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2.8 EVAPOTRANSPIRATION BY COTTON AS AFFECTED BY THE DEPTH OF WATERTABLE

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1. Introduction

Accurate evapotranspiration data are indispensable for rational and economic water use. Cotton being the most common crop in Egypt grown frequently under high watertable conditions, it was considered necessary to undertake some field experiments aimed at the determination of the influence of the depth of the watertable on the evapotranspiration from cotton fields to evaluate the contribution that can be expected from the groundwater to the root zone. The inflow-outflow method in lysimeters was used for these studies.

2. Materials and methods

Sixty double-wall lysimeters 2 m deep and 4 m^2 surface area were filled in 1964 with three different soils, i.e. clay loam, sandy loam and calcareous sandy clay loam (20 lysimeters each). Each lysimeter was provided with a 4" diameter tile drain at a certain depth and with a feeding tube from the bottom. Tile depths were fixed at 40, 70, 100, 130 and 160 cm from the surface soil. Water was fed from the bottom to control the watertable during the growing season.

For three successive seasons lysimeters were planted with cotton: Giza 47 and Monofi varieties in 1964, Giza 66 and Giza 68 in 1965 and Giza 68 in 1966. Planting started late in March and picking started in late August. Spacing was similar to that in the field (8 pairs of plants/m^2). Calcium nitrate, superphosphate and potassium sulphate at the rate of 50, 25 and 10 g/m^2 were applied as fertilizers.

Tap water was applied for irrigation, drainage was measured and the difference was taken as evapotranspiration. Cotton received 13 irrigations in 1964 and 1965 and 9 in 1966, the first at the time of planting and the last at the time of last picking.

In 1964 and 1965 the watertable was kept constant during the season through continuous water supply from the bottom, while in 1966 it was allowed to recede between irrigations but reset to its assigned level just before irrigation. The amount of water fed in resetting was taken as the contribution from groundwater to evapotranspiration. All treatments were run in 4 replicates.

3. Results and discussion

Results shown in Table 1 indicate significant effects on evapotranspiration in all experimental seasons due to the depth of the watertable Effects of the soil factor and of interaction were also significant but only in two seasons. Again, the differences due to the watertable greatly exceeded those due to soil or interaction.

With the increasing depth of the watertable evapotranspiration increased steadily and consistently but with a somewhat different slope from season to season (Fig. 1). The differences due to the depth of the watertable became relatively narrower in 1966 than in the preceding seasons. Average soil and depth of watertable evapotranspiration values, calculated as the difference between the depth of irrigation and that of drainage, were 88.2, 82.2 and 71.2 cm for the three seasons, with the values of 1964 and of 1965 being closer to each other than to those of 1966. Irrigations and vigour of growth as indicated by plant height (Table 1) in the first two seasons were similar, being greater than in 1966. Identical effects on slope or values of evapotranspiration are not of course expected since vigour of growth and frequency of irrigation are involved.

Table 1

Evapotranspiration, mean yield and height of cotton as affected by the depth of the watertable (Evapotranspiration = irrigation water - drainage water)

depth of watertable cm	evapotranspiration (cm)				yield of raw cotton ton/ha	height of plant cm	LSD
	Soil texture			mean			
	cl.	scl.	cal.scl.				
1964 - watertable constant							
40	43.8	29.5	39.8	37.7	2.588	88.9	
70	70.6	62.5	69.8	67.0	3.760	114.8	
100	96.2	91.3	100.7	96.1	4.358	124.5	
130	117.4	111.2	107.9	112.1	4.350	130.5	
160	143.1	122.2	119.9	128.4	4.570	134.8	
mean	94.2	83.3	87.2				
LSD				3.91	0.363	8.20	3.10
LSD for soil x watertable interaction = 6.85							
1965 - watertable constant							
40	40.6	39.5	47.0	42.4	2.950	90.6	
70	59.8	65.3	66.5	63.8	4.270	104.0	
100	83.1	87.5	83.0	84.5	4.520	118.8	
130	103.8	103.3	102.5	103.2	4.515	128.3	
160	113.6	119.8	117.3	116.7	4.613	140.6	
mean	80.2	83.1	83.2				
LSD				4.5	0.453	5.5	non sig.
LSD for soil x watertable interaction non sig.							
1966 - watertable restored just before irrigation							
40	41.2	38.6	39.1	39.6	2.878	72.9	
70	55.1	51.2	60.6	55.6	3.723	74.2	
100	77.2	67.9	71.5	72.2	4.480	81.7	
130	90.3	82.3	89.5	87.3	4.923	98.3	
160	99.4	101.2	104.0	101.5	5.333	101.3	
mean	72.6	68.2	72.9				
LSD				3.11	0.495	7.7	2.41
LSD for soil x watertable interaction = 5.39							

Note: correlation coefficients between evapotranspiration and yield are 0.937, 0.837 and 0.964, and between evapotranspiration and height of plants are 0.963, 0.99 and 0.967 for 1964, 1965 and 1966 respectively.

cl = clay
scl = sandy clay
cal.scl = calcareous sandy clay
LSD = least standard deviation

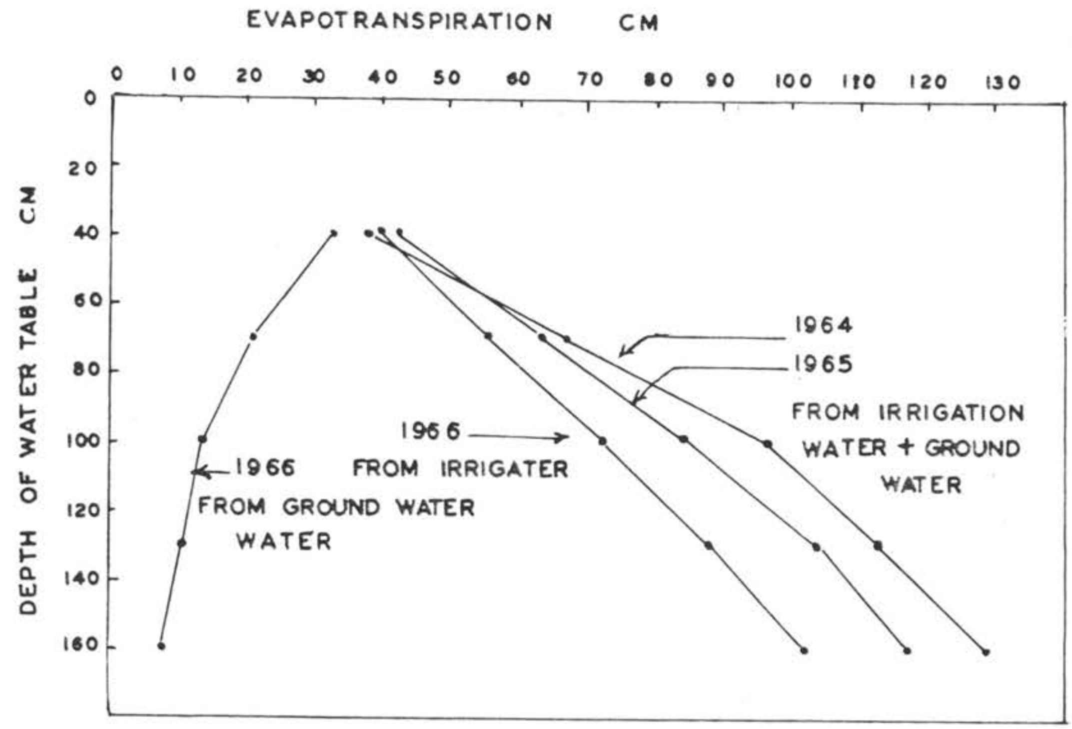

FIG. I. EVAPOTRANSPIRATION OF COTTON AS AFFECTED BY THE DEPTH OF WATER TABLE.

The contribution from groundwater to the root zone determined in 1966 is reported in Table 2. On average soil it declined somewhat steeply as the depth of the watertable increased to 100 cm, then gently towards the 160 cm depth (Fig. 1). Individual soils deviated more or less from this general pattern (Table 2), due perhaps to individual characteristics pertaining to unsaturated water flow. This sort of differentiation between soils did not appear as such in the difference between irrigation and drainage depths as mentioned above (Table 1).

The 1966 experiment seems more relevant to practical experience in Egypt with respect to the number of irrigations and to the variable depth of the watertable between irrigations. The values in Table 3 summarize the results obtained in this experiment expressed as m^3/ha and as relative yields. With the addition of the contribution from irrigation water to that from groundwater, the differences in evapotranspiration due to the depth of the watertable became narrow but still appreciable. It is also obvious from the same Table and Table 1 that there was a high positive association between evapotranspiration and cotton yield or plant vigour represented by its height. This relationship is illustrated in Fig. 2 from which evapotranspiration seemed more correlated to plant height than to yield. Yield increased steeply with constant slope as the depth of the water table increased to 100 cm after which the slope tended to decline. This may suggest maximum efficiency of water utilization by cotton at a watertable depth down to 100 cm.

Working on water consumption by cotton in Egypt, Khalil et al 1966 reported that it differed according to locality but was independent of irrigation frequency or amount of yield. Water consumption figures found by them were 5 500, 6 430 and 8 100 m^3/ha respectively for Sakha in the North Delta, Gimeza in the South Delta and Sids in middle Egypt. Raw cotton yields varied from 1.56 to 3.15 to 2.30 and from 2.3 to 2.9 tons/ha for the three localities respectively. Eid et al 1966 calculated (Blaney and Criddle) water consumption by cotton as 7 188, 7 476 and 8 045 m^3/ha for lower, Middle and Upper Egypt respectively. No use has been made of the depth of the watertable as a factor affecting both growth and evapotranspiration in the present experiment.

Applying the well known relationship U=K.F (Blaney and Criddle , 1950, where U = evapotranspiration, K = empirical coefficient and F = meteorological factor) to the results obtained in 1966, five empirical coefficients for the same crop under the same climate were obtained. They were 0.74, 0.79, 0.89, 1.02 and 1.13 corresponding to the 40, 70, 100, 130 and 160 cm depths of the watertable.

Irrigation schedules and water duty should respond to water needs by crops during their normal course of development. As mentioned before, the amounts of water evapotranspired by cotton between irrigations were determined through the three experimental years. Results show that the water consumption rate invariably increased through June and reached maximum during July and early August. Results of 1966 only are represented in Fig. 3. Lines of cumulative consumption much resemble those for normal growth. The time of maximum water consumption coincided with that of the flowering and boll maturity. The water table depth did not affect the time of maximum consumption.

Table 2

Contribution to evapotranspiration by cotton from groundwater as affected by the depth of the watertable (1966)

Depth of water table cm	Evapotranspiration cm				LSD
	Soil texture			Mean	
	cl	scl	cal.scl		
40	32.5	30.0	33.3	31.9	
70	21.7	15.8	25.2	20.9	
100	9.0	14.9	17.3	13.7	
130	5.9	11.9	14.9	10.9	
160	4.5	0.3	9.0	7.6	
Mean	14.7	16.4	19.9		1.4
LSD				1.9	
LSD for interaction = 3.2					

Table 3

Contribution to evapotranspiration by cotton from irrigation and from groundwater as influenced by the depth of the watertable (1966)

Depth of watertable cm	Contribution from irrigation water m^3/ha	Contribution from ground-water m^3/ha	Total m^3/ha	Relative yield of raw cotton	Relative height of plant
40	3 960	3 190	7 150	100	100
70	5 560	2 090	7 650	129	102
100	7 220	1 370	8 590	156	112
130	8 730	1 090	9 820	171	135
160	10 150	760	10 910	185	153

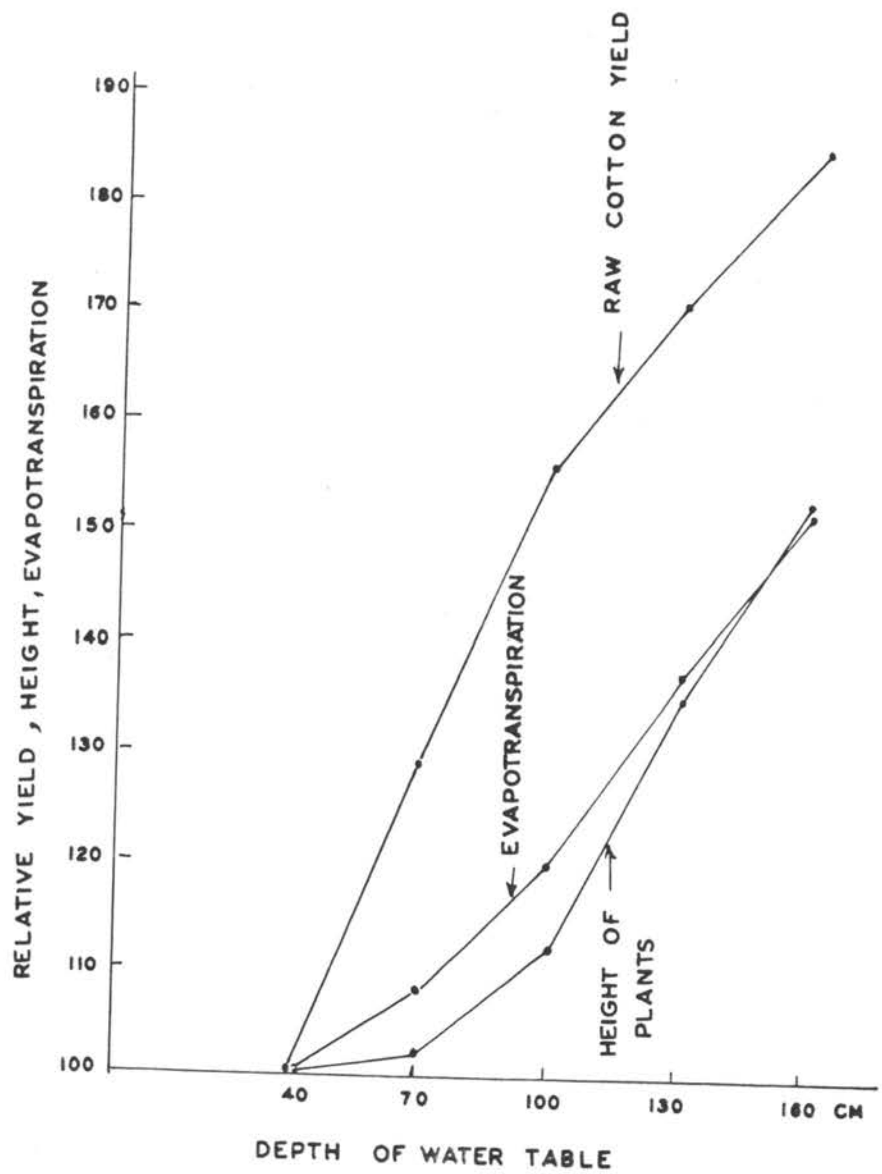

FIG.2. RELATIVE YIELD, HEIGHT, AND EVAPOTRANSPIRATION AS AFFECTED BY THE DEPTH OF WATER TABLE.

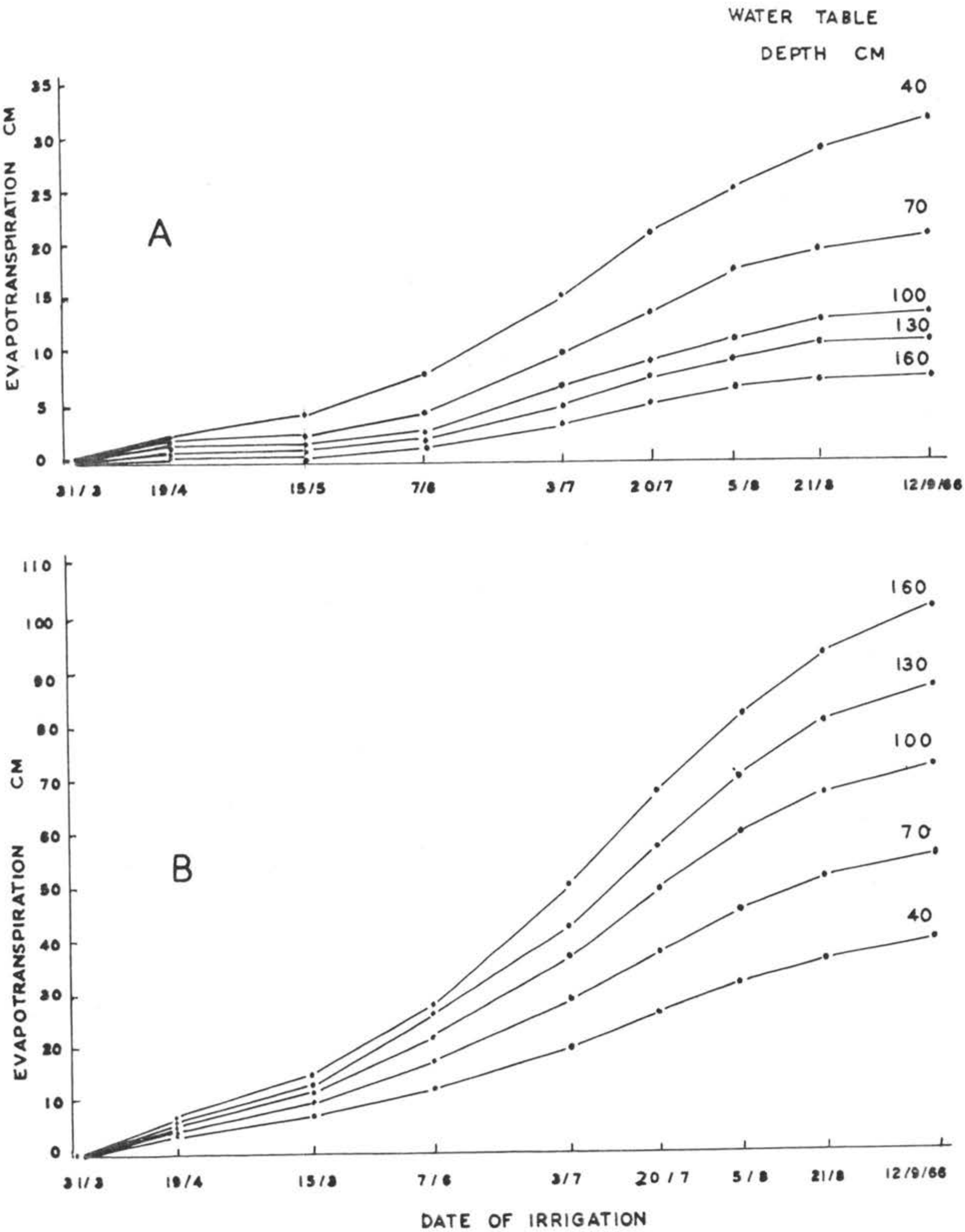

FIG. 3. CUMULATIVE EVAPOTRANSPIRATION FOR COTTON CROP AS AFFECTED BY THE DEPTH OF WATER TABLE, A: FROM GROUNDWATER, B: FROM IRRIGATION WATER. (ONE VARIETY OF COTTON ON AVERAGE 3 SOIL TYPES, 1966)

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