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THE EFFECTS OF SUBSURFACE DRAINING COMMERCE SILT LOAM SOIL ON SUGARCANE YIELDS[1]/

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ABSTRACT

An unreplicated experiment was conducted on a 10-ha tract of Commerce silt loam soil in St. James Parish, Louisiana during 1977-1979 to determine the response of sugarcane to subsurface drainage. Subsurface drainage was accomplished by installing four 10-cm diameter plastic drain tubes about 1.2 m below the soil surface and spaced 24 to 48 m apart. The subsurface drains emptied into a sump equipped with an electric pump for discharging the drain outflow into a surface drainage ditch. Water tables were measured continuously in areas with and without subsurface drains during 1978 and 1979 to determine the effects of subsurface drainage in lowering the water table.

Sugarcane variety CP 48-103 was planted in the fall of 1976. Plant, first ratoon and second ratoon crops were harvested in 1977, 1978, and 1979, respectively. Samples of cane from each treatment were used to estimate cane and sugar yields.

Sugarcane yields from the subsurface drained area were higher than those from the area with only surface drainage during 1977 and 1979 when rainfall and water tables were high. Sugar yield of the second ratoon crop (1979) was higher in the area with subsurface drainage. These higher yields support the concept that subsurface drainage can increase sugarcane yields.

INTRODUCTION

Sugarcane requires a semi-tropical or tropical climate. It is grown commercially in only four states: Hawaii, Texas, Florida, and Louisiana. During a recent 6-year period (1973-1978) yields in Louisiana averaged only 49 t/ha whereas those in Hawaii, Texas, and Florida were 208, 74, and 69 t/ha, respectively (8). One recognized reason for such low yields in Louisiana is a relatively short growing season of 7 months, while in other cane producing states the growing season varies from 12 to 24 months.

Another reason for low yields in Louisiana, one that man can control, is the lack of good water management. Surface drainage is the only water management practice widely used in Louisiana; the other states use either irrigation, subsurface drainage, or water table control along with surface drainage. In Louisiana, additional water management practices must be included in crop production schemes if maximum crop production is to be attained.

To determine the response of sugarcane to water management practices several experiments on small plots were conducted in the late 1960's and early 1970's in Baton Rouge, LA (1, 2, 3). Positive results from these small-plot experiments prompted the expansion of water management research for sugarcane to field size areas. This paper reports the results of an experiment conducted to determine whether subsurface drainage on Commerce silt loam (Aeric Fluvaquents) would improve yields of sugarcane.

PROCEDURE

The nature and size of this experiment did not lend itself to textbook type experimental design with replicated plots. An attempt was made, however, to design the experiment so that trends due to treatments would be indicated. Two adjacent areas of land, each about 5 ha in size, were selected for the study. One was subsurface drained and the other was not.

Subsurface drainage was accomplished by installing 4 subsurface drain lines, 10 cm in diameter and about 290 m long, furnished partially by Hancor, Inc.,* during the summer of 1976 on Commerce silt loam in St. James Parish, LA, using a drain tube plow equipped with a laser grade control system (Figure 1) (6). The drains, which were corrugated, perforated, polyethelyene tubes, were installed about 1.2 m deep and spaced 24, 36, and 48 m apart (Figure 2). The drains were installed on 0.17% slope, which was about the same as the field slope. One drain was extended beyond the others about 12 m before changing direction and was continued at a right angle across the field about 107 m (Figure 2). The surface drainage ditch on the lower side of the field was not deep enough to serve as an outlet for the subsurface drains; therefore, a sump, 1.2 x 1.2 x 3 m, was installed into which water from the drain lines flowed. Electric pumps discharged the water from the sump into a surface drainage ditch.

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2/ Agricultural Engineers, USDA, ARS, Baton Rouge, LA and Florence, SC, respectively.

* The mention of companies or commercial products does not imply recommendation or endorsement by the U. S. Department of Agriculture over others not mentioned.

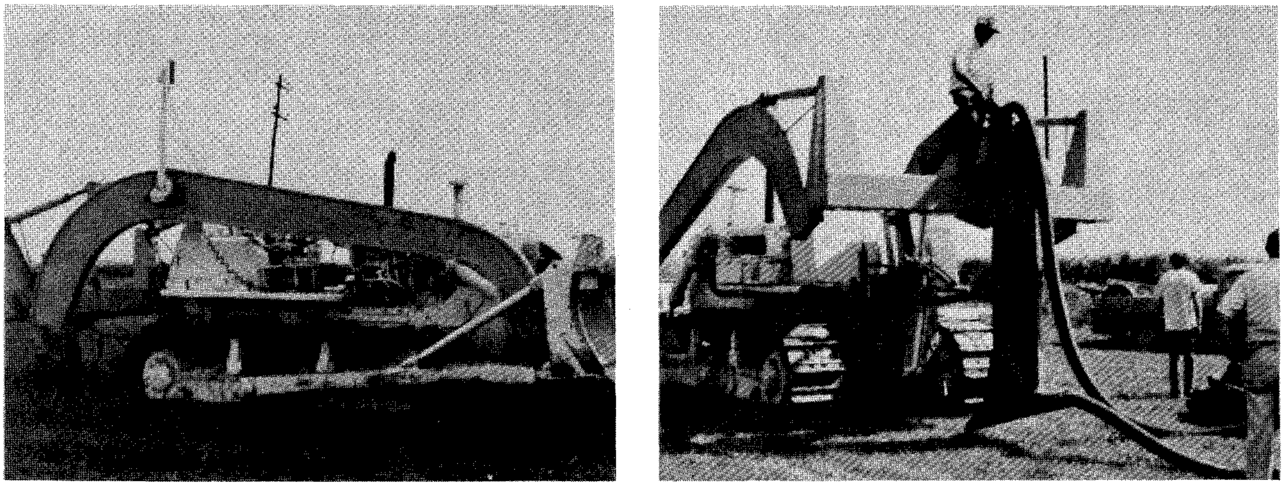

Figure 1. Draintube plow used to install subsurface drains. The upper photo shows the plow in operating position (note the laser signal receiver). The lower photo demonstrates how the drain tube passes through the shank and plow.

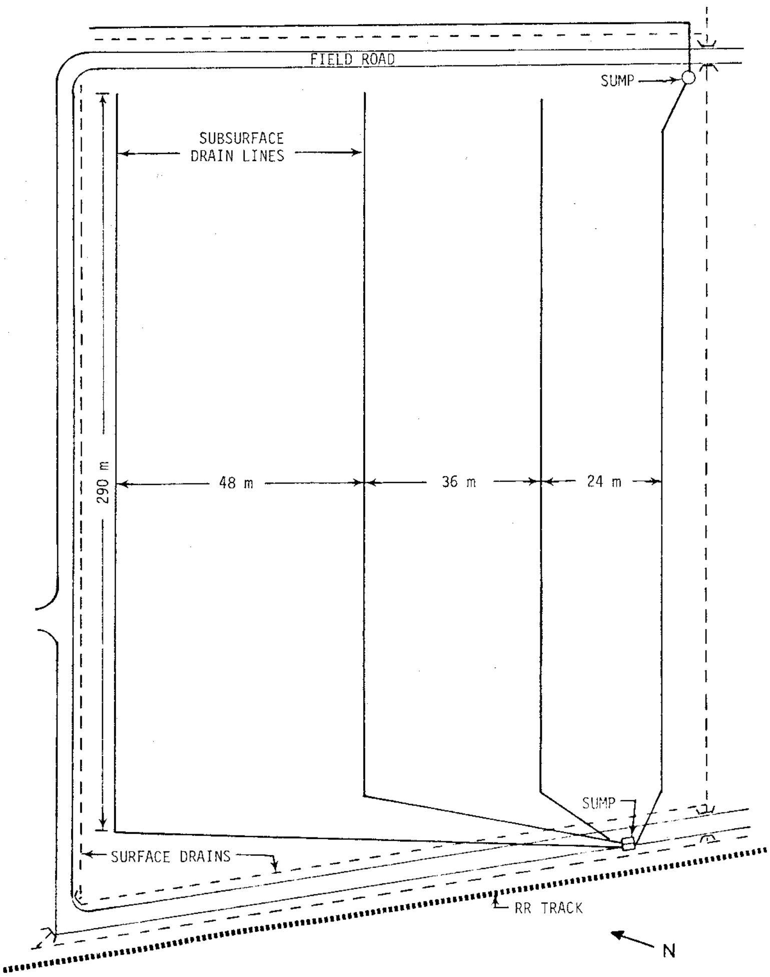

Figure 2. Schematic of subsurface drainage experimental area, St. James, La.

Effectiveness of the subsurface drains in lowering the water table was evaluated in 1977 by measuring the water table depth occasionally using cased wells located in a line across the field perpendicular to the direction of the drains. In 1978 water level recorders were installed at the midpoints of the 24-, 36-, and 48-m spaced drains and in the check area to continuously record the water table. These recorders remained in place through 1979 except for short periods in the fall each year when they were removed for cane harvest.

Rainfall was measured during this experiment with a recording raingauge which was located next to the experimental site.

Sugarcane variety CP 48-103 was planted in both areas in the fall of 1976 using conventional cultural practices which include rows bedded 30 cm high and spaced about 1.8 m apart. Each year recommended practices were used to control weeds and insect pests. Fertilizer was applied each spring using about 180 kg of N, and 67 kg of K_2O per ha except in 1979 when no K_2O was applied. The plant crop was harvested in December 1977 and the first and second ratoons were harvested in December 1978 and November 1979, respectively. A whole-stalk type mechanical harvester was used to cut, top, and place the cane in three-row heaps after which the leaves on the stalks were removed by burning.

For estimating yields, cane samples (trailer loads of cane) were taken from measured distances along selected 3-row heaps, transported to the sugar mill, weighed, and auger-sampled for sugar content. The 78 rows in the drained area were partitioned into 22 three-row and 2 six-row heaps at harvest. Cane samples were taken from heap row Nos. 4, 7, 8, 9, 12, 15, 16, 18, 20, 21, and 23 (heap row No. 1 was on the north side of the drained area). The 99 rows in the undrained area, which was south of and adjacent to the drained area, were partitioned into 29 three-row and 2 six-row heaps. Cane samples were taken from heap row Nos. 23, 24, 26, and 27 (heap row No. 1 was on the north side of the undrained area).

Plant population was estimated at harvest each year by counting the number of stalks in 15 m sections of three-row heaps at two and sometimes three different locations along the heap row. Stalk weights were calculated using crop yield and plant population estimates.

Data from the two areas were analyzed using the F test to determine whether differences were significant.

RESULTS AND DISCUSSION

Sugarcane yields from the subsurface drained area were significantly higher than yields from the area without subsurface drainage 2 of 3 years (Table 1). Cane yields from the subsurface drained area were 10% and 17% more in 1977 and 1979, respectively, than those from the undrained area. Sugar yield from the subsurface drained area was significantly higher only 1 of 3 years. In 1979 the drained area yielded 23% more sugar/ha than did the undrained area (Table 1).

Table 1. Cane and sugar yields, plant populations, and stalk weights for drained and undrained treatments, St. James Parish, Louisiana.

Year	Treatment	Cane Yields (t/ha)	Sugar Yields (kg/t)	Sugar Yields (kg/ha)	Plant Population (Plants/ha)	Plant Weight (kg/stalk)
1977	drained	76.2*	81.9	6244	72,440*	1.06
	undrained	69.0	82.2	5699	65,188	1.08
1978	drained	92.7	80.5	7493	65,488	1.42
	undrained	102.4	83.5	8584	68,666	1.50
1979	drained	91.6*	89.4	8179*	84,350	1.09*
	undrained	78.6	84.0	6629	82,408	0.96

* Significantly higher (95% level) for that year.

Plant population in the subsurface drained area in 1977 was significantly higher at harvest (11% more plants/ha) than in the undrained area. Plant populations were about the same at harvest in 1978 and 1979 (Table 1). Plant populations of the 1979 crop were 20 to 30% higher than those in the previous crops.

Stalk weights from the subsurface drained area in 1979 were significantly heavier (14% more) than those from the undrained area (Table 1). Stalk weights from drained and undrained areas in 1977 and 1978 were similar (Table 1).

Rainfall was higher in 1977 and 1979, the two years during which cane yields were significantly higher in the subsurface drained area (Tables 1 and 2). High water tables are usually asssociated with high rainfall. It is in soils with high water tables that subsurface drains are effective in improving the soil. This improvement is attained by subsurface drains providing an outlet into which water from large pores of a saturated soil may flow. Water which moves out of these large pores is replaced by air. Water in the small (capillary) pores does not move into drains but remains in the pores until used by plant roots or lost to evaporation.

The water table in both the drained and undrained areas fluctuated considerably during this experiment. The effectiveness of the subsurface drains is indicated by the difference in depth of the water table for

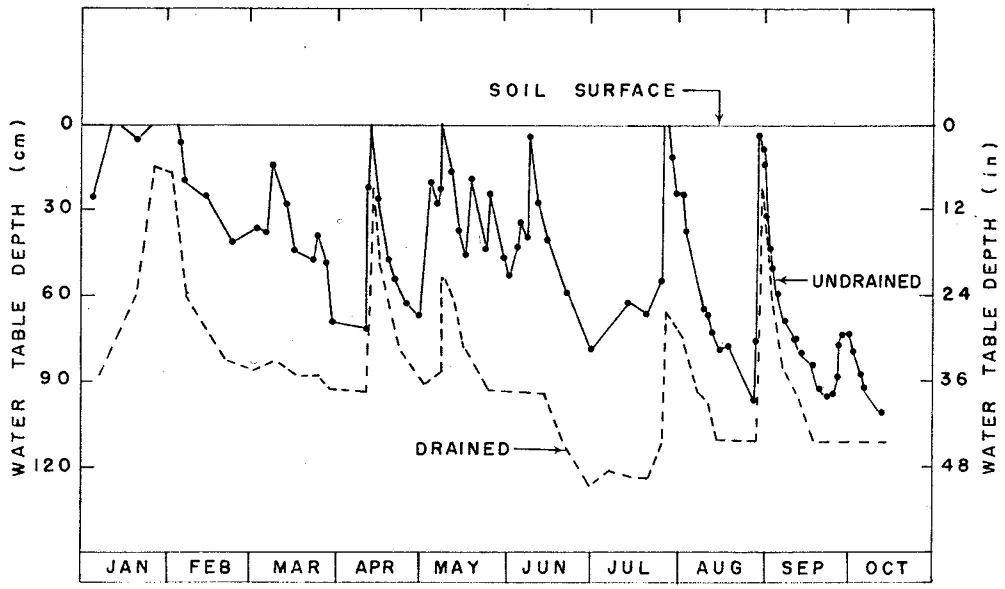

Figure 3. Water table depths in subsurface drained and undrained areas during 1978. The water table in the drained area was measured midway between subsurface drains spaced 36 m apart.

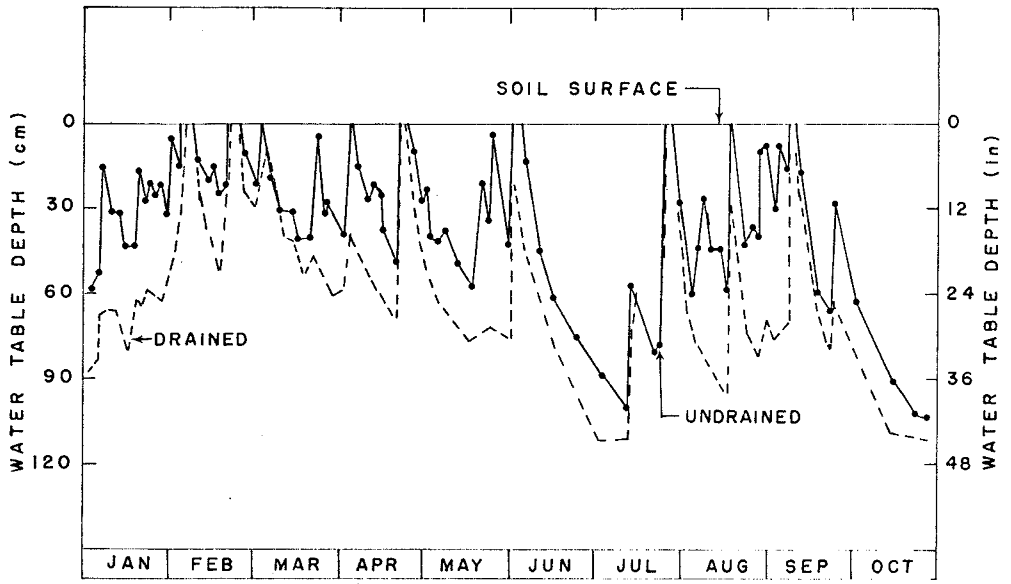

Figure 4. Water table depths in subsurface drained and undrained areas in 1979. The water table in the drained area was measured midway between drains spaced 36 m apart.

the drained and the undrained areas (Figure 3 and 4). The water table depth in the drained area was measured midway between drain lines where the water table was highest. Thus, the average water table depth in the drained area was lower than the midplane water table shown in Figures 3 and 4.

Water table depths for drains spaced 24 m and 48 m apart were similar to those for the 36 m drain spacing presented in Figures 3 and 4. Similar water table depths for differently spaced drains were not expected. Usually closely spaced drains lower the midplane water more quickly than do widely spaced drains. Similar water tables measured from differently spaced drains in this experiment may be a function of a silt layer in the soil profile which provided such good horizontal flow that the rate of change in the water table depended primarily upon the vertical distance through which water must flow to reach the silt layer, a depth of which was about 1.0 to 1.2 m at this site.

Table 2. Monthly and annual rainfall, St. James Parish, Louisiana

Year	1977		1978		1979	
Month	mm	inches	mm	inches	mm	inches
January	130	5.1	274	10.8	122	4.8
February	43	1.7	53	2.1	297	11.7
March	69	2.7	86	3.4	74	2.9
April	190	7.5	107	4.2	335	13.2
May	47	1.8	241	9.5	163	6.4
June	45	1.8	135	5.3	25	1.0
July	169	6.7	236	9.3	228	9.0
August	393	15.5	170	6.7	190	7.5
September	245	9.6	81	3.2	142	5.6
October	121	4.8	0	0.0	46	1.8
November	267	10.5	178	7.0	94	3.7
December	98	3.8	51	2.0	74	2.9
Annual	1817	71.5	1612	63.5	1790	70.5

The higher cane yield in 1977 and the higher cane and sugar yields in 1979 were attributed to subsurface drainage. Apparently high water tables in the undrained area during these years inhibited soil aeration and adversely affected yields. Note the extremely high water table of the undrained area in 1979 (Figure 4).

Although a statistical comparison of the yield data from the drained and undrained areas showed no significant difference in 1978, the magnitude of the yield difference, particularly that of sugar, deserves further comment. The water table in the drained area may have been so low in 1978 that the cane roots could not benefit from the subirrigation effects of the water table during droughts (this is sometimes referred to as overdrainage). Other locations such as those in the Coastal Plains area of South Carolina have experienced problems with overdrainage of the soil profile (4, 5). Since the soil at this experimental site is fine textured and the drainable porosity is relatively low, it is unlikely that overdrainage occurred (7). High yields from the undrained area in 1978 may be due to soil water conditions that just happened to be favorable for sugarcane that year. It is interesting to note that the water table of the high yielding undrained area in 1978 (Figure 3) was similar to the water table in the high yielding drained area in 1979 (Figure 4). Although both fluctuated considerably there was an overall decrease in the water table as the cane growing season progressed. The overall rate at which the water table decreased may have corresponded to the rate at which cane roots grew into the soil profile. If this were responsible for high yields, perhaps a programmed falling water table treatment is needed rather than subsurface drainage alone. In earlier experiments high cane yields were measured from constant water table treatments (1, 3). A gradually falling water table, however, was never tested.

Since there was a tendancy toward increased yields due to subsurface drainage, this water management practice should be considered in crop production schemes in the sugarcane growing area of Louisiana.

SUMMARY

During plant and second ratoon crops when rainfall and the water table were high, sugarcane yields from a subsurface drained area were higher than those from an undrained area. Also, during second ratoon, sugar yields from the drained area were higher than those from an undrained area. These data support the concept that subsurface drainage increases cane and sugar yields during wet years.

ACKNOWLEDGMENT

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