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DRAINAGE INTENSITY EFFECTS ON WATER TABLE CONTROL AND SUGARCANE YIELD

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SUMMARY:

Subsurface drainage intensities of 14m, 28m, and 42m reduced annual average SEW_{30} values more than 50 percent. SEW_{30} values were 62, 162, 292, and 666 cm-days for 14m, 28m, 42m, and nondrained, respectively. Sugar yields from the drained areas were 16 to 21 percent more than that from the nondrained check.

KEYWORDS:

Subsurface drainage, water-table, sugarcane

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DRAINAGE INTENSITY EFFECTS ON WATER TABLE CONTROL AND SUGARCANE YIELD[1]

Cade E. Carter and Carl R. Camp Jr.[2]

ABSTRACT

An experiment was conducted in Iberia Parish Louisiana during 1979-1990 to determine soil and crop response to subsurface drainage. Three drainage intensities, (14m, 28m, and 42m drain spacings), on a Jeanerette silty clay loam soil were evaluated for their effectiveness on water table control by comparing SEW_{30} from each drain spacing with that from a nondrained check. The 14m and 28m spacing effectively controlled the water table with average annual SEWs of 62 and 162 cm-days, respectively. Average annual SEW_{30} for the 42m spacing was 292 cm-days while that from the nondrained check was 666 cm-days. Sugarcane responded favorably to subsurface drainage. Average annual sugar yields were not significantly different among the 14m, 28m, and 42m spacing; thus, there was no crop yield advantage to more intense drainage than 42m. Average annual sugar yields from subsurface drained tracts were 16 to 21 percent more than the nondrained check. In the first three-years of this experiment the accumulated value of the sugar yield increase, due to subsurface drainage with 28m and 42m spacings, was more than enough to pay for installing the drains.

INTRODUCTION

Subsurface drainage is a crop production practice that is widely used in various parts of the United States. In the west, it is used to intercept rising saline water tables before they reach the crop's root zone. In the midwest and northeast, it is commonly used to alleviate excess water problems by aerating the soil and enhancing trafficability at crop planting and harvesting times. In the southeast, particularly in the south atlantic states, farmers are beginning to use subsurface drains for both drainage and subirrigation. Excess water is drained from the soil profile during wet, rainy, periods and the same system is used to add water back to the soil profile during droughts.

In the Lower Mississippi Valley (Louisiana, Mississippi, and Arkansas) farmers do not use subsurface drainage. They use drainage ditches to remove runoff from their fields but no special effort is made for soil profile drainage. The lack of an intense system to remove excess water from the soil profile may be one of the reasons crop yields in the lower Mississippi Valley

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are, in general, below the national average. Conditions exist in the valley which indicate the need for soil profile drainage. For example, the major farming areas are low in elevation and adjacent to large bodies of water. Rainfall varies from 1000 to 2000 mm annually and often causes the water table to rise and fluctuate near the soil surface.

For many years, there was a misconception by many that soils in the Lower Mississippi Valley were too fine textured to respond to subsurface drainage. Support for this misconception was available in soil physical characteristics publications which indicated that the hydraulic conductivities were very low (Lund and Loftin, 1960: Lund et al., 1961). In spite of this misconception and published support for it, experiments were conducted in Baton Rouge, Louisiana, beginning in the mid 1960s, which demonstrated that silt loam soils responded favorably to subsurface drainage. Carter et al. (1983), used $40m^2$ concrete bordered field plots to show that the water table in Mhoon silt loam soil could be maintained readily at 30, 60, 75, 100, or 120cm. Furthermore, sugarcane, a common crop in Louisiana, responded favorably to subsurface drainage and water table control (Camp and Carter, 1983).

Since the initial experiments were conducted on small plots with subsurface drain spacing of only 2.75m, there was a need to determine soil and crop responses to subsurface drainage on field size areas. Furthermore, there was a need to determine soil and crop response to various subsurface drainage intensities since there were no guidelines for drain spacing. Thus, the objectives of this experiment were: to determine the response of Jeanerette silty clay loam soil to three subsurface drainage intensities and to determine the crop (sugarcane) response to these three subsurface drainage intensities.

PROCEDURE

A Jeanerette (Typic Argiaquoll) silty clay loam site at the William Patout III farm in Iberia Parish, Louisiana was selected for this subsurface drainage experiment. Four tracts, each approximately 1.5ha in size, were used. Subsurface drains were installed on three tracts in 1978. One tract, not subsurface drained, was used as a check. The subsurface drains, 100mm diameter, perforated, corrugated, polyethylene pipe with a Typar[3] envelope, were installed approximately one meter deep with a drain tube plow equipped with a laser grade control system. In one tract, four drains were installed and spaced 14m apart. In the next tract, three drains were installed and spaced 28m apart (twice as far apart as the first). In the third tract, two drains were installed and spaced 42m apart (three times as far apart as the first). The drains emptied into two sumps equipped with pumps which discharged drain effluent into a surface drainage ditch. The nondrained tract was just across the drainage ditch from the tract with 42m drain spacing (Figure 1). Each tract was bordered on the sides by surface drainage ditches approximately 0.6m deep and on the lower end by a surface drainage ditch approximately one meter deep (Figure 1). The tracts were bordered on the upper ends with a field road.

All four tracts were planted in sugarcane during the fall of 1979 by the landowner.

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[3]Trade and company names are listed for the benefit of the reader and does not imply endorsement or preferential treatment by the USDA.

Conventional cultural practices were used throughout the experiment which included planting the cane on 30-cm high beds with rows spaced 1.8m apart. Fertilizer, herbicides, and pesticides applied during the experiment were at rates recommended by the Louisiana Agricultural Extension Service personnel.

At harvest time each year, a whole-stalk type mechanical harvester was used to cut, top, and place the cane stalks in either three- or four-row heaps after which the leaves on the stalks were removed by burning. Trailer loads (samples) of cane were taken from measured areas (approximately 0.12ha) from selected heap rows in the experimental areas, transported to the sugar mill, weighed for yield estimates, and sampled for sucrose content. Four samples were taken from each area, a total of sixteen samples each year. Cane weights and sucrose content of the cane's juice was used to calculate sugar yield for each tract. Yields from each tract were compared to determine crop response to the various subsurface drainage intensities.

Three cane crops were harvested from the first planting in the fall of 1980, 1981, and 1982. The land was fallow in spring and summer of 1983 and replanted for the second cropping cycle in the fall. Harvests from this planting were in the fall of 1984, 1985, 1986, and 1987. After the fourth crop of this second cycle, the land was fallow in the spring and summer of 1988 and replanted in the fall. Harvests from this planting were in the fall of 1989 and 1990. Below freezing temperatures in December 1989 severely damaged the cane stubble, consequently yields of the 1990 crop were very low. The yield prediction for the third crop were low, thus plans were made to destroy the stubble and replant for another crop cycle. Since the objectives had been met, the drainage intensity experiment was terminated after the 1990 crop was harvested.

Rainfall was measured with a weighing type raingauge located at the site. The water table was measured in each tract with water stage recorders. In the drained areas, the water stage recorders were located midway between two parallel subsurface drains. In the check area, the recorder was located about mid plot. Each recorder was positioned over a 1.8m long and 20cm diameter PVC pipe that was inserted vertically into the soil in a 1.5m deep augered hole. The lower 1.2 meters of the pipe were perforated so water could readily enter and exit the PVC lined observation well. The pipe extended 30cm above the soil surface. Soil was tamped around the top of the pipes to prevent water from entering the wells from the surface. Recorder stands were positioned over the pipe so the recorder's float and counterweight remained within the PVC pipe.

The recorders were installed in 1979 and remained in place most of the time during the experiment except for periods in November and December each year when they were removed for cane harvest and during the years 1983 and 1988 when the land was fallow. Water table recorder charts were machine read and the data were used for making graphs and for calculating SEW_{30} as described by Sieben (1964) as cited by Wesseling (1974). The SEW_{30} values from the four tracts were compared to determine the effects of drainage intensities.

The size and nature of this experiment made it difficult to replicate. Since nine crops were harvested and 10 years of water table data were collected during this experiment, statistical tests for significant differences were made using years as replications.

RESULTS AND DISCUSSION

Rainfall during this experiment was erratic, both in amounts and distribution. Average annual rainfall during this 12-year experiment (1979-1990) was 1591mm, which was slightly above the long term average of 1500mm for Iberia Parish. Annual rainfall varied from 1145mm in 1981 to 1897mm in 1979 (Table 1). Monthly rainfall varied from 15mm in February 1981 to 478 mm in October 1984.

Table 1. Annual rainfall and SEW_{30} during subsurface drainage intensity study in Iberia Parish, LA.

		-------- Drain Spacing --------			
Year	Rainfall	14 m	28m	42m	Check
	(mm)	---------- SEW_{30} (cm-days) ----------			
1979	1897	213	746	899	1342
1980	1675	190	405	617	844
1981	1139	0	39	83	465
1982	1834	1	86	924	855
1983	1758				
1984	1752	92	134	6	840
1985	1574	14	30	49	658
1986	1497	0	18	30	331
1987	1596	106			
1988	1493				
1989	1503	0	0	19	83
1990	1382	0	0	0	572
Avg.	1591	62a*	162a	292a	666b

* Average SEW values followed by the same letter are not significantly different at the 95 percent level of probability.

Rainfall caused the water table to rise to near the soil surface on many occasions. In the nondrained tract, the water table remained near the soil surface for days while the water table in the drained tracts soon receded out of the top 30 cm of the soil profile (Figure 2). SEW_{30} values for each tract indicated the persistence of the water table within 30cm of the soil surface (Table 1). The annual SEW_{30} values varied considerably. In most cases, SEW_{30} was lowest from the 14m spaced drains and increased as drain spacing increased. The highest values were usually from the check. In 1984, SEW_{30} for the 42m spacing was unusually low, when compared to that from the other tracts and in 1982, SEW_{30} for the 42m spacing exceeded that for the check.

Reasons for these differences are not known. Recorder malfunction may have been responsible. In spite of the variation, the average SEW values were considered an acceptable indicator of the response of Jeanerette silty clay loam soil to subsurface drainage intensities.

Each of the three drainage intensities reduced SEW_{30} values more than 50 percent. Drains spaced 42m apart reduced average SEW_{30} values 56 percent (from 666 cm-days to 292 cm-days). Drains spaced 28m apart reduced average SEW_{30} values 76 percent (from 666 cm-days to 162 cm-days). Drains spaced 14m apart reduced average SEW_{30} values 91 percent (from 666 cm-days to 62 cm-days). Soil response to the 14m and 28m drain spacing was excellent. During the 12 year test, the water table in the 14m and 28m drain spacing tracts was never a serious waterlogging threat, as indicated by relatively low SEW_{30} values. Although the SEW threshold to cause crop damage to sugarcane is not known, it is probably more than 300 cm-days annually. Note in Table 1 that SEW values were relatively low in the 14m and 28m spacing after 1981 and was relatively low in the 42m spacing tract after 1982. This indicates that the soil's drainability may have improved with time. The SEW_{30} data in Table 1 and the data in Figure 2, which is typical of the water table data collected, shows convincingly, that the Jeanerette soil responded favorably to all three drainage intensities.

Sugarcane crop production requires an abundance of water, but, too much water reduces yields. Sugar yields during this study varied considerably (Table 2). The highest yields were in 1989 while the lowest were in 1990. A severe freeze in December 1989 damaged the sugarcane stubble, consequently, yields in the following crop, 1990, were very low (Table 2).

Table 2. Sugar yields from a subsurface drainage intensity experiment in Iberia Parish, LA.

	--------Drain Spacing -------			
	14m	28m	42m	Check
Year	---------- Sugar Yield (kg/ha) ----------			
1980	5893	5915	5671	5166
1981	7968	7974	7505	6003
1982	5399	5577	3941	3116
1983	No crop grown. Land was fallow.			
1984	5417	5809	6287	5765
1985	6398	6780	5750	5944
1986	5895	5451	5790	5742
1987	5454	4657	5306	5288
1988	No crop grown. Land was fallow.			
1989	8412	8069	8185	6409
1990	3535	4031	3660	1480
Avg.	6041a*	6030a	5788a	4990b

* Average yields followed by the same letter are not significantly different at the 95 percent level of probability.

Yields from the tracts with 14m and 28m spacing drains were similar most years. During the first crop cycle (1980, 1981, and 1982), yields from the 42m spacing tract were more than the check but less than the tracts with drains spaced 14m and 28m apart. During the second crop cycle (1984 through 1987), yields were similar from all tracts, including the check. During the third crop cycle (1989 and 1990), yields from the three drained tracts were similar, but they were considerably higher than those from the check (Table 2). A comparison of the yields between the drained and nondrained tracts from all nine crops in this study was considered an acceptable indication of the crop response to subsurface drainage intensities. Sugar yields from the tracts with drains spaced 14m and 28m apart were similar (6035 kg/ha average): this yields was 21 percent more than the check. The tract with drains spaced 42m apart yielded 5788 kg/ha, 16 percent more than the check and four percent less than the tracts with drains 14m and 28m apart. Statistical tests indicated that yields among the drained tracts were not significantly different but yields from the drained tracts were significantly higher than those in the check. These data show that crop response to all three subsurface drainage intensities was positive.

Since there are no drainage contractors in the Lower Mississippi Valley, the cost of installing subsurface drainage is unknown. For this paper, the authors estimated the cost to install drains at $2.50/meter. Thus, drains spaced 14m apart would cost $1786/ha to install: drains spaced 28m apart would cost an estimated $893/ha to install: and drains spaced 42m apart would cost an estimated $595/ha to install. Current raw sugar price is $0.485/kg but sugar farmers receive only $0.29/kg after paying the mill for processing the cane into sugar.

To justify installing subsurface drains, the value of any yield increases, due to subsurface drainage, should pay for the drain installation costs within the amortization period. The drains at the Patout farm in Iberia Parish were installed more than 13 years ago. The drains performed as well in 1991, or perhaps even better, than they did when first installed. The life of these drains should exceed 15 years and perhaps 20 years. Thus, an amortization period of 15 years seems very reasonable. Sugar yield increases, due to subsurface drainage, must accumulate within the amortization time period, to a threshold of 6158 kg/ha for the 14m drain spacing: 3100 kg/ha for the 28m drain spacing: and to threshold of 2052 kg/ha for the 42m drain spacing.

The value of the yield increases from all three drain intensities, as shown in Table 2, exceeded the threshold amounts required to pay for drain installation during the 1980-1990 test period. The accumulated value of the yield increases for the 28m and 42m spacing exceeded the thresholds for their respective drain spacing in the third year of this experiment. The statistical analysis showed that SEW_{30} values and sugar yields were not significant among the three drainage intensities. Thus, the wider spaced drainage system (42m) would be preferred since installation costs for drains spaced 42m apart would be 33 and 67 percent less than for 28m and 14m spacing.

SUMMARY

Three subsurface drainage intensities were tested on Jeanerette silty clay loam soil planted to sugarcane. The SEW_{30} concept was used to determine the water table control effectiveness of the three drainage intensities by comparing their SEW values with those from a nondrained check. Average annual SEW_{30} values were 62, 162, 292, and 666 cm-days for the 14m, 28m,

42m, and nondrained tracts, respectively. SEW values from the drained tracts did not differ significantly among themselves but they were significantly lower than the average SEW from the check.

Average sugar yields from the drained tracts were compared to those from the nondrained check to determine the response of sugarcane to drainage. Average annual sugar yields were 6041kg/ha, 6030kg/ha, 5788kg/ha, and 4990kg/ha for the 14m, 28m, 42m, and nondrained tracts, respectively. Sugar yields did not differ significantly among the 14m, 28m, and 42m drain spacing tracts; thus, there was no advantage in more intense drainage than 42m. Yields from the drained tracts were significantly higher than those from the nondrained check. Yields from the drained tracts were 16 to 21 percent higher than those from the check. In the first three-years of this experiment the accumulated value of the sugar yield increase, due to subsurface drainage with 28m and 42m spacings, was more than enough to pay for installing the drains.

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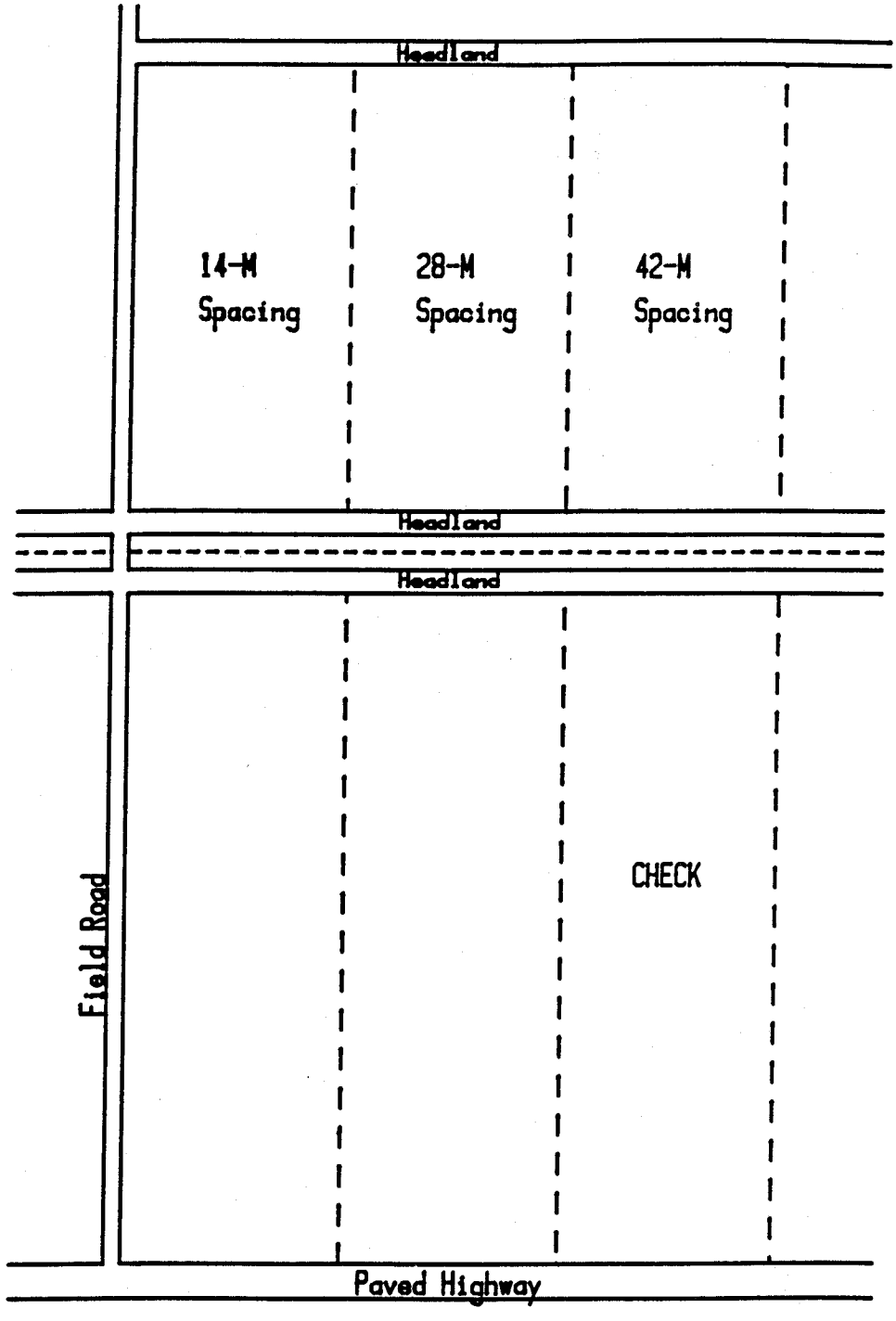

FIGURE 1. Field layout for drainage intensiy experiment in Iberia Parish, LA.

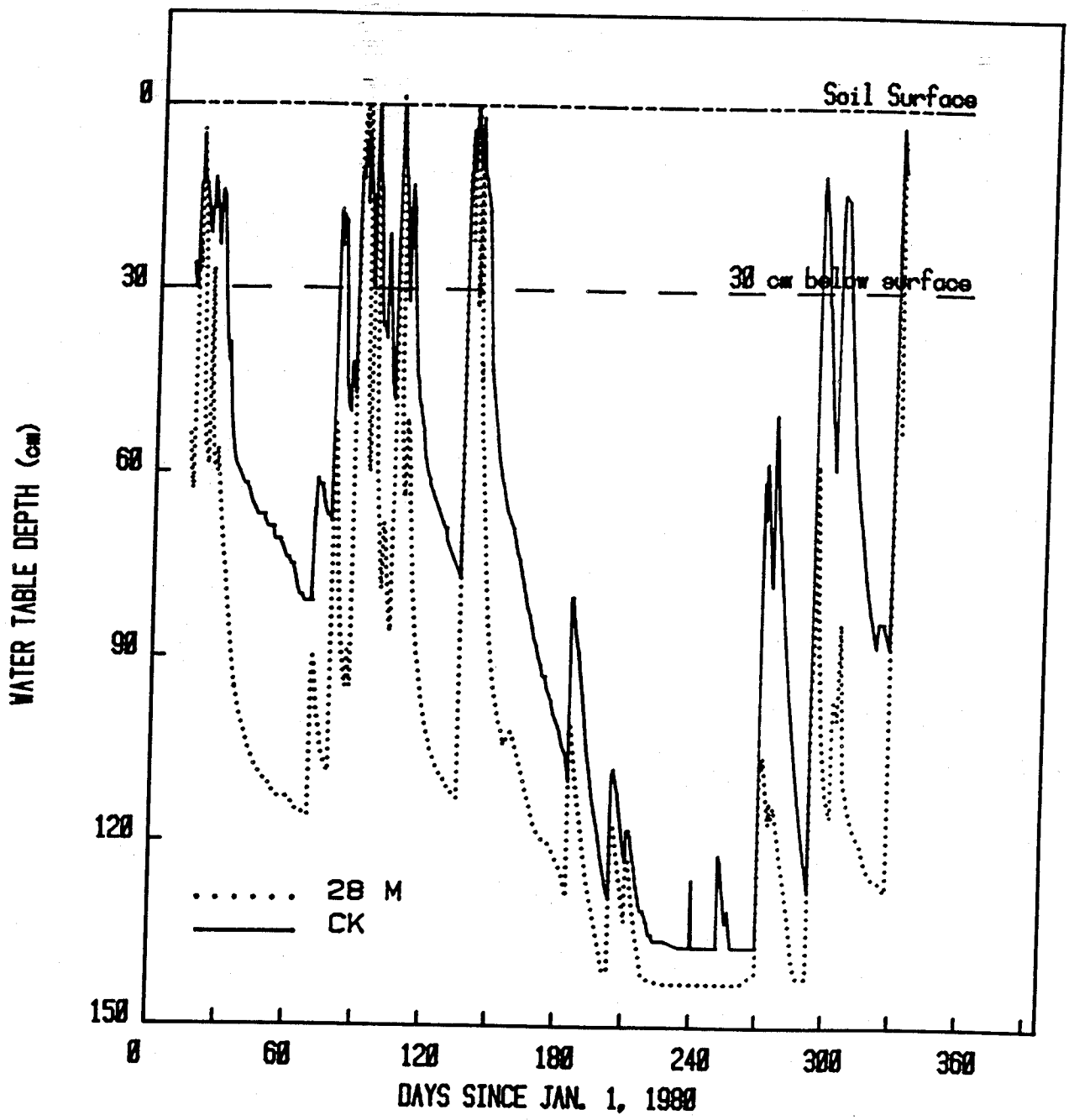

FIGURE 2. Water tables from drained (28m spacing) and nondrained tracts during a drainage intensity experiment in Iberia Parish, Louisiana.