SCHEDULING IRRIGATION FOR TOMATO UNDER DRIP IRRIGATION

BY

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INTRODUCTION

Water is an important factor in agriculture especially in areas of limited water resources such as Jordan. Water scarcity in the Jordan Valley, and profitable irrigation entails an efficient use of the available water resources .

Irrigation scheduling to apply the correct amount of water at the appropriate time is an essential practice for optimizing water use efficiency. Many alternatives exist for scheduling irrigation. Soil moisture depletion measurements give a direct indication of irrigation needs. Soil moisture depletion can be measured directly or indirectly. Direct measurement involves gravimetric method. Indirect measurements , by using instruments that measure parameters related to soil moisture content involve tensiometers , soil moisture blocks, and neutron-probe. Some of the indirect methods for scheduling irrigation are based on climate-crop-soil data. These methods are also called meteorological approaches. One of these methods is based on evapotranspiration and pan evaporation data .

Research has indicated a close relationship between the rate of evapotranspiration of a crop and the rate of pan evaporation . Using this relationship permits one to schedule irrigation easily.

The main objectives of this study are :

1. To determine an appropriate constant to relate pan evaporation from Class-A pan to evapotranspiration requirements of tomatos

in order to develop a simple procedure to schedule drip irrigation for tomato crop in the Jordan Valley.

2. To study the effect of different soil moisture tensions under drip irrigation on yields and water requirements of tomato.

LITERATURE REVIEW

Scheduling irrigation is the most important factor in improving irrigation efficiencies in general, and water use efficiency in specific .

Many methods have been suggested by researchers for scheduling irrigation. Richards and Marsh (1961) explained that soil suction from zero to 0.8 bar is explicity indicated by tensiometers. Higher values can be measured by suitably calibrated soil moisture resistance units. An irrigation program, that gives both time and duration of applications, can be carried out based on day-to-day records of soil suction at two or more depths in the root zone for the crop involved .

Cannel and Bingham (1961) used tensiometers and cylindrical electrode type gypsum blocks for timing irrigation of tomatoes.They showed that the ratios of unit dry matter produced to unit water used were increased with increasing soil water potential .

Jensen and Middleton, in their investigation in Washington State since 1952 have indicated a near constant relationship between rate of consumptive use of water by crops and evaporation rates. The relationship became constant as soon as the crop foliage had approached complete or constant ground cover. This relationship permits one to estimate moisture depletion from the soil water reservoir from evaporation data, and consequently to schedule irrigation by using the following formula :

$$CU = K_c \cdot E_p \quad [1]$$

where CU = Consumptive use by the crop (mm)

K_c = crop Coefficient .

E_p = pan evaporation amounts (mm)

Pruitt (1956) applied consumptive use and pan evaporation data for scheduling irrigation. He and his associates prepared a simple irrigation guide for the farm operators to use.

Denmead and Shaw (1959) showed that the ratio of evapotranspiration of corn to pan evaporation had changed throughout the growing season. The highest ratio was reached at maturity after which it declined .

Bouwer (1959) used an integration recorder of rainfall, irrigation and evapotranspiration with a field capacity ceiling and a lower mark indicating time to irrigate. The field capacity ceiling was obtained by means of syphon. A hook gage was used to indicate the lower limit of the soil moisture balance and time to irrigate .

Fuchs and Stanhill (1963) found that a high degree of correlation exists between the amount of evapotranspiration from large commercial fields of cotton, recieving their optimum irrigation treatment and the evaporation from Class-A evaporation pan. They obtained the following empirical equation that relates cumulative evapotranspiration (E_T) of cotton to cumulative Class-A evaporation (E_o)

$$E_T = 0.69\ E_o - 232 \quad [2]$$

where E_T and E_o are in mm .

Thompson et al.(1963) recommended the use of Class-A pan evaporation method for estimating evapotranspiration rates, and thus for scheduling irrigation, because it is a simple and inexpensive method .

Christiansen (1968) in his studies done at Utah State University Stated that pan evaporation data is useful in estimating evapotranspiration of agricultural crops using procedures such as Hargreaves', Grassi's, or others relating evapotranspiration to pan evaporation .

Jensen (1970) stated that scheduling irrigation using:

a) climate-crop-soil data such as solar radiation, mean air temperature, humidity index, wind speed, mean daily dew point temperature and crop coefficient,

b) computers to facilitate the tedious computations, and

c) field observations by experienced personnel, is a service that appears to be very attractive to the modern irrigation farm manager .

Gornat et al.(1971) found that the ratio between evapotranspiration rates of suger beets and evaporation rates from Class-A pan, which might be useful as an indicator of when to irrigate and how much water to apply,had changed during the growing season.In November the ratio was about 1.25 and in May it was about 0.3 .

Sheerer et al.(1974) used Class-A evaporation pan for scheduling irrigation under drip system using equation [1] .

Bartels (1976) indicated that the accumulated excess of evaporation over rainfall, which for convenience he called SUM(E − R), commencing the summation from the first day after irrigation on which evaporation exceeded rainfall, was a relatively simple means of deciding when to irrigate. He obtained the following relationship for soil moisture content and SUM (E−R):

$$M = 7.75 - 3.68 \text{ Log SUM}(E-R) \quad [3]$$

where M is the amount of water stored in the top 2 feet of soil (inches), and the SUM (E−R) is the depth of water that should be used for irrigation (inches). SUM(E−R) is determined **experimentally** for a given location and crop .

Prihar et al.(1976) found that scheduling irrigation based on pan evaporation data offers a practical means to maximize water use efficiency .

Rodriquez (1976) developed a computer program that would predict the crop water requirements for the coming week based on soil moisture conditions and climatological data. He also found that drip irrigation based on a good irrigation scheduling program would result in more effective water mangement .

Gear (1977) developed a simple and accurate technique for scheduling irrigation using the neutron probe. The techniqe involves the use of a graph to display soil moisture on the **dates** measured . A best fit line is drawn through the points and projected to intersect a horizontal refill line to show the date of the next irrigation. Only the correct refill point and the neutron probe measurements are required for correct irrigation scheduling for a field. If one consistent irrigation procedure is practiced in a field, only one neutron access tube is required . Neutron probe readings need to be made twice a week when hot weather and once a week when cool weather. Water used by plants, root distribution and extension, and soil drainage are useful by-products of this irrigation scheduling technique .

Molenaar and Vincent (1951) found that the intervals between irrigations had little effect on yields of tomatoes in Spokene Valley as long as adequate water was applied during the growing season .

Moore et al.(1958) found that the higher level of irrigation (at 50 percent available soil moisture) had increased total yields , and that the difference in marketable yields between the higher level of irrigation and lower level of irrigation (at wilting point) was not significant .

Flocker and Lingle (1961) used tensiometers and soil moisture blocks to decide on time and amounts of irrigating tomatoes for canning purposes. Irrigation treatments were applied when mean soil moisture suctions reached 7.0, 2.0 and 0.7 bars . The respective amounts of water used were 13.67, 25.20 and 38.24 acre-inches.The high irrigation rate (0.7 bar) delayed fruit maturity enough to lower the yields of these plots. Highest yield were obtained from the moderate irrigation treatments (2.0 bars).

Cannell and Asbell (1974) obtained a highly significant yield increase of tomatoes with decreasing soil moisture tension. Yield differences were largely attributed to small ripe and green fruits acceptable for processing, obtained at soil moisture stress under dry treatments (3.0 - 6.0 bars) .

MATERIALS AND METHODS

1. Location of the experiment:

The experiment was conducted at Kawar's Farm which is located about 3700 meters north of the University Farm. The site is 80 meters east of the Jordan Valley highway and 150 meters north of the farm's main road. The experiment plots were located between plastic houses.

2. Experimental Design:

A latin square design (4 by 4) was used. There were 16 plots, each plot 4 x 3.6 m., with a border between plots ranging from 30 to 50 cm. The plot consisted of 4 rows that were 1.2 m. apart and 3.6 m. in length. The rows were covared by black plastic mulch (Figure 1).

3. Irrigation System:

Drip irrigation system was used. The East Ghor Canal feeds a private reservoir in the farm. Water was delivered from the reservoir to the experiment by gravity through sand and screen filters, (Figure 2). A water meter was installed on the main pipe line to determine the amount of water applied. The system was calibrated by adjusting the pressure in the sub-main pipe lines at 4-5 psi to provide 4 liters per hour per dripper. Each plot had its own irrigation valve. Each lateral had eight drippers of B_{34} type, that were installed 50 cm. apart, (Figure 1).

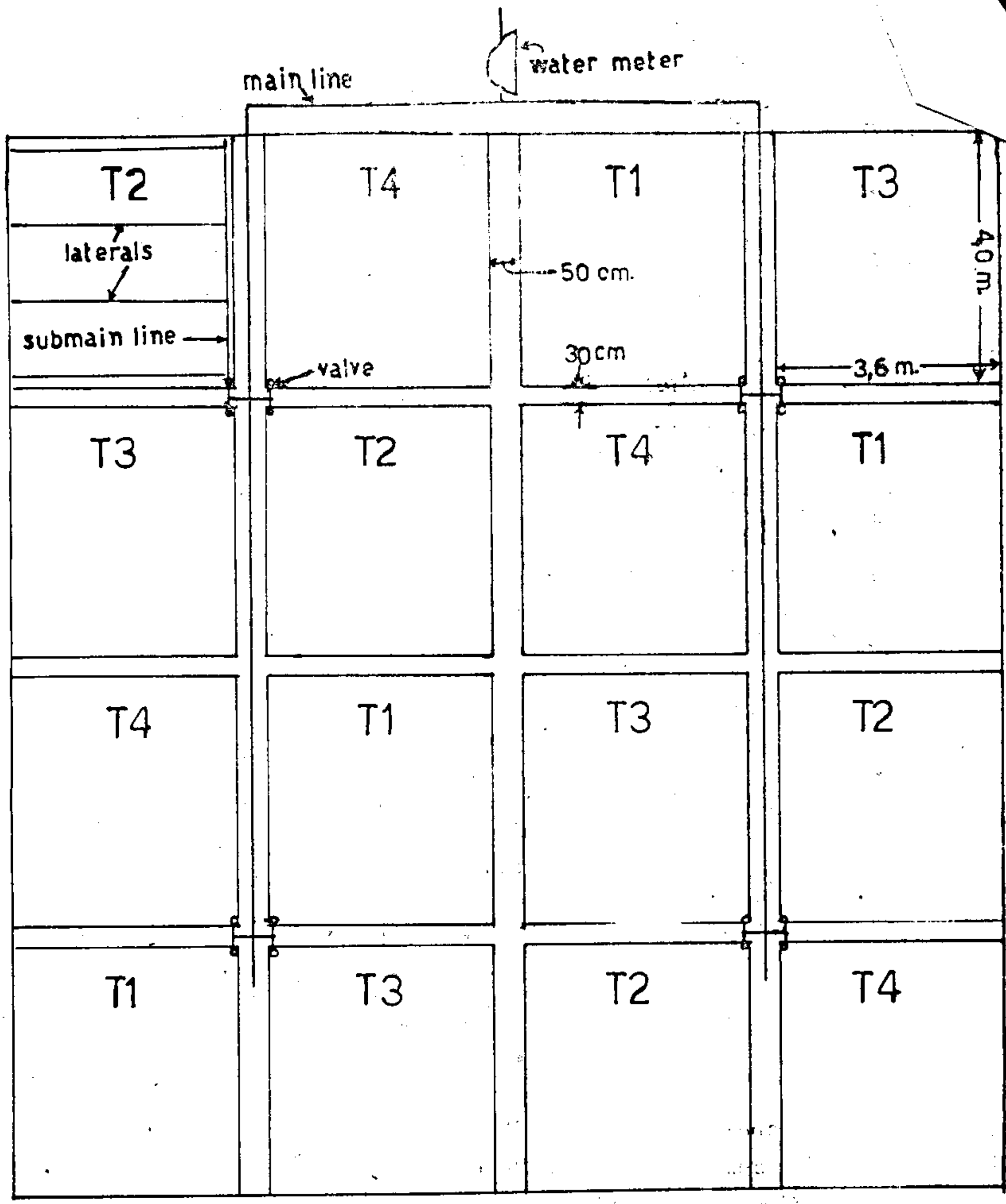

Figure 1.- Layout of the experiment and irrigation system .

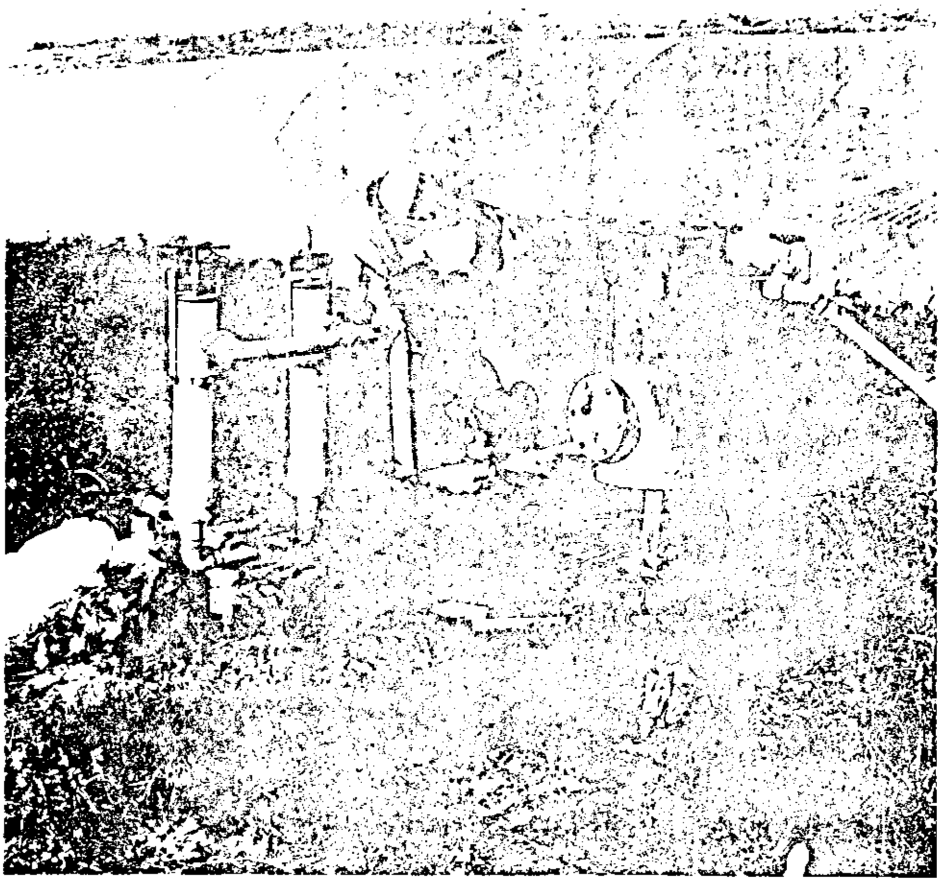

Figure 2 — Photographic view showing sand and screen filters.

4. Planting of Tomatoes :

The land was ploughed, leveled, and then divided into plots. Superphosphate fertilizer was added before planting at a rate of 180 kg./dun. . On December 20, 1978 tomato seedlings (RAF variety) were planted at a rate of 8 seedlings per row(50 cm apart). They were then sprayed weekly with Zenib against any possible infection of early and late blights .

5. Irrigation Treatments:

The experiment involved four treatments of irrigation under different soil moisture tensions. The tensions selected for the treatments were 20, 30, 40 and 50 centibars and were signed to as T_1, T_2, T_3 and T_4 respectively. Four tensiometers were installed in the soil at a depth of 30cm. in four plots so as to have one tensiometer for each treatment . The depth of water applied in each irrigation for all treatments was about thirty nine millimeters .

6. Irrigation Efficiencies:

a. Application efficency was calculated for each irrigation using the following equation(Israelsen et al., 1962)

$$E_a = \frac{W_s}{W_a} 100 \quad [4]$$

where E_a = application efficiency .

W_s = water stored(mm) in the root zone during irrigation .

W_a = water applied (mm)

The water stored in the root zone was calculated using the following equation :

$$W_s = \sum_{i=1}^{nr} (\theta_a - \theta_b)_i \quad S_i \quad \text{..........} [5]$$

where nr = number of the layers

θ_a = volumetric moisture content after irrigation(cm^3 cm^{-3}) .

θ_b = volumetric moisture content before this irrigation (cm^3 cm^{-3}) .

S_i = the thickness of the layer (mm)

Then the average of the application efficiencies of all irrigations were calculated to reflect the application efficiency for the whole season .

b. Water use efficiency(as a percentage) was also calculated for the whole season by using the following equation(Israelsen et al , 1962):

$$E_u = \frac{W_u}{W_a} 100 \quad \text{..........} [6]$$

where E_u = water use efficiency (%)

W_u = total evapotranspiration (mm)

W_a = total water applied (mm)

c. Water use efficiency (kg/m^3) was determined by using the following equation (Viets, 1962):

$$WUE = \frac{Y}{ET} \quad \text{..........} [7]$$

Where WUE = water use efficiency (kg/m^3)

Y = crop yield (kg.)

ET = evapotranspiration of crop area (m^3)

7. <u>Evapotranspiration Measurements:</u>

The soil moisture depletion method was used to measure the evapotranspiration (Tanner, 1967), and (Robins, 1965). This method is based on the following equation :

$$ET = \frac{\sum_{i=1}^{nr} (\theta_1 - \theta_2)_i \quad Si + Re - Wd}{t} \quad \ldots\ldots\ldots\ldots\ldots [8]$$

Where ET = evapotranspiration rate (mm/day)

nr = number of soil layers of the root zone

θ_1 and θ_2 = volumetric moisture contents on the first and the second dates of measurement respectively (cm^3 cm^{-3})

Si = thickness of each soil layer (mm)

Re = rainfall that does not run off the area (mm)

Wd = deep percolation losses from the root zone(mm)

t = interval between irrigations(days)

Rainfall effect was eliminated by using plastic mulch, but the effect of deep percolation losses was eliminated by waiting at least 2 days after each irrigation before taking the first measurement .

Soil moisture measurements were taken with Campbell Pacific Nuclear Hydro-Probe Model 503 and serial NO H38062365 . Holes for access tubes were made by two-inch diameter auger . Aluminum access tubes of two-inch diameter and 1 meter length were then inserted into the holes leaving 15 cm of the tube above the soil. The measurements were taken at three different depths, namely: 15, 45, and 75 cm. In each plot one access tube was installed. At the end of the experiment calibration curve for hydro-probe was done. The calibration method was nearly as that used by Gornat and Goldberg (1972) with the following modification: A basin (1m X 1m) was made in the center of each plot. Different amounts of water were applied to each of the basins. Soil samples for gravimetric moisture measurements were collected using the two-inch diameter auger at 30 cm increments. An aluminum access tube was then inserted the sampling hole. Measurements were then taken with the hydro-probe at half of the depths from which gravimetric samples were collected. The results were used to contstruct a separate calibration curve for each depth between the count ratios of the hydro-probe readings (field count dividid by standard count), and the soil moisture content by volume, using the regression analysis technique (Little et al, 1975).

From these calibration curves, θ_1 and θ_2 at different depths were determined. Thus evapotranspiration for each interval of irrigation was calculated using equation[8]. The evapotranspiration amount during the two days before irrigation was estimated by using the following equation :

$$ET = Kc_1 \cdot E_p \qquad [9]$$

where ET= evapotranspiration for the first two days (mm)

E_p= pan evaporation during the two days (mm)

Kc_1= crop coefficient for the period after the two days

8. Evaporation Measurements:

A Class-A Weather Bureau pan evaporation was used to measure evaporation. This pan is 47½ inches in diameter and 10 inches in depth. A still well with hook gauge was placed in the pan to measure to amount-of evaporation(mm).The pan was put over a wood-stand base. The measurements were taken every other day and were accumulated according to intervals of irrigation .

9. Crop Coefficient (Kc):

K_c ratio for each period of irrigation was determined using equation[1] and data for evapotranspiration and pan evaporation were obtained from equation[8]and step 8 above respectively.

10. Yield :

Yields of tomatoes were obtained by weighing the harvested crop from 12 plants in the middle two rows from each plot.Harvesting of red fruits had started on April 2 and completed on May 16 .

Analysis of variance of Latin square design for the yields and consumptive use amounts of different treatments was done in order to find if there were any significant differences in yield and consumptive use. SSD test was also done to compare between treatments.

11. Soil Analysis :

One profile was dug in the experiment area. Undisturbed soil samples were taken at depths of 15, 45, and 75 cm.. Disturbed soil samples were taken from the following layers: 0 - 30, 30 - 60, and 60 - 90 cm. . Some physical and chemical properties were determined, as shown in tables 1 and 2 and in Figure 3.These properties were:

a. Bulk Density: It was determined by core method as described by Taylor and Aschroft (1972), using rings with suitable sleeve (undisturbed sample).

b. Soil moisture sorption curve: Undisturbed samples were used and their moisture contents have been determined under the following pressures: 0.1, 0.3, 0.5, 0.75, 1.0, 3.0, 5.0, 10.0 and 15.0 bars by using the ceramic plate extractor as described by USDA. Handbook No. 60 (1954). Field capacity and wilting points were considered at 0.1 and 15.0 bars respectively.

c. Texture: Pipette method, as described by Day (1965), was used to determine the textural classes of the soils.

d. Organic matter: Schollen-Berger method as described by Allison (1965), using potassium dichromate-1N and ferrous sulfate 0.5 N, was used to determine the organic matter content .

e. $CaCO_3$ %: It was determined by the calcimeter method as described by Allison and Moodie (1965) .

f. Electrical conductivity(EC): It was determined by the use of conductivity bridge in soil saturated extract as described by USDA. Handbook No. 60 (1954).

g. PH : It was measured using glass electrode in soil saturated extract as described by USDA. Handbook. No. 60 (1954) .

Table 1. Some physical properties of the soil .

Layer depth (cm)	Bulk density (gm/cm 3)	FC 1)	WP 2)	CS 3)	FS 4)	Silt	Clay	Textural class
0 - 30	1.46	27.78	16.71	40.84	24.11	13.73	21.32	Sandy Clay Loam
30 - 60	1.58	24.07	14.39	39.31	28.46	13.53	18.70	Sandy Loam
60 - 90	1.56	27.74	17.68	37.59	24.05	15.60	27.76	Sandy Clay Loam

1) FC = Field capacity (% by volume).

2) WP = Welting point (% by volume).

3) CS = Coarse sand .(2 - 0.2 mm)

4) FS = Fine sand . (0.2 - 0.02 mm)

Table 2. Some chemical properties of soil .

Layer depth (cm)	Organic matter %	$CaCO_3$ %	PH_e	EC_e X10 $^{-3}$ (mmho/cm)
0 - 30	0.96	19.15	7.9	2.59
30 - 60	0.34	21.27	8.0	1.66
60 - 90	0.18	23.56	8.0	1.84

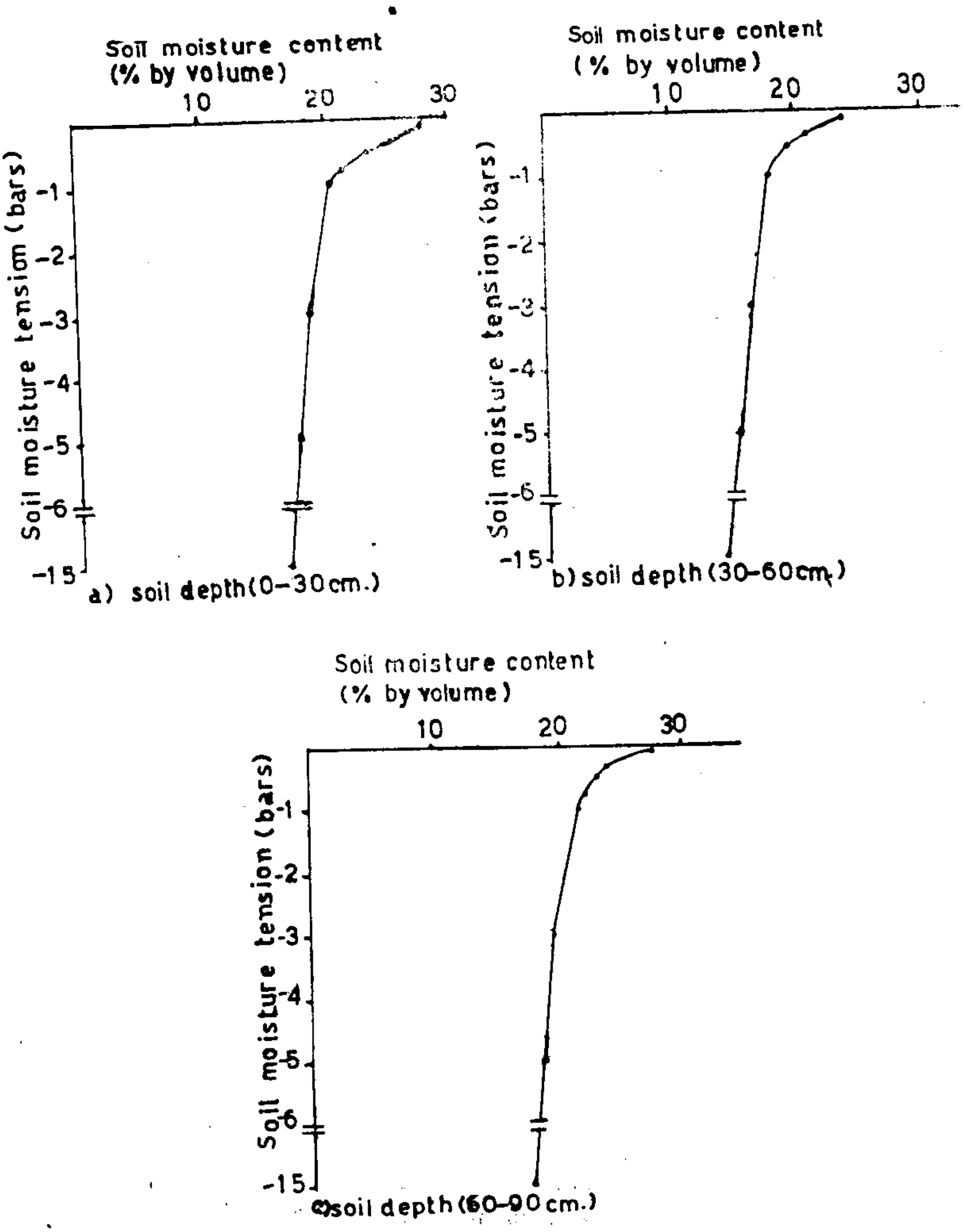

Figure 3 – Soil moisture desorption curves at 3 different depths.

RESULTS AND DISCUSSION

1. Effect of Irrigation Treatments on Yield :

The yield averages were: 8.72, 8.11, 7.16, and 6.78 tons per dunum for treatments T_1, T_2, T_3 and T_4 respectively(Table 3). Analysis of variance was done to study the differences between the treatments. The observed F test for rows, columns, and treatments (0.86, 0.23, and 1.28 respectively) were less than the values of the required F (4.76 and 9.78 at both 5% and 1% levels respectively)(Table 4). This indicates that the differences among rows, columns, and treatments were not statistically significant.

2. Water Applied and Consumptive Use:

Irrigation treatments and soil moisture depletion measurements needed for determining evapotranspiration had started in late February(2/20), when tomato plants were growing rapidly . The number of irrigations and the total amounts of water applied for the four irrigation treatments, from that time to the end of the season (5/11), are presented in table 5. It can be seen that the total amount of water applied per season for T_1 was 741 mm, while for T_4 was 429 mm. This shows that the total amount of water applied decreased as the soil moisture tension before irrigation was left to increase. The total amounts of consumptive use for the four treatments during the growing season(Feb. 20 - May 11), amounted to 451, 401,348, and 298 mm for T_1, T_2, T_3, and T_4 respectively (Tables 6, 7, 8, and 9). The accumulative use data for the four treatments is shown in figure 4 .

Table 3. Average yield of tomatoes under the four different irrigation treatments .

Treatments	Soil moisture tension (cb)	Yield (kg/dunum)
T_1	20	8720
T_2	30	8110
T_3	40	7160
T_4	50	6780

Table 4. Analysis of variance table for yield data .

Source of variation	SS 1)	df 2)	MS 3)	observed F	Required F 5 %	Required F 1%
Total	31.97	15				
Rows	6.31	3	2.10	0.86*	4.76	9.78
Columns	1.70	3	0.57	0.23*		
Treatments	9.37	3	3.12	1.28*		
Error	19.59	6	2.43			

1) SS = sum of squares .

2) df = degrees of freedom .

3) MS = mean of squares .

* = not significant .

Table 5. Number of irrigations and total amounts of water applied during the season.

Treatments	Soil moisture tension (cb)	Number of irrigations	Total amount of water applied(mm)
T_1	20	19	741
T_2	30	15	585
T_3	40	13	507
T_4	50	11	429

Table 6. Consumptive use of water by tomatoes and pan evaporation data during corresponding periods for treatment T_1 .

Periods	Consumptive use (mm)			Pan evaporation (mm)			K_c
	periodic	daily	Total*	periodic	daily	Total*	
2/21 - 2/24	7.38	4.38	7.38	10.91	3.64	10.91	0.68
2/28 - 3/3	13.17	4.39	29.06	13.67	4.56	30.27	0.96
3/12 - 3/17	13.77	2.75	39.53	13.04	2.61	37.29	1.06
3/19 - 3/21	12.51	6.26	22.13	10.16	5.08	17.99	1.23
3/23 - 3/28	16.47	3.29	36.81	10.17	2.03	22.72	1.62
3/30 - 3/31	12.39	12.39	36.93	4.51	4.51	13.43	2.75
4/2 - 4/4	23.91	11.96	39.36	14.03	7.02	23.15	1.07
4/6 - 4/7	5.79	5.79	20.62	5.84	5.84	20.83	0.99
4/11 - 4/13	8.04	4.02	34.47	8.60	4.30	37.06	0.93
4/14 - 4/16	11.40	5.70	16.55	12.59	6.30	18.19	0.91
4/18 - 4/20	16.05	8.03	27.76	16.64	8.32	28.92	0.96
4/22 - 4/23	8.04	8.04	21.27	6.85	6.85	18.18	1.17
4/25 - 4/27	15.57	7.79	31.07	16.24	8.12	32.36	0.96
4/29 - 4/30	12.51	12.51	28.87	17.99	17.99	41.24	0.70
5/2 - 5/5	14.88	4.96	27.82	26.10	8.70	48.80	0.57
5/7 - 5/9	8.46	4.23	16.20	18.43	9.22	35.21	0.46
5/11 - 5/12	5.53	5.55	14.69	12.40	12.40	32.64	0.45
			450.52				

* Total = periodic depth + depth for the period between irrigation day and first day of the period .

Table 7. Consumptive use of water bytomatoes and pan evaporation data during corresponding periods for treatment T_2 .

Periods	Consumptive use in(mm)			Pan evaporation in(mm)			K_c
	periodic	daily	Total*	periodic	daily	Total*	
2/20 - 2/24	7.38	1.85	7.38	15.57	3.89	15.57	0.47
2/26 - 3/3	31.94	6.39	47.17	21.43	4.29	30.27	1.49
3/12 - 3/17	20.88	4.18	59.66	13.04	2.61	37.29	1.60
3/19 - 3/21	16.32	8.16	28.96	10.16	5.08	17.99	1.61
3/23 - 3/31	22.77	2.85	34.70	23.60	2.95	36.15	0.96
4/2 - 4/6	27.81	6.95	36.61	29.02	7.26	38.14	0.96
4/7 - 4/11	20.28	5.07	24.35	28.46	7.12	34.30	0.71
4/13 - 4/18	22.11	4.42	28.52	30.47	6.09	39.07	0.73
4/20 - 4/23	13.35	4.45	25.42	18.18	6.06	34.82	0.73
4/25 - 4/28	30.27	10.09	48.07	27.58	9.19	43.70	1.10
4/30 - 5/2	12.03	6.02	15.84	22.70	11.35	29.88	0.53
5/5 - 5/9	14.91	3.73	25.75	35.21	8.80	61.31	0.42
5/11 - 5/12	6.90	6.90	18.60	12.40	12.40	32.64	0.57
			401.03				

* Total = periodic depth + depth for the period between irrigation day and first day of the period .

Table 8. **Consumptive use of water by tomatoes and pan evaporation data during corresponding periods for treatment T_3.**

Periods	Consumptive use (mm)			Pan evaporation(mm)			K_c
	periodic	daily	Total*	periodic	daily	Total*	
2/20 - 2/24	8.01	2.00	8.01	15.57	3.89	15.57	0.51
2/26 - 3/3	15.57	3.11	23.11	21.43	4.29	31.66	0.73
3/12 - 3/19	25.29	3.61	54.60	20.87	2.98	45.12	1.21
3/23 - 3/31	30.57	3.82	60.20	23.6	2.95	46.31	1.30
4/2 - 4/6	25.44	6.36	33.56	29.02	7.26	38.14	0.88
4/7 - 4/11	22.53	5.63	27.10	28.46	7.12	34.30	0.79
4/13 - 4/20	24.15	3.45	28.41	47.11	6.73	55.71	0.51
4/22 - 4/25	18.48	6.16	27.44	22.97	7.66	34.30	0.80
4/27 - 4/29	10.92	5.46	18.55	23.23	11.62	39.47	0.47
4/30 - 5/2	9.78	4.89	17.50	22.70	11.35	40.69	0.43
5/5 - 5/9	13.23	3.31	23.30	35.21	8.80	61.31	0.38
5/11 - 5/14	15.36	7.68	25.85	29.48	14.74	49.72	0.52
			347.63				

* Total = periodic depth + depth for the period between irrigation day and first day of the period.

Table 9. Consumptive use of water by tomatoes and pan evaporation data during corresponding periods for treatment T_4 .

Periods	Consumptive use(mm.)			Pan evaporation(mm.)			K_c
	periodic	daily	Total*	periodic	daily	Total*	
2/20 - 2/26	11.40	1.90	11.40	27.80	4.63	27.80	0.41
2/28 - 3/5	25.98	5.20	34.52	23.62	4.72	31.38	1.10
3/12 - 3/19	24.84	3.55	41.85	20.87	2.98	35.17	1.19
3/23 - 4/4	44.73	3.73	66.68	46.75	3.90	69.46	0.96
4/5 - 4/9	20.64	5.16	24.59	26.55	6.64	31.53	0.78
4/10 - 4/13	15.81	5.27	21.62	19.22	6.41	26.36	0.82
4/15 - 4/20	16.53	3.31	22.14	35.17	7.03	47.11	0.47
4/22 - 4/27	16.47	3.29	21.23	39.21	7.84	50.54	0.42
4/29 - 5/2	11.40	3.80	17.90	40.69	13.56	63.94	0.28
5/3 - 5/9	12.99	2.17	15.33	51.27	2.17	61.31	0.25
5/11 - 5/18	15.87	2.27	21.13	61.04	8.72	81.28	0.26
			298.36				

* Total = periodic depth + depth for the period between irrigation day and first day of the period .

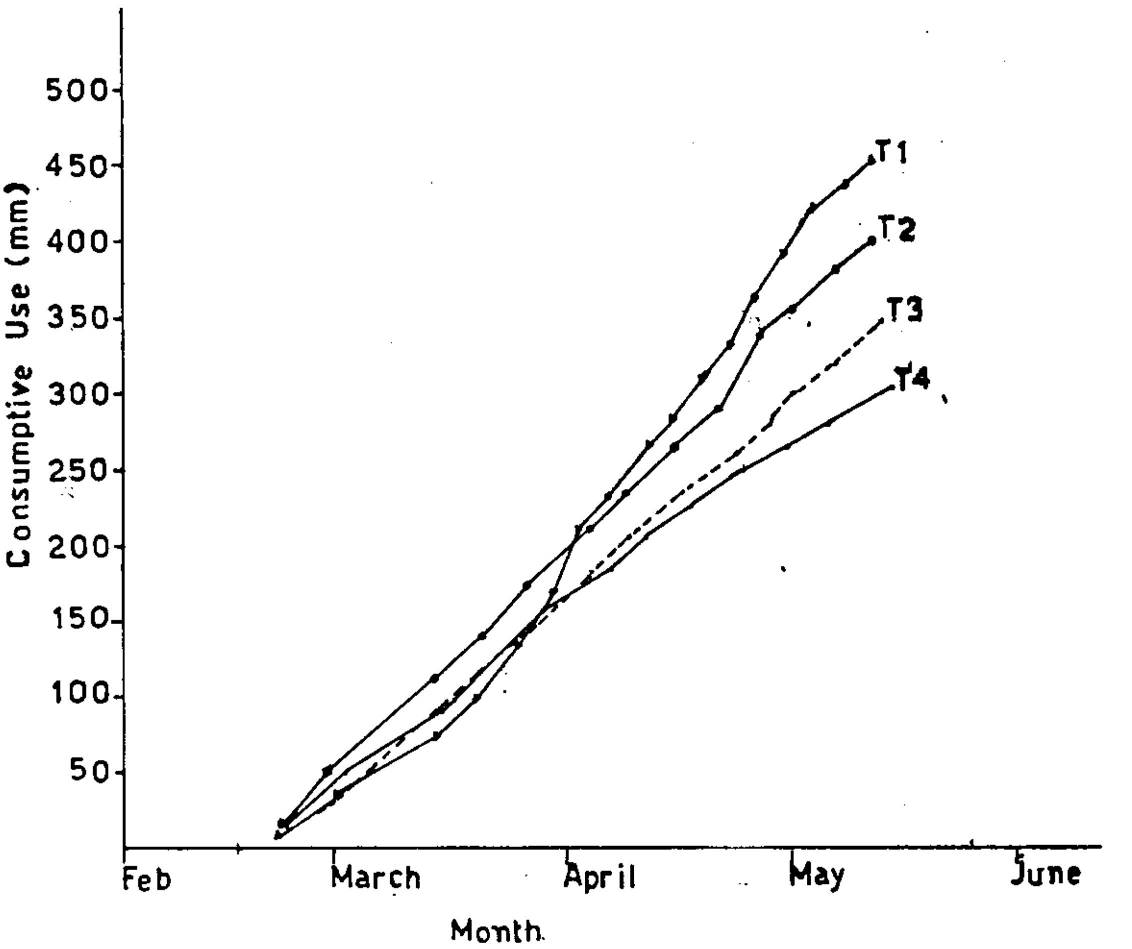

Figure 4 - Accumulative consumptive use for the 4 treatments during the season.

Analysis of variance for the consumptive use data was done and the results are given in table 10. From table 10 it can be seen that there are significant differences among treatments. SSD test was done to compare between the treatments (Table 11). The results show that significant differences exist between all treatments . The rates of the consumptive use and the rate averages of the four treatments during the same period are shown in figures 5, 6, 7, 8, and 9. The results show that the rate of consumptive use for each treatment fluctuates during the growing season along the same pattern as the fluctuation in evaporation. The average rate of consumptive use for the growing season (not including the dormant stage) decreased from 6.6 mm/day to 3.6 mm/day as the soil moisture tension before irrigation had increased from 20 cb to 50 cb .

3. <u>Irrigation Efficiencies:</u>

The amount averages of water stored in the root zone during the growing season between irrigations,the amount of water applied in each irrigation,and the application efficiencies(E_a)for the four irrigation treatments are shown in table 12($E_a$was 34.64% for T_1,and 49.82% for T_4).The total amounts of consumptive use, total amount of water applied and the water use efficiences (E_u)for the four treatments are shown in table 13($E_u$was 60.86% for T_1,and 69.46% for T_4). The total amounts of consumptive use, yields, and water

Table 10. Analysis of variance table for consumptive use data.

Source of variation	SS[1]	df[2]	MS[3]	Observed F	Required F 5%	Required F 1%
Total	56909.3	15				
Rows	376.7	3	125.57			
Columns	376.2	3	125.40			
Treatments	52592.2	3	17530.73	28.86*	4.76	9.78
Error	3644.2	6	607.37			

1) SS : sum of squares .

2) df : degrees of freedom

3) MS : mean of squares .

* **: not significant at both levels .**

Table 11. Comparison between the consumptive use data for the four treatments by the use of SSD test .

a) LSD = 42.64

b)

Relative position in array	2	3	4
Values of R(5 % level)	1.00	1.04	1.07
SSD = R(LSD)	42.64	44.35	45.62

c)

Treatment	T_4	T_3	T_2	T_1
Mean	298	348	401	451

d) Comparison

Comparison	Mean difference	SSD
T_1 vs T_2	50*	42.64
T_1 vs T_3	103*	44.35
T_1 vs T_4	153*	45.62
T_2 vs T_3	53*	42.64
T_2 vs T_4	103*	44.35
T_3 vs T_4	50*	42.64

* = significant .

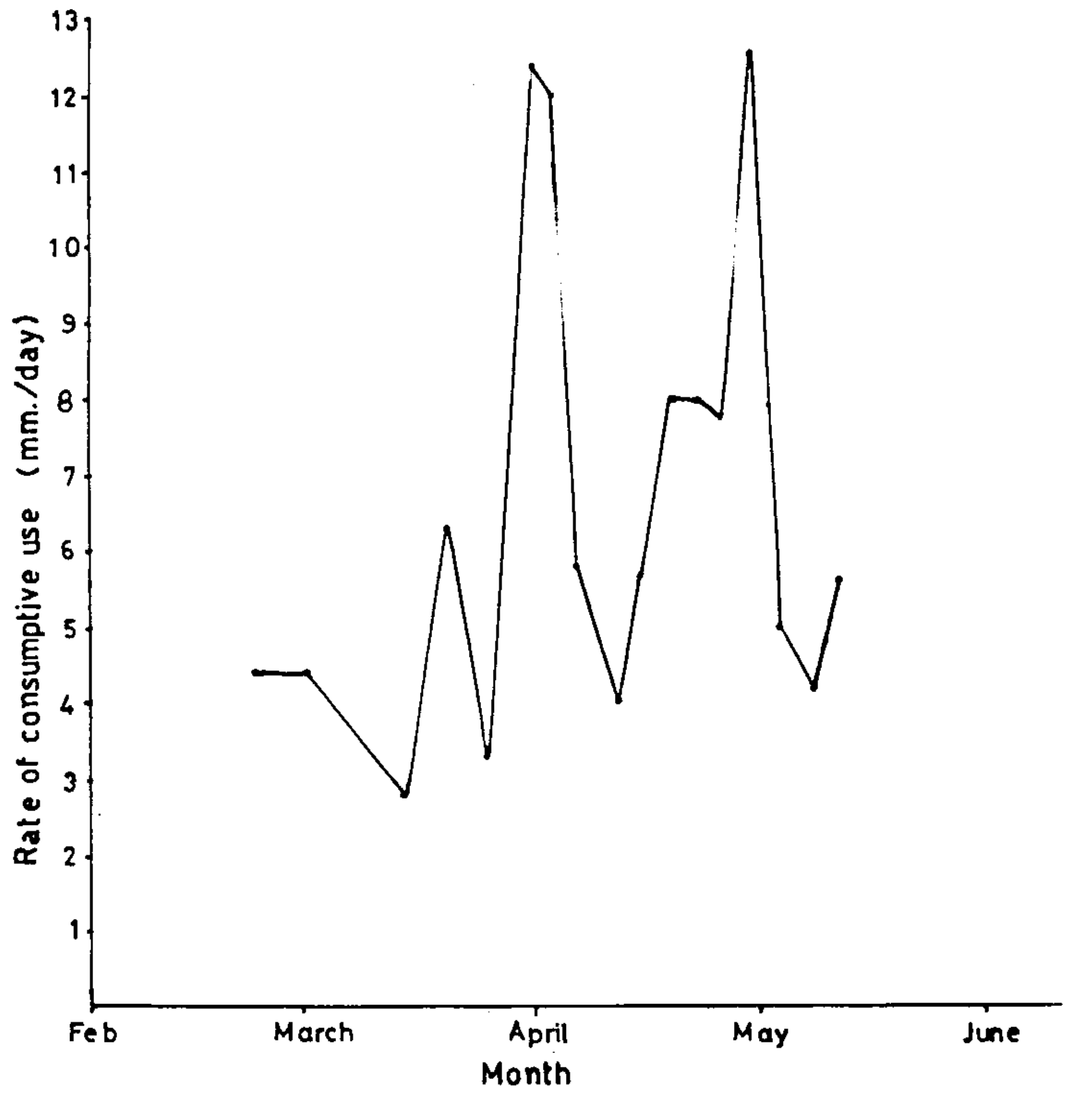

Figure 5 - Rates of consumptive use for treatment T_1 during the season .

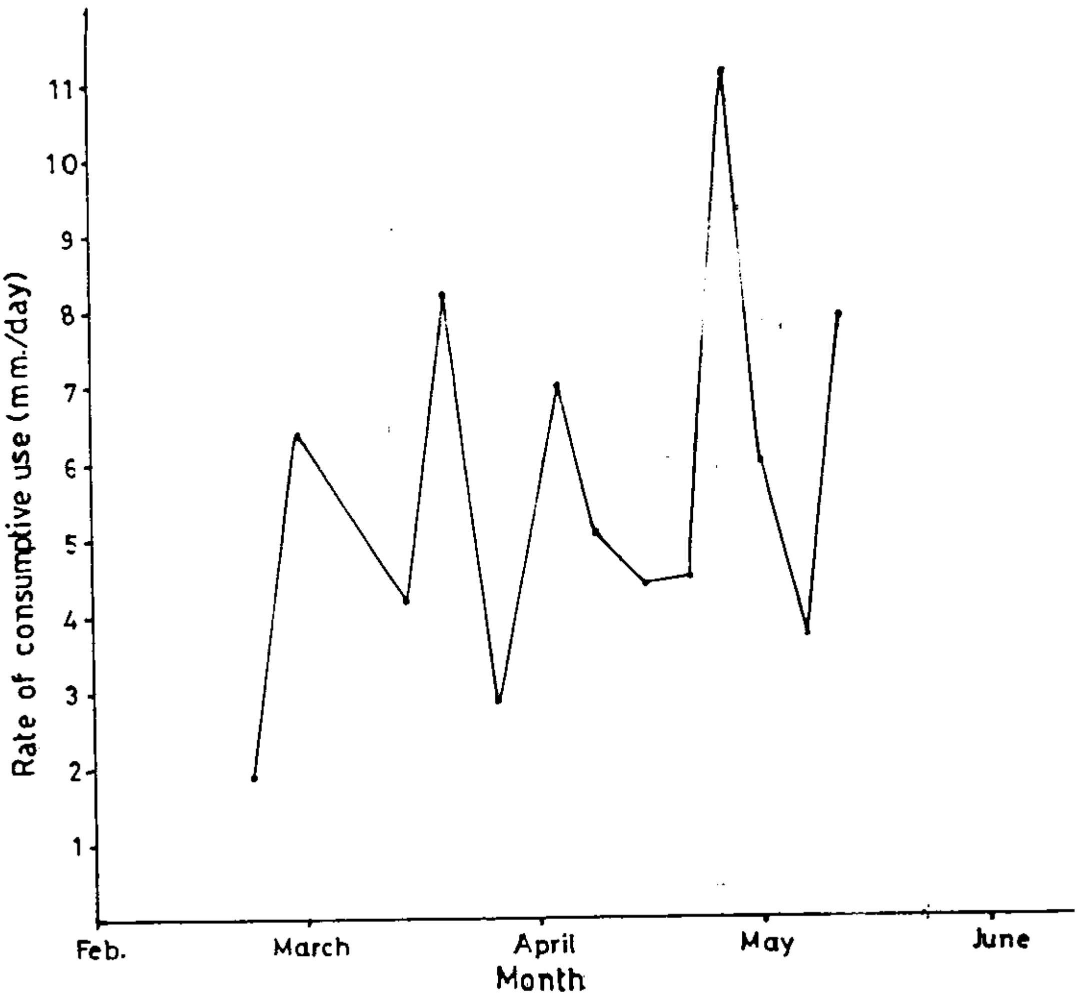

Figure 6 - Rates of consumptive use for treatment T_2 during the season.

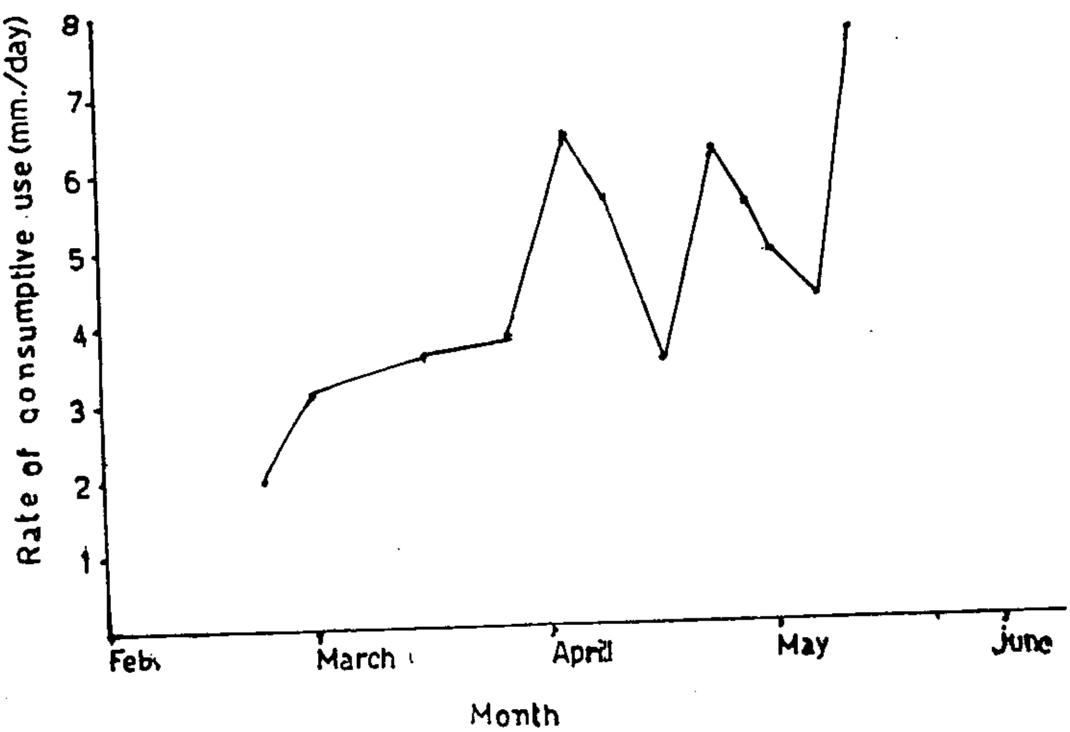

Figure 7- Rates of consumptive use for treatment T_3 during the season .

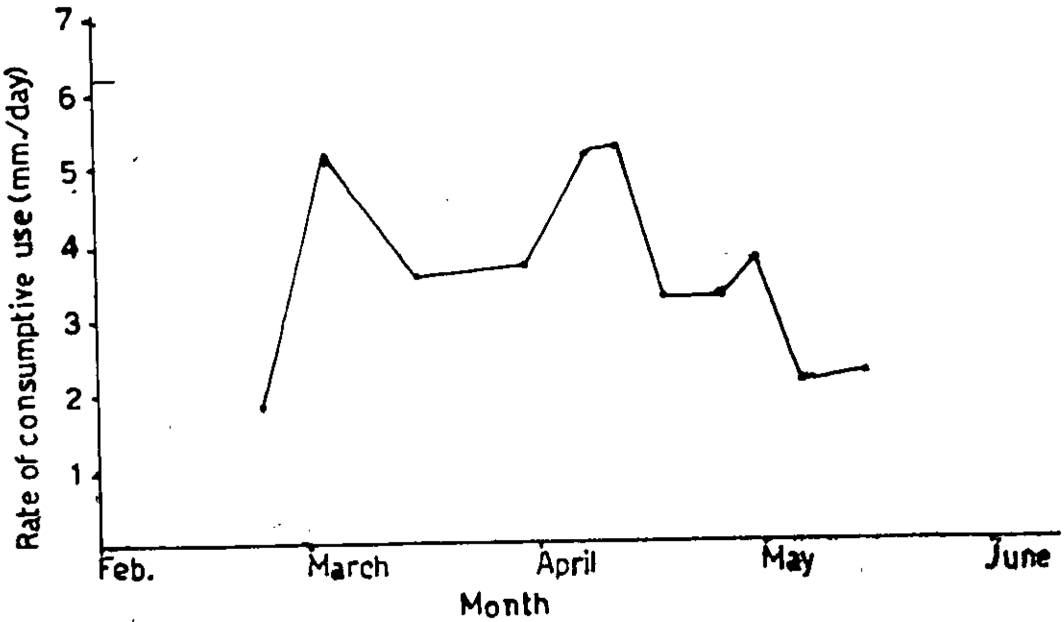

Figure 8 - Rates of consumptive use for treatment T_4 during the season .

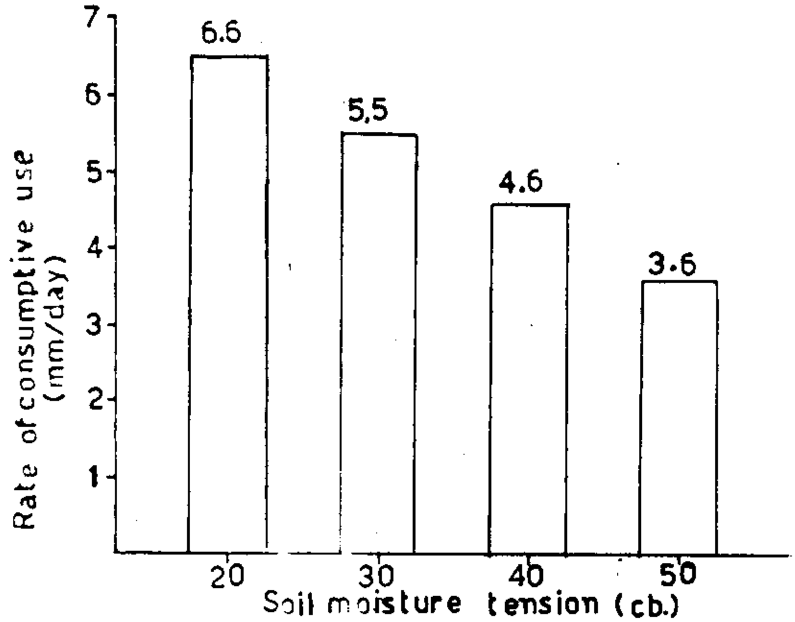

Figure 9 - Average rates of consumptive use for the 4 treatments .

Table 12. Averages of water stored , water applied, and application efficiency .

Treatments	Soil moisture tension (cb)	Average depth of water stored between irrigations (mm)	Average depth of water applied in each irrigation (mm)	Application efficiency (%)
T_1	20	13.51	39	34.64
T_2	30	18.71	39	47.97
T_3	40	18.91	39	48.49
T_4	50	19.43	39	49.82

Table 13. Averages of total water applied, total evapotranspiration, and water use efficiency (%) .

Treatments	Soil moisture tension(cb)	Total depth of applird (mm)	Total evaportanspiration (mm)	Water - use efficiency(%)
T_1	20	741	451	60.86
T_2	30	585	401	68.54
T_3	40	507	348	68.64
T_4	50	429	298	69.46

(W_u) for the four treatments are shown in table 14(W_u was 17.34 kg/m^3 for T_1 and 22.75 kg/m^3 for T_4). The results show that the irrigation efficiencies were low for the four treatments. This could be explained by: the amount of water applied in each irrigation was 39 mm. This amount is more than the average depletion amount which was 19.70 mm for T_4 .

4. Crop Coefficient (K_c) :

K_c is the ratio of consumptive use amount to evaporation amount as obtained from Class-A pan. K_c values were calculated for the growing season (2/20 - 5/11). Consumptive use amounts of water, pan evaporation amounts, and K_c values during corresponding periods for the four treatments are presented in tables 6, 7, 8, and 9. The results show that the K_c value for each treatment had changed during the growing season as shown in figures 10 through 13. For example in treatment T_4, K_c increased rapidly from 0.41 to a maximum equals to 1.19 attained during flowering stage, then it declined to 0.26 at the end of the growing season .

Second degree (Quadratic) equation between computed K_c values and number of days after dormant stage (Dec. 20 - Feb. 5) for T_4 was determined. The equation is as follows :

$$K_c = 0.311035 + 0.028837\,X - 3.2128 \times 10^{-4} X^2 \quad \ldots\ldots [10]$$

where X is the number of days after the dormant stage. Analysis of variance for this equation was done (Table 15).The results show that there were no significant differences between the computed K_c values,and the estimated values obtained by using equation [10] .

Table 14. Averages of total evapotranspiration , yield, and water use efficiency (kg/m^3) .

Treat-ments	Soil moisture tension (cb)	Total evaportrans-piration (m^3/dun)	Average yield (kg/dun)	water use effeciency (kg/m^3)
T_1	20	451	8720	17.34
T_2	30	401	8110	20.22
T_3	40	348	7160	20.57
T_4	50	298	6780	22.75

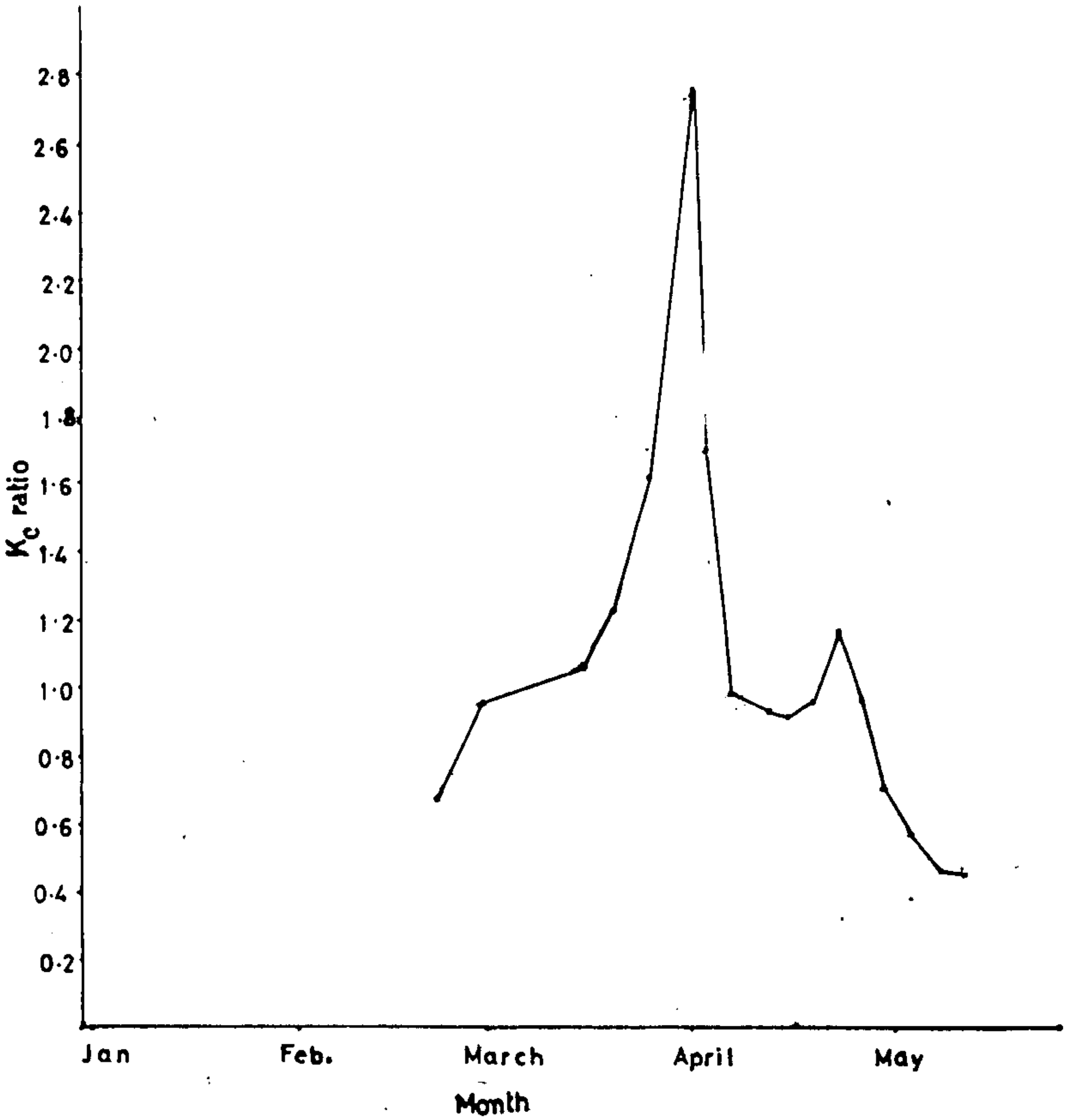

Figure 10 – The change of K_c ratio for treatment T_1 during the season.

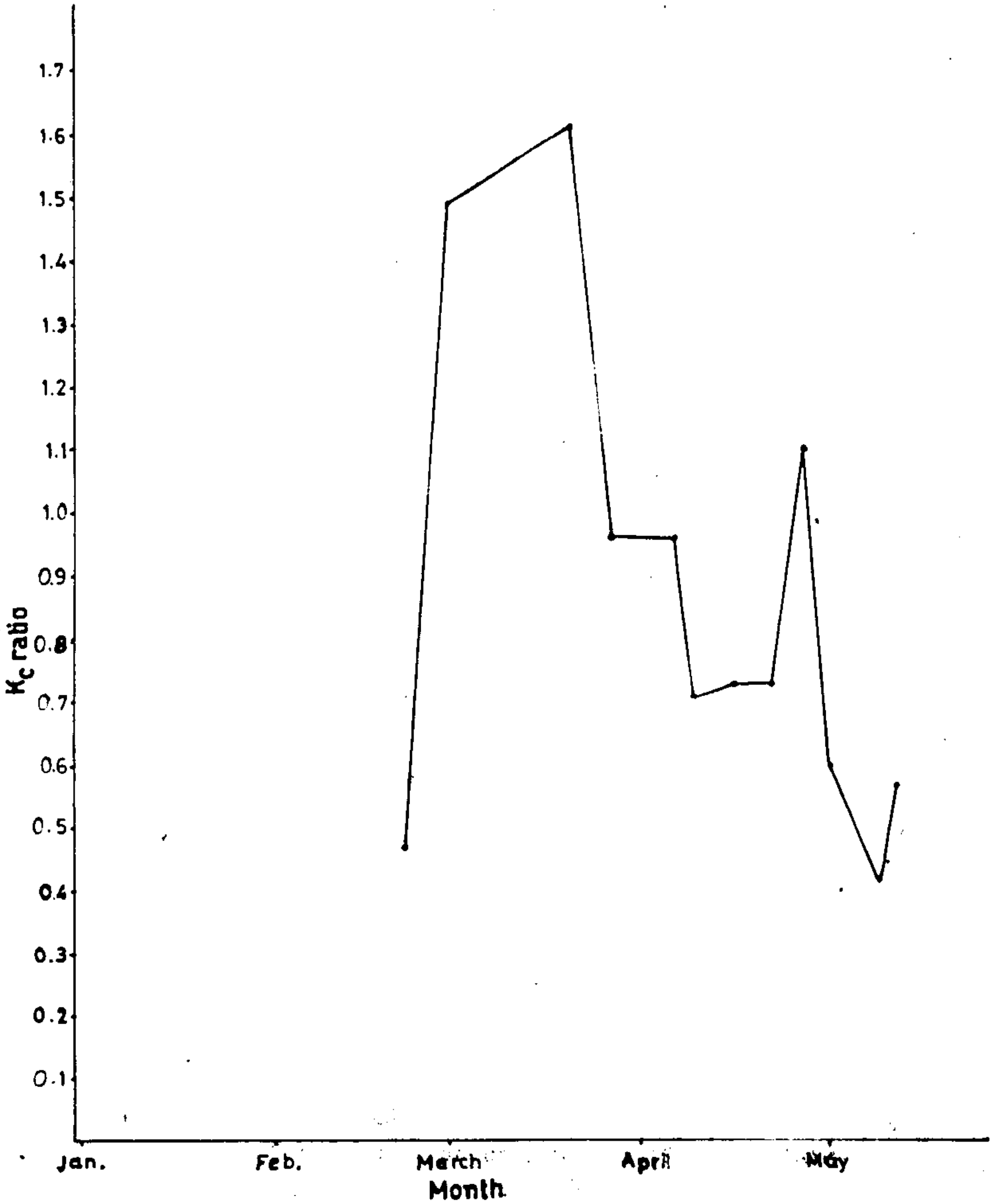

Figure 11- The change of K_c ratio for treatment T_2 during the season .

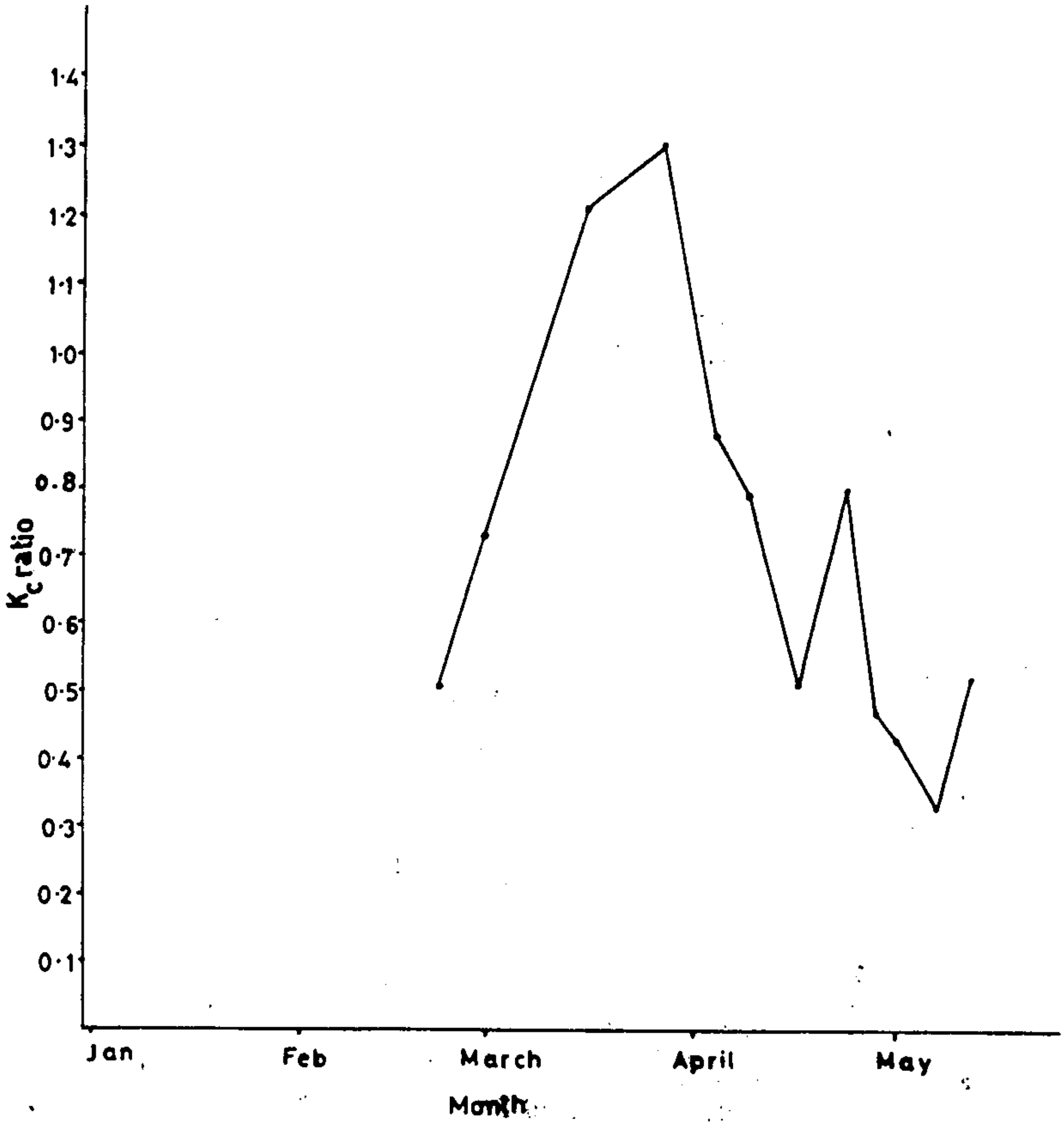

Figure 12 – The change of K_c ratio for treatment T_3 during the season.

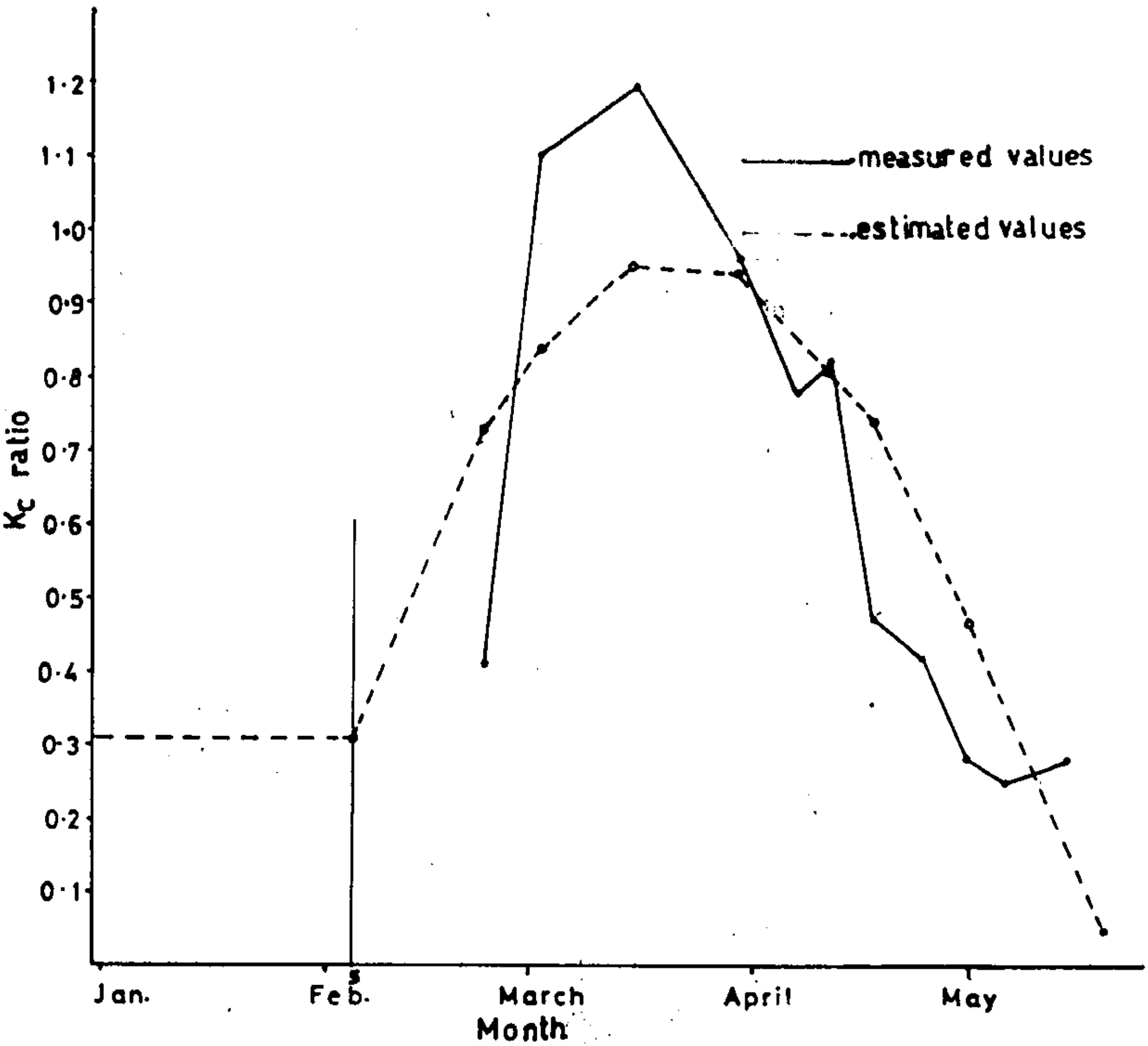

Figure 13 - The change of K_c ratio for treatment T_4 during the season .

Table 15. The analysis of variance table of the quadratic equation for treatment T_4

Source of variation	SS 1)	df 2)	MS 3)	Observed F	Required F 5%	Required F 1%
Total	0.99	7				
Linear	0.33	1				
Deviation from linear	0.66	6				
Quadratic component	0.27	1	0.27	3.38 *	6.61	4.06
Deviation from quadratic	0.39	5	0.08			

1) SS = sum of squares.

2) df = degrees of freedom.

3) MS = mean of squares.

* = not significant to both level.

During the dormant stage the K_c value can be considered constant as given by Robins and Haise (1961). Thus, the estimated K_c value for dormant stage is 0.31(equation 10). The importance of the K_c values is to calculate the equivalent of pan evaporation between irrigations using the following equation :

$$E_p = \frac{ET_u}{K_c} \quad \text{.......................................} \quad [11]$$

where E_p =the equivalent of pan evaporation (mm).

ET_u =the usable evapotranspiration (mm).

K_c =crop coefficient(dimensionless).

The number of K_c values for treatment T_4 (Table 9) were reduced by using the average of the respective values that are close to each other (Table 16), in order to simplify the use of K_c values in scheduling irrigation .

5. <u>Soil Moisture Extraction Patterns :</u>

The soil moisture extraction percentages (E_x) for the four treatments during the growing season are shown in tables 17, 18, 19, and 20. The results show that each treatment had four soil moisture extraction patterns as shown in figures 14, 15, 16, and 17. Also the results show that the upper 30 cm was the soil depth from which most the feeder roots of the plants extract moisture. So the upper 30 cm layer was considered to be the design moisture extraction depth .

The average amounts of water extracted between irrigations from the upper 30 cm layer, and the percentages of these amounts

Table 16 . The average K_c ratio for treatment T_4 during the season .

Period	Average K_c
12/20 - 2/5	0.30
2/5 - 2/20	0.36
2/20 - 2/26	0.76
2/26 - 3/19	1.15
3/19 - 4/13	0.94
4/13 - 4/27	0.57
4/27 - 5/18	0.30

Table 17. Average soil moisture extraction percentages(E_x) for treatment T_1 during the season.

Period	depth (cm)	soil moisture depletion(mm) per layer	Total	E_x %
2/21 - 2/24	0 - 30	6.09	7.38	82.52
	30 - 60	1.29		17.48
	60 - 90	0.00		00.00
2/28 - 3/3	0 - 30	11.22	13.17	85.19
	30 - 60	1.29		9.79
	60 - 90	0.66		5.01
3/12 - 3/17	0 - 30	11.22	13.77	81.48
	30 - 60	1.89		13.73
	60 - 90	0.66		4.79
3/19 - 3/21	0 - 30	10.56	12.51	84.41
	30 - 60	1.29		10.31
	60 - 90	0.66		5.28
3/23 - 3/28	0 - 30	13.92	16.47	84.51
	30 - 60	1.89		11.48
	60 - 90	0.66		4.01
3/30 - 3/31	0 - 30	7.83	12.39	63.20
	30 - 60	3.9		31.48
	60 - 90	0.66		5.32
4/2 - 4/4	0 - 30	15.06	23.91	62.99
	30 - 60	6.48		27.10
	60 - 90	2.37		9.91

Table 17 (continued) .

Period	depth (cm)	Soil moisture depletion(mm) per layer	Soil moisture depletion(mm) Total	ϵ_x %
4/6 - 4/7	0 - 30	3.84	5.79	66.32
	30 - 60	1.29		22.28
	60 - 90	0.66		11.40
4/11 - 4/13	0 - 30	6.09	8.04	72.96
	30 - 60	1.29		23.58
	60 - 90	0.66		3.46
4/14 - 4/16	0 - 30	9.45	11.40	82.89
	30 - 60	1.29		11.32
	60 - 90	0.66		5.79
4/18 - 4/20	0 - 30	12.81	16.05	79.81
	30 - 60	2.58		16.07
	60 - 90	0.66		4.11
4/22 - 4/23	0 - 30	6.09	8.04	75.75
	30 - 60	1.29		16.04
	60 - 90	0.66		8.21
4/25 - 4/27	0 - 30	12.33	15.57	79.19
	30 - 60	2.58		16.57
	60 - 90	0.66		4.24
4/29 - 4/30	0 - 30	10.56	12.51	84.41
	30 - 60	1.29		10.31
	60 - 90	0.66		5.28

Table 17 (continued) .

Period	depth (cm)	Soil moisture depletion (mm) per layer	Soil moisture depletion (mm) Total	E_x %
5/2 - 5/5	0 - 30	12.33	14.88	82.86
	30 - 60	1.89		12.70
	60 - 90	0.66		4.44
5/7 - 5/9	0 - 30	7.20	8.46	85.11
	30 - 60	0.60		7.09
	60 - 90	0.66		7.80
5/11 - 5/12	0 - 30	4.95	5.53	89.19
	30 - 60	0.60		10.81
	60 - 90	0.00		0.00

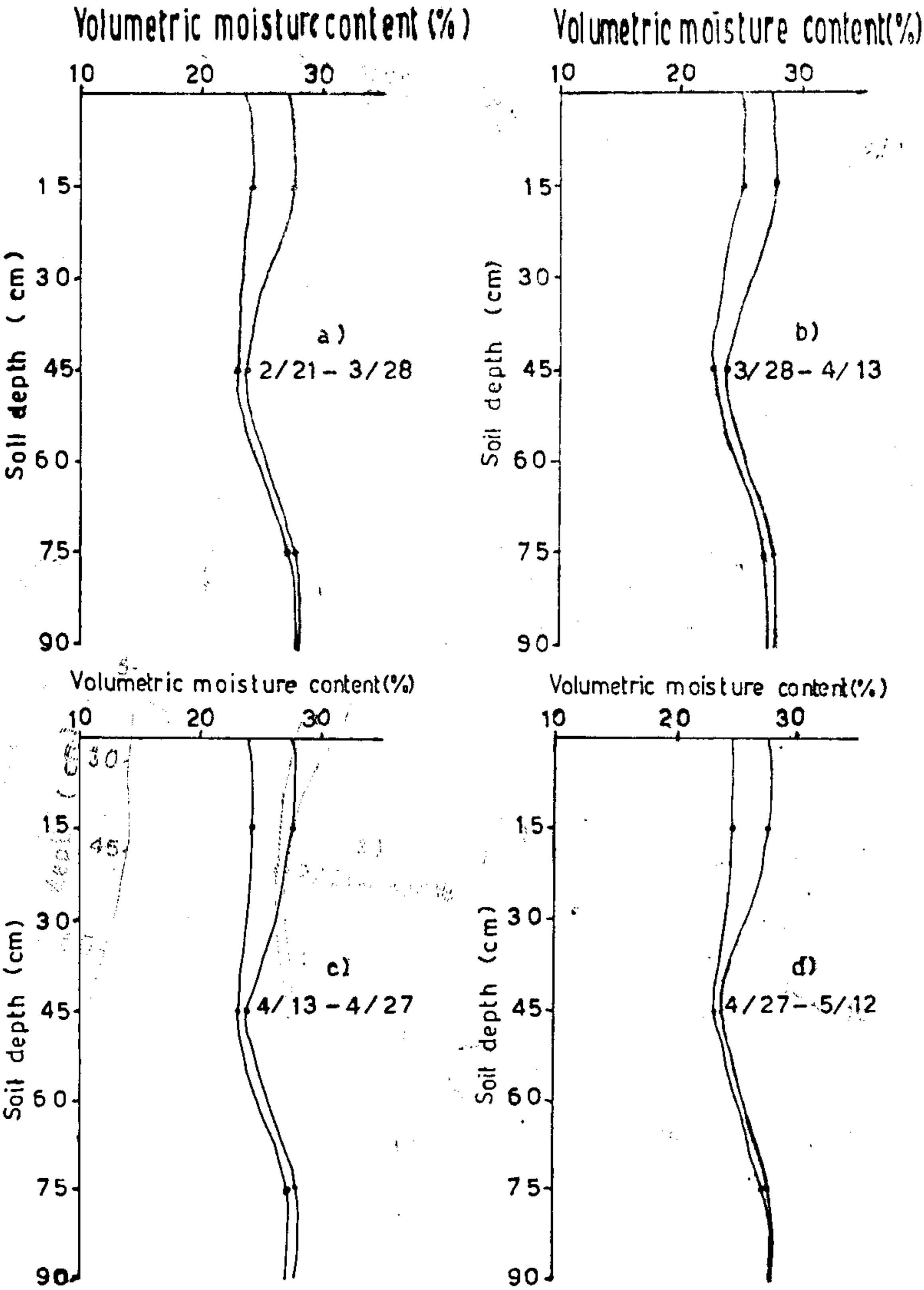

Figure 14 -Soil moisture extraction patterns for treatment T_4 during the season.

Table 10. Average soil moisture extraction percentages(E_x) for treatment T_2 during the season.

Period	depth (cm)	Soil moisture depletion(mm) per layer	Soil moisture depletion(mm) Total	E_x %
2/20 - 2/24	0 - 30	6.09	7.38	82.52
	30 - 60	1.29		17.48
	60 - 90	0.00		0.00
2/26 - 3/3	0 - 30	26.25	31.94	82.19
	30 - 60	4.50		14.09
	60 - 90	1.19		3.73
3/12 - 3/17	0 - 30	12.81	20.88	61.20
	30 - 60	4.50		21.63
	60 - 90	13.57		17.16
3/19 - 3/21	0 - 30	9.45	16.32	57.90
	30 - 60	4.50		27.57
	60 - 90	2.37		14.52
3/23 - 3/31	0 - 30	13.92	22.77	62.23
	30 - 60	6.48		28.46
	60 - 90	2.37		10.41
4/2 - 4/6	0 - 30	19.05	27.81	68.50
	30 - 60	5.19		18.66
	60 - 90	3.57		12.84
4/7 - 4/11	0 - 30	14.58	20.28	71.89
	30 - 60	4.50		22.19
	60 - 90	1.20		5.92
4/13 - 4/18	0 - 30	14.58	22.11	65.94
	30 - 60	4.50		20.35
	60 - 90	3.03		13.70

Table 18 (continued).

Period	depth (cm)	Soil moisture depletion(mm) per layer	Total	%
	0 - 30	8.97		67.19
4/20 - 4/23	30 - 60	3.18	13.35	23.82
	60 - 90	1.20		8.99
	0 - 30	19.05		62.93
4/25 - 4/28	30 - 60	6.48	30.27	21.41
	60 - 90	4.74		15.66
	0 - 30	10.08		83.79
4/30 - 5/2	30 - 60	1.29	12.03	10.72
	60 - 90	0.66		5.49
	0 - 30	12.33		82.70
5/5 - 5/9	30 - 60	2.58	14.91	17.30
	60 - 90	0.00		0.00
	0 - 30	5.61		81.30
5/11 - 5/12	30 - 60	1.29	6.90	18.70
	60 - 90	0.00		0.00

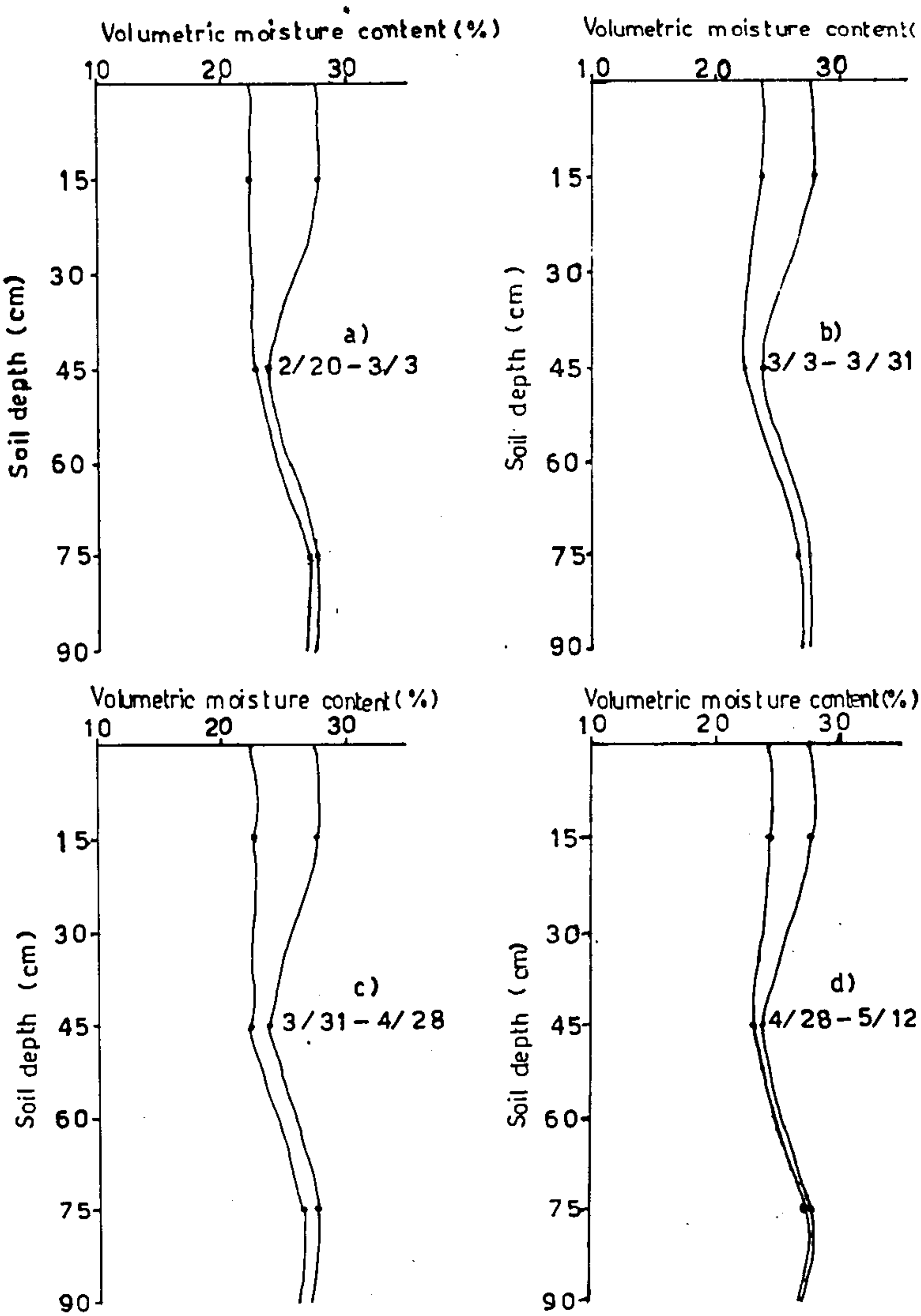

Figure 15 - Soil moisture extraction patterns for treatment T_2 during the season .

Table 19. Average soil moisture extraction percentages (E_x) for treatment T_3 during the season

Period	depth (cm)	Soil moisture depletion(mm) per layer	Soil moisture depletion(mm) Total	E_x %
	0 - 30	6.72		83.90
2/20 - 2/24	30 - 60	1.29	8.01	16.10
	60 - 90	0.00		0.00
	0 - 30	12.33		79.19
2/26 - 3/3	30 - 60	2.58	15.57	16.57
	60 - 90	0.66		4.23
	0 - 30	18.42		72.84
12/3 - 3/19	30 - 60	4.50	25.29	17.79
	60 - 90	2.37		9.37
	0 - 30	19.53		63.89
3/23 - 3/31	30 - 60	7.08	30.57	23.16
	60 - 90	3.96		12.95
	0 - 30	17.28		67.92
4/2 - 4/6	30 - 60	5.79	25.44	22.76
	60 - 90	2.37		12.95
	0 - 30	16.17		71.77
4/7 - 4/11	30 - 60	4.50	22.53	19.97
	60 - 90	1.86		8.26
	0 - 30	17.28		71.55
4/13 - 4/20	30 - 60	4.50	24.15	18.63
	60 - 90	2.37		9.81

Table 19 (continued) .

Period	depth (cm)	Soil moisture depletion (mm) per layer	Total	E_x %
4/22 - 4/25	0 - 30	13.44	18.48	72.73
	30 - 60	3.18		17.21
	60 - 90	1.86		10.06
4/27 - 4/29	0 - 30	8.97	10.92	82.14
	30 - 60	1.29		11.81
	60 - 90	0.66		6.04
4.30 - 5/2	0 - 30	7.83	9.78	80.06
	30 - 60	1.29		13.19
	60 - 90	0.66		6.75
5/5 - 5/9	0 - 30	10.08	13.23	76.19
	30 - 60	1.29		9.75
	60 - 90	1.86		14.06
5/11 - 5/14	0 - 30	12.81	15.36	83.40
	30 - 60	1.89		12.30
	60 - 90	0.66		4.30

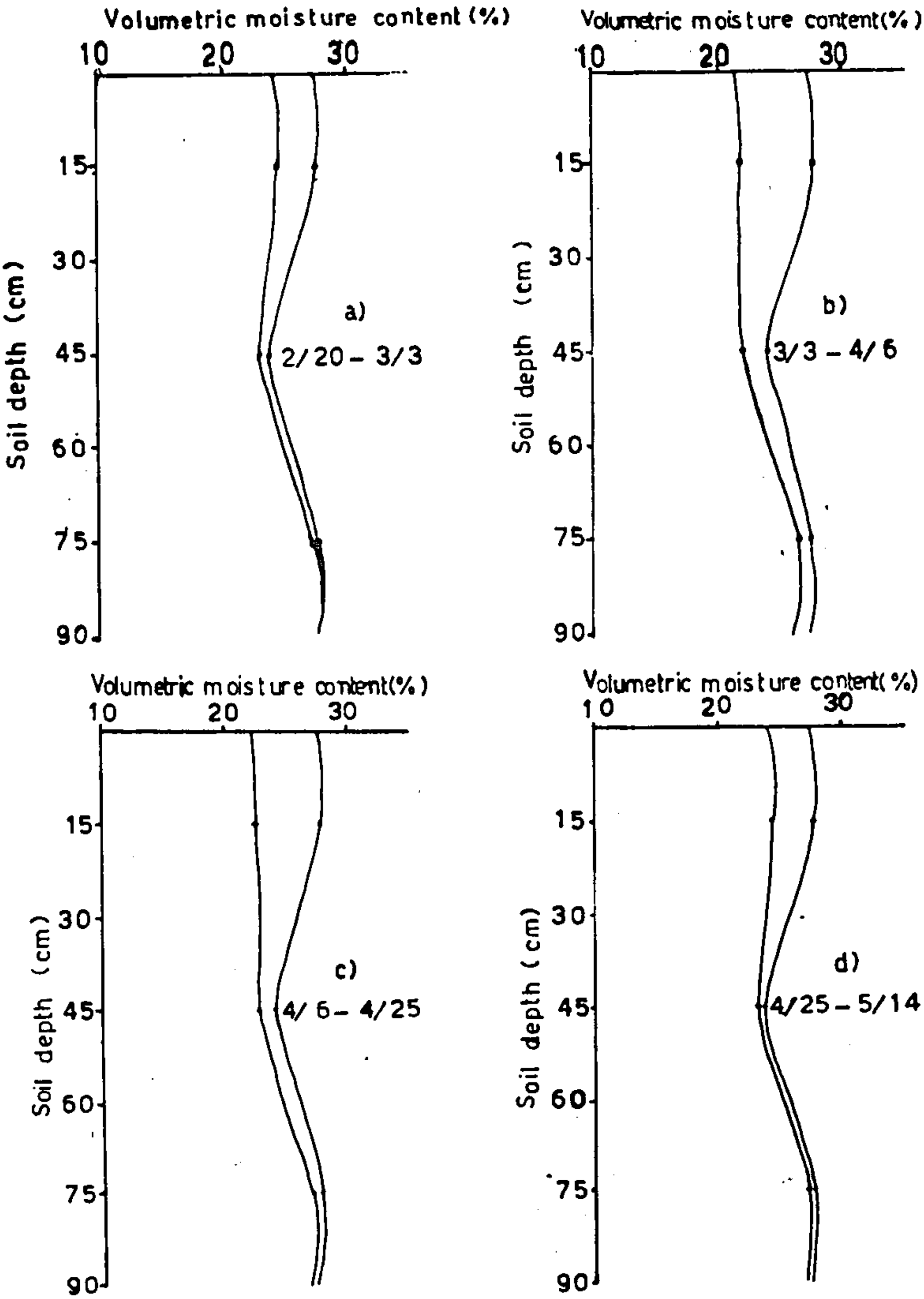

Figure 16 – Soil moisture extraction patterns for treatment T_3 during the season .

Table 20. Average soil moisture extraction percentages (E_x) for treatment T_4 during the season.

Period	depth (cm)	Soil moisture depletion (mm) per layer	Soil moisture depletion (mm) Total	E_x %
2/20 - 2/26	0 - 30	9.45	11.40	82.89
	30 - 60	1.29		11.32
	60 - 90	0.66		5.79
2/28 - 3/5	0 - 30	18.42	25.98	70.90
	30 - 60	5.19		19.98
	60 - 90	2.37		9.12
3/12 - 3/19	0 - 30	17.28	24.84	69.57
	30 - 60	5.19		20.89
	60 - 90	2.37		9.54
3/23 - 4/4	0 - 30	26.91	44.73	60.16
	30 - 60	13.59		30.38
	60 - 90	4.23		9.46
4/5 - 4/9	0 - 30	12.33	20.64	59.74
	30 - 60	6.45		31.23
	60 - 90	1.86		9.01
4/10 - 4/13	0 - 30	9.45	15.81	59.77
	30 - 60	4.50		28.46
	60 - 90	1.86		11.76
4/15 - 4/20	0 - 30	13.44	16.53	81.31
	30 - 60	1.89		11.43
	60 - 90	1.20		7.26

Table 20 (continued).

Period	depth (cm)	Soil moisture depletion(mm) per layer	Total	$\bar{E}_x$ %
	0 - 30	13.92		84.52
4/22 - 4/27	30 - 60	1.89	16.47	11.47
	60 - 90	0.66		4.01
	0 - 30	9.45		82.89
4/29 - 5/2	30 - 60	1.29	11.40	11.32
	60 - 90	0.66		5.79
	0 - 30	11.70		90.07
5/3 - 5/9	30 - 60	1.29	12.99	9.33
	60 - 90	0.00		0.00
	0 - 30	14.58		91.87
5/11 - 5/18	30 - 60	1.29	15.87	8.13
	60 - 90	0.00		0.00

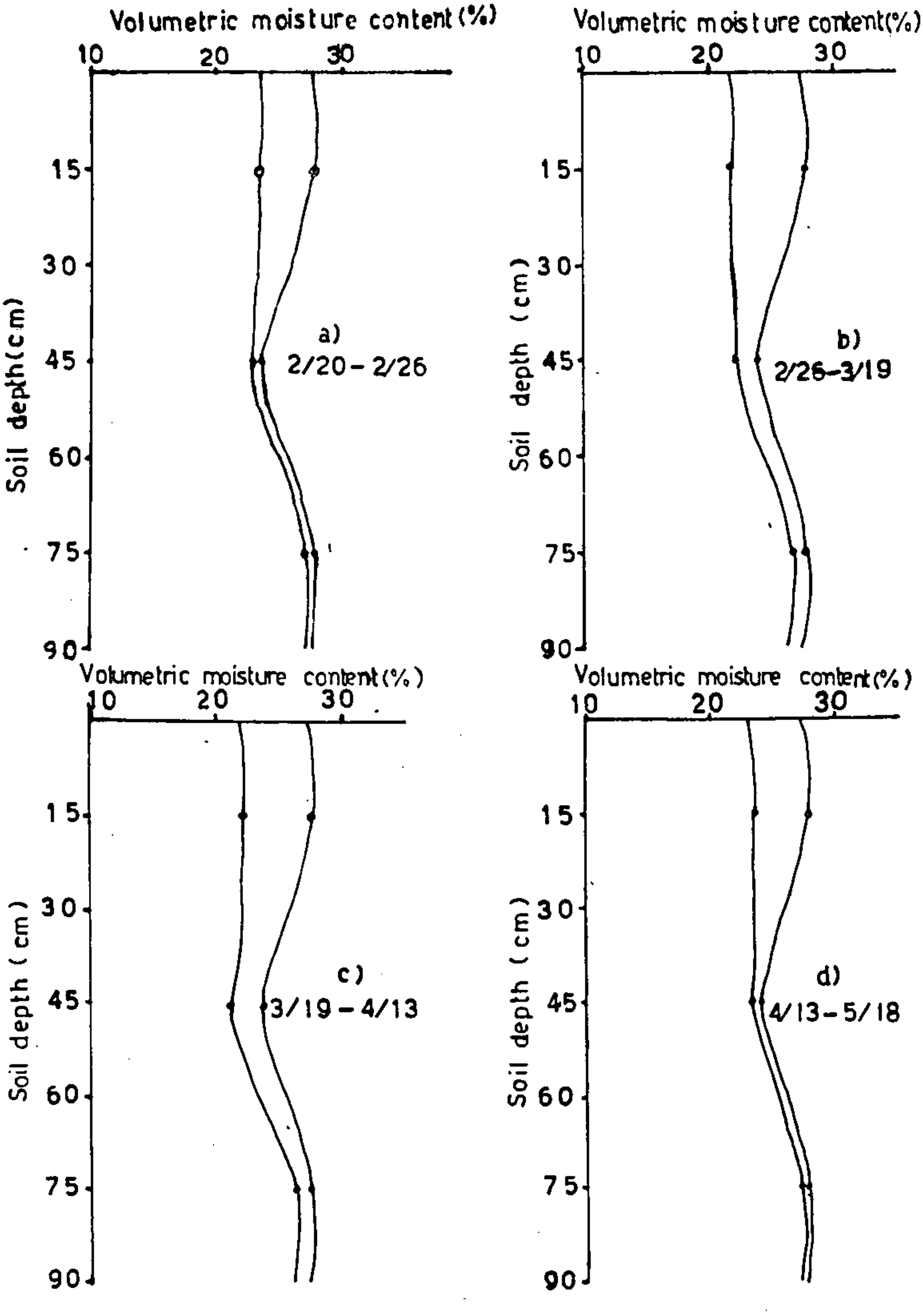

Figure 17 - Soil moisture extraction patterns for treatment T_4 during the season.

to total amount of available water in the root zone (E_{xa}) for the four treatments are shown in table 21. The values of both E_{xa} and the soil moisture extraction percentages from the upper 30 cm layer (E_{x30}) are very important in calculation the usable evapotranspiration (ET_u) using the following equation :

$$ET_u = \frac{E_{xa} \times \text{Total available water in the root zone}}{E_{x30}} \quad \ldots\ldots [12]$$

6. Scheduling Irrigation:

By using the values of both K_c, E_{xa}, and E_{x30}, one can schedule irrigation .

For example, to schedule irrigation for treatment T_4 at 50 cb, one can proceed as follows :

The usable evapotranspiration can be calculated using equation [12] and data from tables 20 and 21.

$$ET_u = \frac{15.37 \times 92.43}{82.89} = 17.14 \text{ mm for the period(2/20-2/26).}$$

The equivalent of pan evaporation can be calculated using equation [11] and data from table 16.

$$E_p = \frac{17.14}{0.76} = 22.55 \text{ mm for the same period.}$$

Thus the irrigation schedule for treatment T_4 will be as shown in table 22.

7. Hydro-probe Calibration:

The calibration curves and the equations for the following different depths: 0 - 30 cm, 30 - 60 cm, and 60 - 90 cm, are

Table 21 . The percentage of soil moisture extracted from the upper 30cm. layer to available water in the root zone(E_{xa}) .

Treat-ments	Soil moisture tension ([illegible])	Average soil moisture extracted from(0-30cm) (mm)	Amount of available water(0-90cm) (mm)	E_{xa} %
T_1	20	9.50	92.43	10.28
T_2	30	13.29	92.43	14.38
T_3	40	13.35	92.43	14.44
T_4	50	14.21	92.43	15.37

Table 22. Scheduling irrigation for treatment T_4 .

Period	K_c	E_{x30}	E_{xa}	Available water in the root zone (mm)	ET_u * (mm)	E_p ** (mm)
12/20 - 2/5	0.30	86.13	15.37	92.43	16.49	54.97
2/5 - 2/20	0.36	82.89	15.37	92.43	17.14	47.61
2/20 - 2/26	0.76	82.89	15.37	92.43	17.14	22.55
2/26 - 3/19	1.15	70.24	15.37	92.43	20.23	17.59
3/19 - 4/13	0.94	59.89	15.37	92.43	23.72	25.23
4/13 - 4/27	0.57	86.13	15.37	92.43	16.49	28.93
4/27 - 5/18	0.30	86.13	15.37	92.43	16.49	54.97

* ET_u = amount of water applied in each irrigation (assuming that application efficiency is 100 %).

** E_p = accumulated amount of pan evaporation between irrigations .

presented in table 23 and in figure 18. The regression lines were obtained by plotting the volumetric moisture content of each 30 cm increments against the ratio of the hydro-probe counts (field count divided by standard count). The results show that there were deviations in the calibration curves due to variation in soil texture and bulk density. These deviations are consistent with the findings of other researchers(Gornat and Goldberg, 1972 ; and Lal, 1974).

Table 23. The calibration curve equations for three soil depths.

Layer depth (cm)	Bulk density (gm/cm3)	Textural Classes	equation	r
0 - 30	1.46	Sandy Clay Loam	$R^{*} = 0.2907982 + 0.02618\ Pv^{**}$	0.99
30 - 60	1.58	Sandy Loam	$R = 0.5200602 + 0.023084\ Pv$	0.97
60 - 90	1.56	Sandy Clay Loam	$R = 0.4307898 + 0.0253952\ Pv$	0.99

* R = Ratio of hydro-probe counts .

** Pv= Soil moisture content (% by volume) .

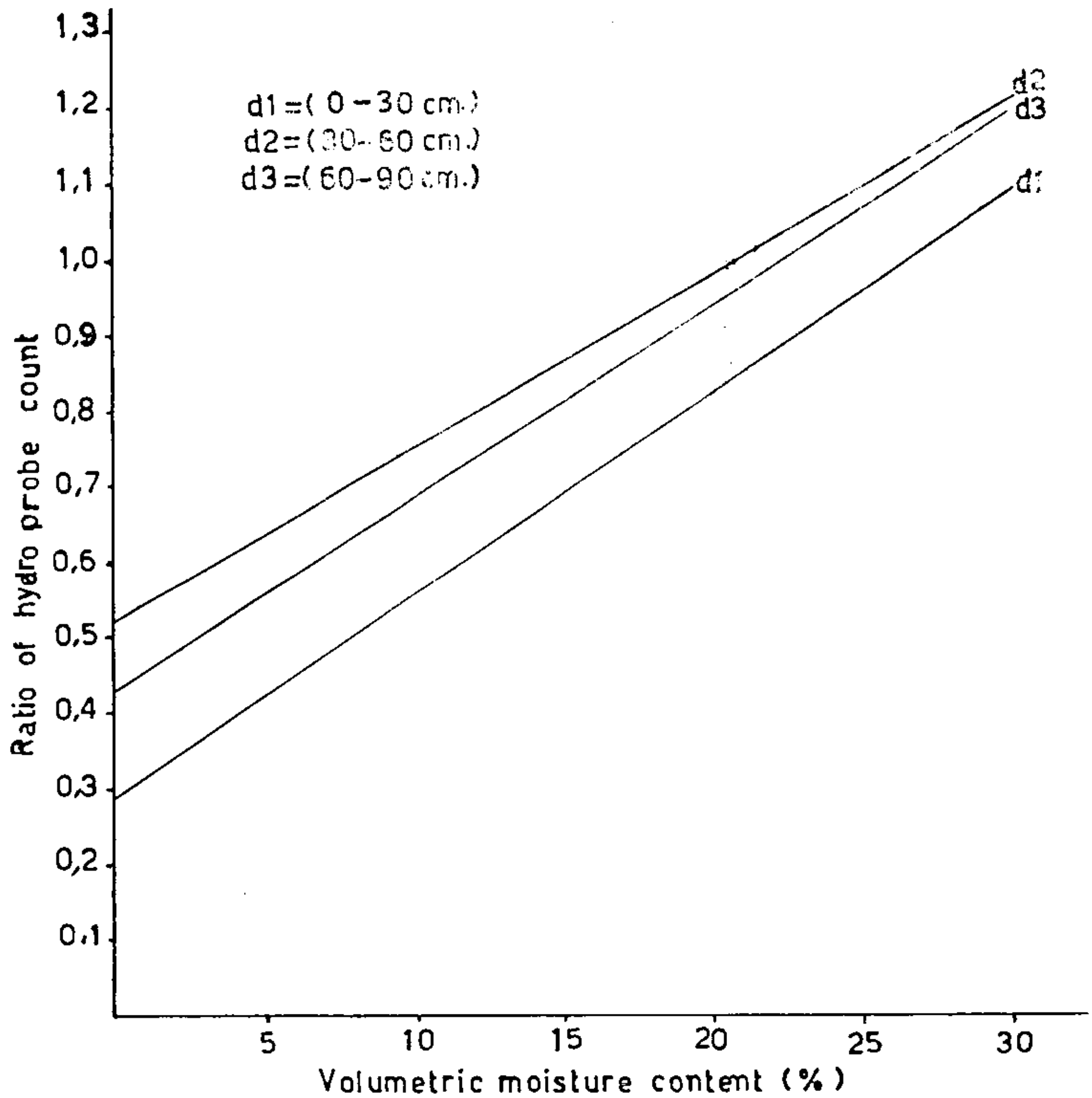

Figure 18 - the calibration curves of hydro-probe for different depths

SUMMARY AND CONCLUSION

Optimizing water use efficiency in the Jordan Valley in order to increase the irrigated area entails a proper irrigation schedule.

This study, was carried out in order :

a. to develop a simple procedure to schedule drip irrigation for tomato crop in the Jordan Valley using class-A evaporation pan, by determining an appropriate constant that relates pan evaporation to evoptranspiration requirements, and

b. to study the effect of different soil moisture tensions (20, 30, 40, and 50 centribars) under drip irrigation on tomato yield.

The results obtained may be summarized as follows :-

1. Tomato can be irrigated by drip when the soil moisture tension reaches 50 centibars with no significant differences in yields compared to the lower tension treatments (20, 30, and 40 cb).

2. The water applied and consumptive use (CU) were found to decrease with increasing soil moisture tension (CU 451 mm for treatment T_1 and 298 mm for treatment T_4). The daily average rate of consumptive use was found to decrease with increasing soil moisture tension (6.6 mm/day for treatment T_1 and 3.6mm/day for treatment T_4).

3. Crop coefficient (K_c) had increased rapidly to a maximum during the flowering stage (from 0.41 to 1.19 for treatment T_4), and then declined at the end of the season to reach a value of 0.26 for the same treatment .

4. The soil moisture extraction percentages were found to be in four different patterns during the season. The soil moisture extraction percentage from the upper 30 cm. layer (E_{x30}) was found to be the highest. The ratio (E_{xa}) of the average amount of soil moisture extracted from this layer to total available water in the root zone was found to increase with decreasing soil moisture tension (10.28 for treatment T_1 and 15.37 for treatment T_4).
5. It was found that one can schedule irrigation by using the obtained values of K_c , E_{xa}, and E_{x30} .
6. The hydro-probe calibration curves were found to be affected by variation in the bulk density and soil texture through the soil profile .

SUGGESTIONS FOR FURTHER RESEARCH

It is belived that if further research efforts are carried out in the Jordan Valley, to deal with scheduling irrigation, the following should be considered.

1. For exactly similar studies the effective area of the plot should not be less than 100 m^2 so as to get more dependable yield data . And that each plot should have a tensiometer so as to account for soil variation. Each tensiometer should have been calibrated in order to determine the actual amounts of water to be applied for each plot. Besides, the deep percolation losses should be exactly measured.
2. The effect of dates of planting on evapotranspiration rates should be considered .
3. The effects of both microclimatic and soil differences on evapotranspiration, in the Jordan Valley, should be studied in order to be able to apply effective irrigation scheduling .
4. Similar studies using different irrigation methods should be carried out for the major crops grown in the Jordan Valley .

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Table 24. A four by four latin square, treatments, and tomato yields (ton/dun).

Row	Column I	Column II	Column III	Column IV
I	T_2 8.55	T_4 5.24	T_1 7.33	T_3 5.33
II	T_3 5.60	T_2 8.45	T_4 7.14	T_1 10.48
III	T_4 6.98	T_1 9.32	T_3 8.38	T_2 7.72
IV	T_1 7.68	T_3 9.32	T_2 7.71	T_4 7.76

Table 25. A four by four latin square, treatments, and total evapotranspiration (mm).

Row	Column I	Column II	Column III	Column IV
I	T_2 420	T_4 282	T_1 473	T_3 331
II	T_3 334	T_2 414	T_4 306	T_1 473
III	T_4 290	T_1 431	T_3 361	T_2 388
IV	T_1 425	T_3 367	T_2 383	T_4 311

Table 26. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_1 replication 1.

	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/21 - 2/24	0 - 30	1.04	28.00	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/28 - 3/3	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/17	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/19 - 3/21	0 - 30	1.04	28.00	0.93	23.88
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/23 - 3/28	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
3/30 - 3/31	0 - 30	1.03	27.62	0.96	25.01
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.14	27.93	1.13	27.54
4/2 - 4/4	0 - 30	1.04	28.00	0.90	22.76
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.14	27.93	1.11	26.75
4/6 - 4/7	0 - 30	1.04	28.00	0.99	26.13
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/11 - 4/13	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/14 - 4/16	0 - 30	1.04	28.00	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 26 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/18 - 4/20	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/22 - 4/23	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/25 - 4/27	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/29 - 4/30	0 - 30	1.04	28.00	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/2 - 5/5	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
5/7 - 5/9	0 - 30	1.04	28.00	0.96	25.01
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.13	27.54
5/11 - 5/12	0 - 30	1.04	28.00	0.99	26.13
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.14	27.93

Table 27. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_1 replication 2.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/21 - 2/24	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/28 - 3/3	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/17	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
3/19 - 3/21	0 - 30	1.04	28.00	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/23 - 3/28	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/30 - 3/31	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.07	23.82	1.04	22.52
	60 - 90	1.14	27.93	1.13	27.54
4/2 - 4/4	0 - 30	1.04	28.00	0.90	22.76
	30 - 60	1.08	24.26	1.02	21.66
	60 - 90	1.13	27.54	1.11	26.75
4/6 - 4/7	0 - 30	1.04	28.00	1.00	26.50
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/11 - 4/13	0 - 30	1.04	28.00	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/14 - 4/16	0 - 30	1.04	28.00	0.93	23.88
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 27 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_1
4/18 - 4/20	0 - 30	1.04	28.00	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/22 - 4/23	0 - 30	1.04	28.00	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/25 - 4/27	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/29 - 4/30	0 - 30	1.04	28.00	0.93	23.88
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/2 - 5/5	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/2 - 5/9	0 - 30	1.04	28.00	0.97	25.38
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.13	27.54
5/11 - 5/12	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.14	27.93

Table 28. Hydro-probe ratios (R) and computed values of volumetric soil soil moisture percentage (Pv) at different depths during corresponding period for treatment T_1 replication 3.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/21 - 2/24	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/28 - 3/3	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/17	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/19 - 3/21	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/23 - 3/28	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/30 - 3/31	0 - 30	1.03	27.62	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/2 - 4/4	0 - 30	1.04	28.00	0.90	22.76
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.13	27.54	1.11	26.75
4/6 - 4/7	0 - 30	1.03	27.62	1.00	26.50
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/11 - 4/13	0 - 30	1.03	27.62	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 28(Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/14 - 4/16	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/18 - 4/20	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/22 - 4/23	0 - 30	1.03	27.62	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/25 - 4/27	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/29 - 4/30	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/2 - 5/5	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.13	27.54
5/7 - 5/9	0 - 30	1.03	27.62	0.97	25.38
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.13	27.54
5/11 - 5/12	0 - 30	1.04	28.00	0.99	26.13
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.14	27.93

Table 29. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_1 replication 4.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/21 - 2/24	0 - 30	1.04	28.00	0.99	26.13
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/28 - 3/3	0 - 30	1,03	27.62	0.93	23.88
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/17	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
3/19 - 3/21	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/23 - 3/28	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.13	27.54
3/30 - 3/31	0 - 30	1.03	27.62	0.96	25.01
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/2 - 4/4	0 - 30	1.04	28.00	0.90	22.76
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
4/6 - 4/7	0 - 30	1.04	28.00	1.00	26.50
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
4/11 - 4/13	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93

Table 29(Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/14 - 4/16	0 - 30	1.04	28.00	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/18 - 4/20	0 - 30	1.04	28.00	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.14	27.93
4/22 - 4/23	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
4/25 - 4/27	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
4/29 - 4/30	0 - 30	1.04	28.00	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/2 - 5/5	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/7 - 5/9	0 - 30	1.04	28.00	0.97	25.38
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.14	27.93
5/11 - 5/12	0 - 30	1.04	28.00	1.00	26.50
	30 - 60	1.08	24.26	1.07	23.82
	60 - 90	1.14	27.93	1.14	27.93

Table 30. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depth during corresponding periods for treatment T_2 replication 1.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/26 - 3/3	0 - 30	1.04	28.00	0.80	19.03
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.12	27.14
3/12 - 3/17	0 - 30	1.04	28.00	0.92	23.51
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.10	26.35
3/19 - 3/21	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.07	23.82	1.01	21.22
	60 - 90	1.13	27.54	1.11	26.75
4/2 - 4/6	0 - 30	1.03	27.62	0.86	21.27
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.14	27.93	1.10	26.35
4/7 - 4/11	0 - 30	1.03	27.62	0.90	22.76
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.54	1.12	27.14
4/13 - 4/18	0 - 30	1.03	27.62	0.90	22.76
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.14	27.93	1.11	26.75
4/20 - 4/23	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.14	27.93	1.12	27.14

Table 30 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/25 - 4/28	0 - 30	1.03	27.62	0.86	21.27
	30 - 60	1.07	23.62	1.02	21.66
	60 - 90	1.13	27.54	1.08	25.57
4/30 - 5/2	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.12	27.14
5/5 - 5/9	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
5/11 - 5/12	0 - 30	1.03	27.62	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 31. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_2 replication 2.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.04	28.00	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/26 - 3/3	0 - 30	1.04	28.00	0.80	19.03
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.12	27.14
3/12 - 3/17	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.10	26.35
3/19 - 3/21	0 - 30	1.04	28.00	0.94	24.26
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.13	27.54	1.11	26.75
4/2 - 4/6	0 - 30	1.04	28.00	0.86	21.27
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.10	26.35
4/7 - 4/11	0 - 30	1.04	28.00	0.90	22.76
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.12	27.14
4/13 - 4/18	0 - 30	1.03	27.62	0.89	22.39
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.11	26.75
4/20 - 4/23	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.12	27.14

Table 31 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
	0 - 30	1.03	27.62	0.86	21.27
4/25 - 4/28	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.13	27.54	1.09	25.96
	0 - 30	1.03	27.62	0.94	24.26
4/30 - 5/2	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
	0 - 30	1.04	28.00	0.92	23.51
5/5 - 5/9	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.13	27.54	1.13	27.54
	0 - 30	1.04	28.00	0.98	25.75
5/11 - 5/12	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.13	27.54	1.13	27.54

Table 32. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_2 replication 3.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.04	28.00	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/26 - 3/3	0 - 30	1.04	28.00	0.80	19.03
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.12	27.14
3/12 - 3/17	0 - 30	1.04	28.00	0.92	23.51
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.10	26.35
3/19 - 3/21	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
4/2 - 4/6	0 - 30	1.03	27.62	0.86	21.27
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.10	26.35
4/7 - 4/11	0 - 30	1.03	27.62	0.90	22.76
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.12	27.14
4/13 - 4/18	0 - 30	1.03	27.62	0.90	22.76
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.14	27.93	1.11	26.75
4/20 - 4/23	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.12	27.14

Table 32(Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/25 - 4/28	0 - 30	1.03	27.62	0.86	21.27
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.13	27.54	1.10	26.35
4/30 - 5/2	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
5/5 - 5/9	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.13	27.54	1.13	27.54
5/11 - 5/12	0 - 30	1.03	27.62	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.13	27.54	1.13	27.54

Table 33. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_2 and replication 4.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.04	28.00	0.99	26.13
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/26 - 3/3	0 - 30	1.04	28.00	0.80	19.03
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.12	27.14
3/12 - 3/17	0 - 30	1.04	28.00	0.93	23.88
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.10	26.35
3/19 - 3/21	0 - 30	1.04	28.00	0.96	25.01
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.13	27.54	1.11	26.75
4/2 - 4/6	0 - 30	1.03	27.62	0.87	21.64
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.10	26.35
4/7 - 4/11	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.12	27.14
4/13 - 4/18	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.11	26.75
4/20 - 4/23	0 - 30	1.03	27.62	0.96	25.01
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.12	27.14

Table 33 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/25 - 4/28	0 - 30	1.03	27.62	0.86	21.27
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.13	27.54	1.09	25.96
4/30 - 5/2	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/5 - 5/9	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.13	27.54	1.13	27.54
5/11 - 5/12	0 - 30	1.03	27.62	0.99	26.13
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.13	27.54	1.13	27.54

Table 34. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_3 replication 1.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.03	27.62	0.98	25.75
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/26 - 3/3	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/19	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.08	24.26	1.02	21.66
	60 - 90	1.13	27.54	1.10	26.35
4/2 - 4/6	0 - 30	1.04	28.00	0.89	22.39
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
4/7 - 4/11	0 - 30	1.03	27.62	0.89	22.39
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.12	27.14
4/13 - 4/20	0 - 30	1.04	28.00	0.89	22.39
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
4/22 - 4/25	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.12	27.14
4/27 - 4/29	0 - 30	1.03	27.62	0.96	25.01
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 34 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/30 - 5/2	0 -30	1.03	27.62	0.96	25.01
	30 -60	1.07	23.82	1.07	23.82
	60 -90	1.14	27.93	1.13	27.54
5/5 - 5/9	0 -30	1.03	27.62	0.95	24.63
	30 -60	1.07	23.82	1.06	23.39
	60 -90	1.14	27.93	1.12	27.14
5/11 - 5/14	0 -30	1.04	28.00	0.93	23.88
	30 -60	1.08	24.26	1.06	23.39
	60 -90	1.14	27.93	1.13	27.54

Table35. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_3 replication 2.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.03	27.62	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/26 - 3/3	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/19	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.86	21.27
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.10	26.35
4/2 - 4/6	0 - 30	1.04	28.00	0.88	22.02
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
4/7 - 4/11	0 - 30	1.04	28.00	0.89	22.39
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.12	27.14
4/13 - 4/20	0 - 30	1.04	28.00	0.88	22.02
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.11	26.75
4/22 - 4/25	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.13	27.54	1.12	27.14
4/27 - 4/29	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 35 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/30 - 5/2	0 - 30	1.03	27.62	0.96	25.01
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/5 - 5/9	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/11 - 5/14	0 - 30	1.04	28.00	0.92	23.51
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 36. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_3 replication 3.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.04	28.00	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/26 - 3/3	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/19	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.85	20.90
	30 - 60	1.08	24.26	1.02	21.66
	60 - 90	1.13	27.54	1.10	26.35
4/2 - 4/6	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
4/7 - 4/11	0 - 30	1.04	28.00	0.89	22.39
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.12	27.14
4/13 - 4/20	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
4/22 - 4/25	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.08	24.26	1.05	22.96
	60 - 90	1.14	27.93	1.12	27.14
4/27 - 4/29	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 36 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/30 - 5/2	0 - 30	1.03	27.62	0.96	25.01
	30 - 60	1.07	23.82	1.05	22.96
	60 - 90	1.14	27.93	1.13	27.54
5/5 - 5/9	0 - 30	1.03	27.62	0.93	23.08
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.12	27.14
5/11 - 5/14	0 - 30	1.04	28.00	0.92	23.51
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 37. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentate (Pv) at different depths during corresponding periods for treatment T_3 replication 4.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/24	0 - 30	1.03	27.62	0.97	25.38
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
2/26 - 3/3	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.04	22.52
	60 - 90	1.14	27.93	1.13	27.54
3/12 - 3/19	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 3/31	0 - 30	1.04	28.00	0.86	21.27
	30 - 60	1.08	24.26	1.01	21.22
	60 - 90	1.13	27.54	1.10	26.35
4/2 - 4/6	0 - 30	1.04	28.00	0.88	22.02
	30 - 60	1.08	24.26	1.02	21.66
	60 - 90	1.13	27.54	1.11	26.75
4/7 - 4/11	0 - 30	1.04	28.00	0.88	22.02
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.12	27.14
4/13 - 4/20	0 - 30	1.04	28.00	0.88	22.02
	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
4/22 - 4/25	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.12	27.14
4/27 - 4/29	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 37 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
4/30 - 5/2	0 - 30	1.03	27.62	0.96	25.01
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
5/5 - 5/9	0 - 30	1.03	27.62	0.94	24.26
	30 - 60	1.07	23.82	1.06	22.96
	60 - 90	1.14	27.93	1.11	26.75
5/11 - 5/14	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 38. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_4 replication 1.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/26	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
2/28 - 3/5	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.07	23.82	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
3/12 - 3/19	0 - 30	1.04	28.00	0.88	22.02
	30 - 60	1.07	23.82	1.04	22.52
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 4/4	0 - 30	1.03	27.62	0.79	18.65
	30 - 60	1.07	23.82	0.97	19.49
	60 - 90	1.13	27.54	1.10	26.35
4/5 - 4/9	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.14	27.93	1.12	27.14
4/10 - 4/13	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.13	27.54	1.12	27.14
4/15 - 4/20	0 - 30	1.03	27.62	0.92	23.51
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.13	27.54	1.12	27.14
4/22 - 4/27	0 - 30	1.04	28.00	0.91	22.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.13	27.54	1.13	27.54
4/29 - 5/2	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.13	27.54	1.13	27.54

Table 36 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
5/3 - 5/9	0 - 30	1.04	28.00	0.94	24.26
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
5/11 - 5/18	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93

Table 39. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage(Pv) at different depths during corresponding periods for treatment T_4 replication 2.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/26	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
2/28 - 3/5	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.14	27.93	1.11	26.75
3/12 - 3/19	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 4/4	0 - 30	1.03	27.62	0.78	18.28
	30 - 60	1.08	24.26	0.97	19.49
	60 - 90	1.14	27.93	1.10	26.35
4/5 - 4/9	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.14	27.93	1.12	27.14
4/10 - 4/13	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.12	27.14
4/15 - 4/20	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.13	27.54	1.12	27.14
4/22 - 4/27	0 - 30	1.04	28.00	0.91	23.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/29 - 5/2	0 - 30	1.04	28.00	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 39 (Continued)

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
5/3 - 5/9	0 - 30	1.04	28.00	0.92	23.51
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
5/11 - 5/18	0 - 30	1.03	27.62	0.89	22.39
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93

Table 40. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_4 replication 3.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
2/20 - 2/26	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
2/28 - 3/5	0 - 30	1.04	28.00	0.87	21.64
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
3/12 - 3/19	0 - 30	1.04	28.00	0.89	22.39
	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.13	27.54	1.11	26.75
3/23 - 4/4	0 - 30	1.03	27.62	0.80	19.03
	30 - 60	1.08	24.26	0.97	19.49
	60 - 90	1.14	27.93	1.10	26.35
4/5 - 4/9	0 - 30	1.03	27.62	0.93	23.88
	30 - 60	1.07	23.82	1.02	21.66
	60 - 90	1.14	27.93	1.12	27.14
4/10 - 4/13	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.12	27.14
4/15 - 4/20	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.13	27.54	1.12	27.14
4/22 - 4/27	0 - 30	1.03	27.62	0.91	23.14
	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
4/29 - 5/2	0 - 30	1.03	27.62	0.95	24.63
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 40 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
	0 - 30	1.04	28.00	0.93	23.88
5/3 - 5/9	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
	0 - 30	1.03	27.62	0.90	22.76
5/11 - 5/18	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93

Table 41. Hydro-probe ratios (R) and computed values of volumetric soil moisture percentage (Pv) at different depths during corresponding periods for treatment T_4 replication 4.

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
	0 - 30	1.04	28.00	0.94	24.26
2/20 - 2/26	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
	0 - 30	1.04	28.00	0.87	21.64
2/28 - 3/5	30 - 60	1.07	23.82	1.03	22.09
	60 - 90	1.14	27.93	1.11	26.75
	0 - 30	1.04	28.00	0.88	22.02
3/12 - 3/19	30 - 60	1.08	24.26	1.03	22.09
	60 - 90	1.14	27.93	1.11	26.75
	0 - 30	1.03	27.62	0.79	18.65
3/23 - 4/4	30 - 60	1.08	24.26	0.96	19.06
	60 - 90	1.14	27.93	1.10	26.35
	0 - 30	1.03	27.62	0.92	23.51
4/5 - 4/9	30 - 60	1.07	23.82	1.01	21.22
	60 - 90	1.14	27.93	1.12	27.14
	0 - 30	1.04	28.00	0.94	24.26
4/10 - 4/13	30 - 60	1.08	24.26	1.04	22.52
	60 - 90	1.14	27.93	1.12	27.14
	0 - 30	1.03	27.62	0.91	23.14
4/15 - 4/20	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.12	27.14
	0 - 30	1.04	28.00	0.90	22.76
4/22 - 4/27	30 - 60	1.08	24.26	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54
	0 - 30	1.04	28.00	0.94	24.26
4/29 - 5/2	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.13	27.54

Table 41 (Continued).

Period	Soil depth (cm)	R_1	Pv_1	R_2	Pv_2
5/3 - 5/9	0 - 30	1.04	28.00	0.93	23.88
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93
5/11 - 5/18	0 - 30	1.03	27.62	0.90	22.76
	30 - 60	1.07	23.82	1.06	23.39
	60 - 90	1.14	27.93	1.14	27.93

Appendix C

Pan evaporation data

Table 42. Pan evaporation values for the corresponding periods .

Period	Pan evaporation (mm.)	period	Pan evaporation (mm.)
2/20 - 2/21	6.66	4/13 - 4/14	5.60
2/21 - 2/24	10.91	4/14 - 4/15	6.34
2/24 - 2/26	10.23	4/15 - 4/16	6.25
2/26 - 2/28	7.76	4/16 - 4/18	12.28
2/28 - 3/3	13.67	4/18 - 4/20	16.64
3/3 - 3/5	9.95	4/20 - 4/21	6.25
3/5 - 3/7	6.84	4/21 - 4/22	5.08
3/7 - 3/10	rainfall	4/22 - 4/23	6.85
3/10 - 3/12	7.46	4/23 - 4/25	16.12
3/12 - 3/14	5.41	4/25 - 4/27	16.24
3/14 - 3/17	7.63	4/27 - 4/28	11.34
3/17 - 3/19	7.83	4/28 - 4/29	11.89
3/19 - 3/21	10.16	4/29 - 4/30	17.99
3/21 - 3/23	12.55	4/30 - 5/2	22.70
3/23 - 3/26	4.25	5/2 - 5/3	10.04
3/26 - 3/28	5.92	5/3 - 5/5	16.06
3/28 - 3/30	8.92	5/5 - 5/7	16.78
3/30 - 3/31	4.51	5/7 - 5/9	18.43
3/31 - 4/2	9.12	5/9 - 5/11	20.24
4/2 - 4/4	14.03	5/11 - 5/12	12.40
4/4 - 4/5	4.98	5/12 - 5/14	17.08
4/5 - 4/6	10.01	5/14 - 5/18	31.56
4/6 - 4/7	5.84		
4/7 - 4/9	10.70		
4/9 - 4/10	7.14		
4/10 - 4/11	10.62		
4/11 - 4/13	8.60		

Table 43. Ratios of hydro-probe counts (R) versus determined values of volumetric soil moisture percentage (Pv) for calibration curve of soil layer (0 - 30 cm.).

No.	R	Pv
1	0.64	12.69
2	0.62	13.15
3	0.60	12.28
4	0.65	13.81
5	0.69	15.12
6	0.65	13.79
7	1.25	36.18
8	1.04	27.79
9	0.92	24.39
10	0.88	24.32
11	0.97	23.58
12	0.99	24.73
13	0.91	21.82
14	0.93	22.96
15	0.79	18.05
16	0.95	24.73
17	1.09	31.75
18	1.13	30.73
19	0.95	23.77
20	0.92	23.29
21	1.00	26.78

Table 45. Ratios of hydro-probe counts (R) versus determined values of volumetric soil moisture percentage (Pv) for calibration curve of soil layer (60 - 90 cm.).

No.	R	Pv.
1	0.85	15.57
2	0.82	15.73
3	0.80	14.64
4	0.85	16.71
5	1.10	25.82
6	0.91	18.83
7	0.92	19.61
8	0.96	20.70
9	0.88	17.56
10	0.87	17.27
11	0.85	16.85
12	0.98	21.52
13	0.91	19.20
14	1.08	25.12
15	1.04	23.72
16	1.02	24.04
17	1.01	22.78
18	1.09	25.83
19	0.90	18.78
20	0.90	18.93
21	0.87	17.15
22	1.29	34.16
23	1.17	28.95
24	0.91	18.07
25	0.90	18.75

Table 44. Ratios of hydro-probe counts (R) versus determined values of volumetric soil moisture percentage (Pv) of calibration curve of soil layer (30 - 60 cm.).

No.	R	Pv
1	0.74	10.12
2	0.83	9.20
3	0.76	12.66
4	0.78	8.94
5	0.76	12.59
6	0.78	11.61
7	0.86	12.97
8	0.91	16.93
9	0.83	15.09
10	1.18	28.46
11	0.66	8.96
12	0.80	10.40
13	0.81	12.94
14	0.78	12.14
15	1.00	18.82
16	1.04	21.42
17	0.99	22.39
18	1.00	19.85
19	1.05	22.89
20	0.86	15.20
21	0.79	12.57
22	1.16	27.38
23	1.15	26.92
24	1.03	22.39

الملخص والمضمون

تحديد مواعيد الري للبندورة تحت الري بالتنقيط

رفع كفاءة استعمال الماء في غور الاردن لزيادة المساحة المروية يتطلب برنامج مناسب للري .

وعلية عملت هذه الدراسة (١) لتطوير طريقة مبسطة لتحديد مواعيد ومقادير الري بالتنقيط للبندوره في غور الاردن وذلك باستعمال حوض البخر (أ) عن طريق تقدير ثابت مناسب يربط بين مقدار التبخر ومن حوض البخر واحتياجات البخر ـ النتح .
(٢) كذلك لدراسة تأثير درجات مختلفه من الشد الرطوبي الارضي (٢٠، ٣٠، ٤٠، ٥٠ سنتي بار) على محصول البندورة تحت الري بالتنقيط .
والنتائج المتحصل عليها يمكن تلخيصها فيما يلي :-

١- يمكن ري البندورة بالتنقيط حتى درجة شد رطوبي مقداره ٥٠ سنتي بار دون أن يكون هناك فروق معنويه في المحصول بالمقارنه . مع الري تحت درجات شد رطوبي منخفض (٢٠، ٣٠، ٤٠ سنتي بار) .

٢- وجد ان مقدار الماء المضاف، الاستهلاك المائي يقل بزيادة الشد الرطوبي الارضي (٤٥٠مم للمعاملة ٢٠ سنتي بار، ٢٩٨ مم للمعامله ٥٠ سنتي بار) .
كذلك وجد ان معدل سرعة استهلاك الماء خلال الموسم يقل بزيادة الشد الرطوبي الارضي (٦ر٦مم/يوم للمعاملة ٢٠ سنتي بار و ٦ر٣ مم/يوم للمعاملة ٥٠ سنتي بار) .

٣- معامل المحصول (مقدار البخر ـ النتح / مقدار البخر من حوض التبخر) يتغير خلال الموسم بحيث يزيد بسرعة حتى يصل الى القيمة العظمى خلال فترة التزهير وبعدئذ ينخفض في نهاية الموسم (٤١ر٠ - ١٩ر١ - ٢٦ر١ للمعامله ٥٠ سنتي بار) .

٤- وجد ان نسب استنفاذ الرطوبه الارضيه من طبقات التربه خلال الموسم تأخذ اربعة انماط مختلفه كما وجد ان نسبة استنفاذ الرطوبه الارضيه المستنفذه من هذه الطبقه خلال الموسم الى الماء المتيسر الكلي في منطقه الجذور يزيد بزيادة الشد الرطوبي الارضي (٢٨ر١٠٪ للمعاملة ٣٧،٢٠، ١٥ للمعاملة ٥٠ سنتي بار) .

٥- وجد انه يمكن تحديد مواعيد ومقادير الري بالتنقيط باستعمال القيم المتحصل عليها لكل من معامل المحصول ، نسبة الرطوبة الارضيه المستنفذه من الطبقه السطحيه (٥ - ٣٠ سم) ، ونسبة معدل مقدار الرطوبة المستنفذه من هذه الطبقه خلال الموسم الى الماء المتيسر الكلي في منطقه الجذور .

٦- منحنيات المعايره لجهاز قياس الرطوبة الارضيه النيوتروني تتأثر بتباين كل من الكثافة الظاهريه والقوام خلال قطاع التربه .