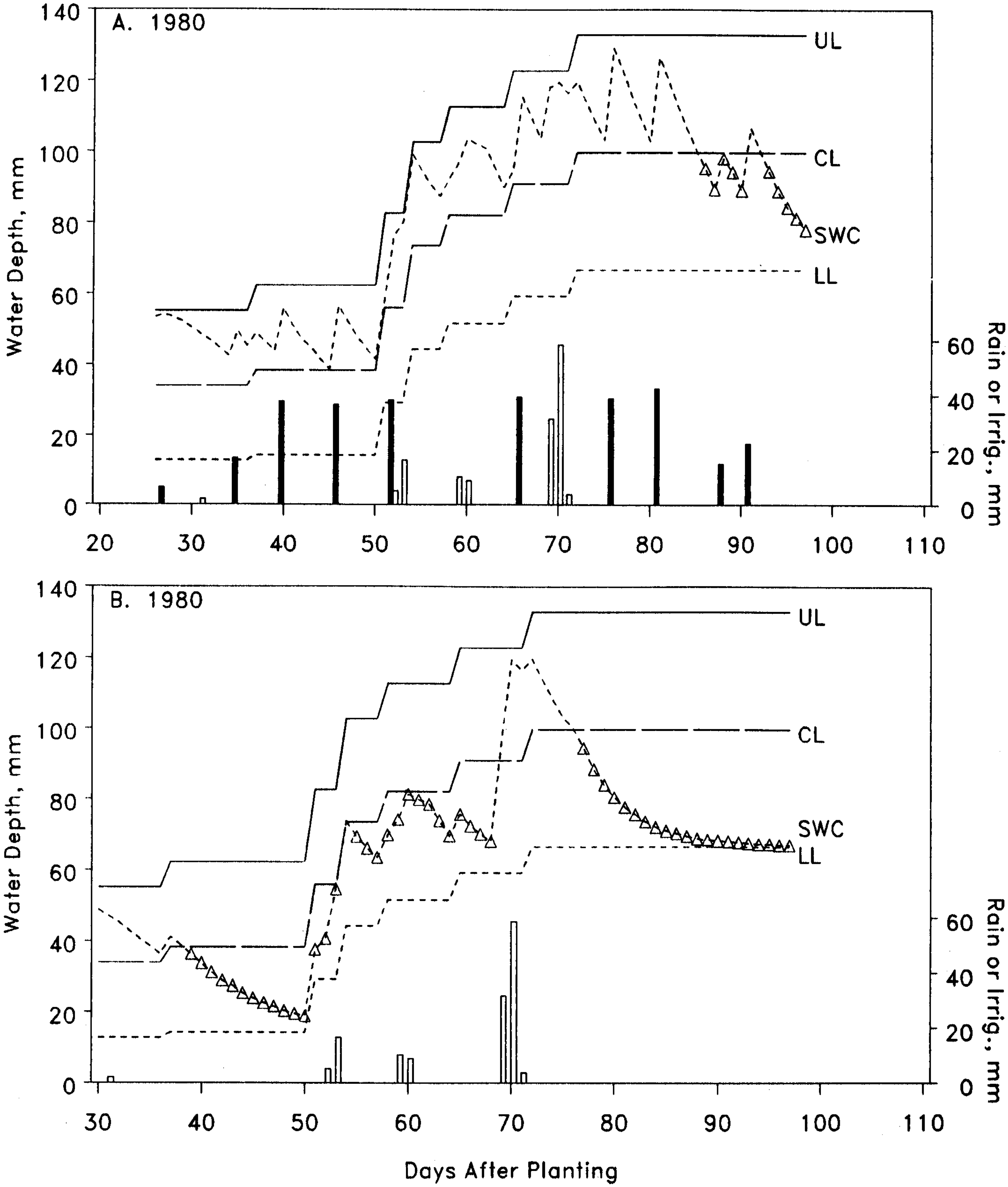

Figure 6.
Daily root-zone water content, irrigation, and rainfall data for (A) CBWB treatment and (B) NI treatment at Florence in 1980. See figure 5 legend for explanation of symbols.

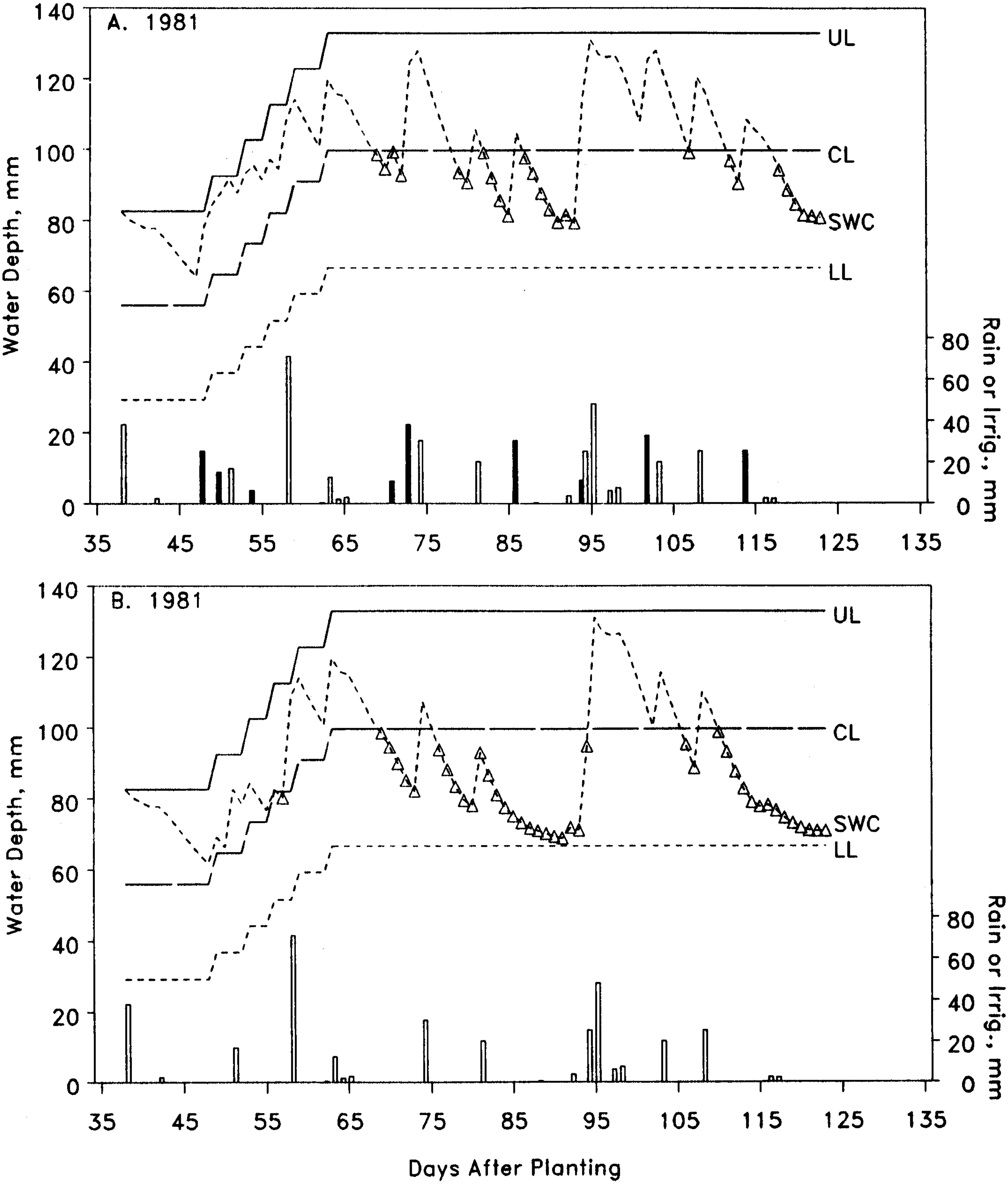

Figure 7.
Daily root-zone water content, irrigation, and rainfall data for (A) CBWB treatment and (B) NI treatment at Florence in 1981. See figure 5 legend for explanation of symbols.

yields on irrigated treatments. This indicates that irrigation management was not precisely matched with need or was not executed as specified. Water supply problems in 1981 prevented the timely application of irrigation, particularly during the period 29 June-3 July (91-95 days from planting).

Soil water pressure data as determined by tensiometers could not be used to accurately estimate volumetric soil-water content because of soil variation within and among treatments; therefore, simulated and measured soil water contents could not be compared. Also, tensiometer data were not sufficient in scope and number to accurately estimate water loss via deep percolation; however, losses of this type probably occurred, particularly during periods of high soil water content.

Potential evapotranspiration (PET) and actual evapotranspiration (AET) values calculated by the CBWB procedure for equal time periods (22 May-31 July) were 404 and 322 mm in 1979, 453 and 307 mm in 1980, and 446 and 348 mm in 1981. AET values calculated by the CBWB procedure for NI treatments were 231, 164, and 275 mm for the same time periods.

Tillage

Mean corn grain yields for the deep tillage (DDSS, MTSS, CP) treatments were significantly higher than those for the other tillage treatments during the 3 years of this study for both irrigated and NI conditions (table 7). Subsoiled treatments (DDSS, MTSS) produced the highest yields, and the nonsubsoiled treatments (DD, MT) produced the lowest yields. There were no significant differences in yield between the two subsoiled tillage treatments (DDSS, MTSS). Tensiometer data showed that water was extracted at the 0.60-m depth on a deep tillage treatment but not in shallow tillage treatments, 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 treatments (0.40-0.45 m) than in shallow tillage treatments (0.18-0.20 m).

The magnitude of yield differences among tillage treatments varied with year and with irrigation treatment, but the yield rankings of tillage treatments were consistent across time and irrigation treatment with few exceptions. Based on the 3-year means for the irrigated treatments, subsoiling increased corn grain yield 2.21 Mg/ha for the DD treatment and 2.81 Mg/ha for the MT treatment, while CP increased yields 0.89 Mg/ha when compared with the DD treatment (table 7). Without irrigation the yield increases were 1.73, 1.91, and 1.25 Mg/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 have been 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 for the other tillage treatments.

With irrigation, deep tillage further increased corn yield over the shallow tillage treatments. For example, a 3-year mean corn yield increase of 2.21 Mg/ha was obtained with subsoiling for the DD treatment with irrigation. The yield increase due to subsoiling for the same treatment without irrigation was 1.73 Mg/ha. The yield increase due to irrigation was 3.41 and 3.89 Mg/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 because of better nutrient recovery from

Table 7.
Mean corn grain yields for 5 tillage treatments, both with and without irrigation, on Coastal Plain soils for 1979-81

Year	Tillage treatment				
	DDSS*	MTSS	CP	DD	MT
	Mg/ha				
			Irrigated**		
1979	9.81 a***	9.33 ab	9.00 ab	8.24 bc	7.24 c
1980	7.18 a	7.33 a	5.56 b	4.45 b	5.12 b
1981	9.04 a	8.67 a	7.52 b	6.72 c	4.51 d
Mean	8.68 a	8.44 ab	7.36 bc	6.47 cd	5.63 d
			Nonirrigated		
1979	6.47 a	6.82 a	6.74 a	5.27 a	4.95 a
1980	2.99 a	3.06 a	2.03 ab	1.44 b	1.72 b
1981	4.90 a	4.31 ab	4.17 ab	2.47 bc	1.79 c
Mean	4.79 a	4.73 a	4.31 a	3.06 b	2.82 b

* DDSS = double disking and in-row subsoiling; MTSS = minimum tillage and in-row subsoiling; CP = chisel plowing; DD = double disking; and MT = minimum tillage.
** Means of three irrigation scheduling treatments.
***Values followed by the same letter within a row are not statistically different at $P \leq .05$ according to Duncan's multiple range test.

the deeper soil layers by deeper penetrating roots in the deep tillage treatments.

In these soils, N and K are very mobile and, following rainfall, easily leach from the surface soil layer to the subsoil, where they may be unavailable to plants with restricted root systems. Leaching is especially likely when rainfall occurs shortly after irrigation or a previous rainfall, when the upper soil profile is very wet. 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 stress may have become high enough to reduce yield even under irrigation. In this case, the soil-water regime in the deep tillage treatments would have been more nearly optimal than that in the shallow tillage treatment; but no observations, including SWP 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.

CONCLUSIONS

Irrigation water required by the three irrigation scheduling treatments varied considerably for the 3-year study, but no method consistently required the highest or lowest amounts of water. Some of the differences in the amounts of irrigation water applied were due to the random occurrence of rainfall; that is, there was usually 1 to 3 days' difference in the time irrigation was scheduled by the three methods, and rainfall often occurred during that interval. This removed the need to irrigate those treatments scheduled for the later part of the interval. The 3-year mean irrigation totals were very similar among the three scheduling methods.

Likewise, there were no significant differences in the 3-year mean corn grain yields among the three methods. There were significant differences in yield among the irrigation scheduling treatments in 1979 and 1980; but, again, no method consistently produced the highest or lowest yields. Therefore, until refinements are made in these methods of scheduling irrigation, the farmer should choose the method best suited to his/her needs.

Deep tillage increased corn grain yields for both irrigated and NI conditions over the 3-year period, but the yield increase was 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.

Deep tillage and irrigation produced an additive increase in corn grain yield. The yield increase due to deep tillage without irrigation was 1.74 Mg/ha while the yield increase due to the combined effects of irrigation and deep tillage was 5.62 Mg/ha. Consequently, where root restrictions occur in these layered soils, it may be profitable to both subsoil and irrigate.

REFERENCES

Campbell, R. B. and C. J. Phene. 1976. Estimating potential evaptranspiration from screened pan evaporation. Agric. Meteorol. 16:343-352.

Doty, C. W., C. R. Camp, and G. D. Christenbury. 1982. Scheduling irrigation in the southeast with a screened evaporation pan. Proc. Spec. Conf. Environ. Soil & Water and Soil Mgt., Amer. Soc. Civil Engrs. July 20-23, 1982. pp. 475-483.

Langdale, G. W., J. E. Box, Jr., C. O. Plank and W. C. Fleming. 1981. Nitrogen requirements associated with improved conservation tillage for corn production. Comm. Soil Sci. Plant Anal. 12(11):1133-1149.