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EFFECT OF GROUND WATER LEVEL ON LEGUME CROPS IN FAYOUM GOVERNORATE 6-OPTIMUM IRRIGATION OF FABA BEAN

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ABSTRACT

A field experiment in El-Fayoum with the layout of 3 depths of ground water (25.8, 61.2 and 114.4 cm.) X 5 irrigation treatments from sowing to maximum flowering (irrigation at 25, 40, 55, 77 and 85% depletion of soil available water) X 5 same irrigation treatments from maximum flowering to harvest was carried out on faba bean (Vicia faba L.). Contribution of ground water to evapotranspiration, grain yield and water use efficiency were taken as criteria.

Contribution of ground water to evapotranspiration decreased as the ground water depth increased and as the depletion of available water at irrigation either before or after maximum flowering decreased. Grain yield generally was not affected by the depth of ground water on average irrigation treatments, but was greatest with irrigation at 70% depletion of available water from sowing to maximum flowering followed by irrigation at 40% depletion of available water. Number of irrigations would increase as the depth of ground water increases to obtain same yield. Maximum water use efficiency occurred in plots of 25.8 cm depth of ground water when irrigated at 70% depletion of available water up to maximum flowering stage and at 40% depletion from then to harvest.

INTRODUCTION

Moisture stress interacts with different environmental conditions and soil properties to affect legume crop production (Vincent, 1965; Abdel-Ghaffar, 1982 and Hamdi 1982). Shallow ground water is the most critical soil-environment interactant that dominates the arable land in different countries and restrict field crops production (Varallyay 1981 and Balba 1984).

Irrigation requirements of field crops had been investigated by El-Gibali and Badawi (1978), Doorenbos and Pruitt (1977) and Saxena and Stewart (1983). However, information on the effect of ground water depth on water requirement by faba bean legume is lacking under Egyptian conditions. El-Shakweer et al (1982) studied evapotranspiration by faba bean crop and the contribution of ground water to it in a single irrigation regime field experiment.

The present work aimed, therefore, to find out the effect of water regime on faba bean under different ground water depths beside the contribution of ground water to evapotranspiration and water use efficiency.

MATERIALS AND METHODS

Three sites, similar in soil characteristics but different in ground water table, in the farm of El-Fayoum Faculty of Agriculture were chosen for this study. Soil properties determined according to Black et al (1965) were : course sand ranged from 3.1 to 3.3%, fine sand from 21.4 to 21.7%, silt from 33.5 to 33.7%, clay from 41.5 to 41.6%, field capacity from 47.2 to 47.6%, wilting point from 21.2 to 21.4%, electrical conductivity of saturated soil-water extract from 2.10 to 2.25 mmhos/cm at 25°C, pH of the extract from 7.8 to 8.0, organic matter from 1.40 to 1.45% and total carbonates from 2.5 to 2.9%.

In each site, 100 experimental units, each having an area of 3.0 X 3.5 m^2 and surrounded with a border of 2.5 m width to avoid seepage, were sown to faba bean (Vicia faba L.) variety Giza 2 on 30/10/1983. In a split-split design, the experimental units of each site were splitted to 4 blocks, each comprised 5 X 5 irrigation treatments. The first 5 treatments were irrigation at 25, 40, 55, 70 and 85% depletion of available water uptil maximum flowering stage (12 weeks from sowing) and the second 5 treatments were at the same depletion values from then till harvest.

All plots received superphosphate and potassium sulphate fertilizers at a rate of 200 and 100 kg./feddan, respectively, just before sowing. Urea at a rate of 20 kg N/feddan was applied ahead of the post-planting irrigation. The ground water depth in each of the three sites was measured by means of an observation well and a graduated tape at 6-day intervals and just before irrigation. Weighted average of ground water depth throughout the growth season of faba bean was found 25.8, 61.2 and 114.4 cm for the sites No's 1, 3 and 9, respectively. The electrical conductivity of ground water as measured in the observation wells of the sites ranged from 0.60 to 0.68 mmhos/cm at 25°C.

Soil moisture was determined in layers of 30 cm depth down to the ground water level before each irrigation to follow up moisture de pletion. Also, depletion of available water (DAW) from the 0-30 cm soil layer was determined every 3 days to find out the time of irrigation according to assigned treatments.

The contribution from ground water to evapotranspiration by the crop was then calculated by substracting total soil moisture depletion during the growth season from actual evapotranspiration derived from the following Penman equation (Doorenbos and Pruitt, 1977) :

$$ETp = W\,Rn + (1 - W).\ F(U).\ (ea - ed)$$

where :

ETp = Potential evapotranspiration, mm/day.

W = Temperature, an altitude-depending weighted factor.

Rn = Total net radiation in equivalent evaporation, mm/day.

F (U) = Wind-related function = $0.27 \left(1 + \frac{U_2}{100}\right)$, where

U_2 is the wind speed, Km/day measured at 2 m height.

(ea — ed) = Vapour pressure deficit i.e. the difference between saturation vapour pressure (ea) in mbar at mean air temperature and actual vapour pressure (ed) in mbar.

Then, potential evapotranspiration (ETp) multiplied by the crop coeffcient (Kc) recommended by Saxena and Stewart (1983) would give actual evapotranspiration (E Tact). Meteorological data of Fayoum used for calculating the (E Tact) of faba bean crop during the growth season from 30/10/1983 to 29/3/1984, as provided by the General Directorate of Irrigation in Fayoum, were :

	November	December	January	February	March
W	0.67	0.56	0.51	0.50	0.57
Rn, mm/daya	2.00	1.60	1.50	1.40	2.20
F (U)	0.78	0.77	0.80	0.81	0.79
(ea-ed), mbar	9.2	8.1	8.0	8.1	9.0
Kc	0.51	0.54	0.57	0.71	0.70
ETp, mm/day	3.71	3.64	3.90	3.98	4.31
Days of growth during the month	30	31	31	29	29
ETact, mm/month	56.73	60.93	68.93	79.13	87.52

Accordingly, actual evapotranspiration (ETact) of the season was found 353.2 mm.

At harvest (29/3/1984), grain yield was taken and water use efficiency hence calculated as Kg grain/m^3 moisture depleted during the growth season.

Statistical analysis was carried out according to Steel and Torrie (1960).

RESULTS AND DISCUSSIONS

Mean values of moisture contributed from ground water, grain yield and water use efficiency as affected by water regime treatments at different ground water levels are given in tables 1, 2 and 3, respectively.

As seen in Table 1, contribution of ground water to evapotraspiration was affected significantly by the depth of ground water, irrigation regime before and after maximum flowering stage and by the first and second order interactions between these factors. Generally, it decreased as ground water depth increased and as the depletion of available water at irrigation, either before or after maximum flowering stage, decreased. Since the second order interaction is significant, any two values within the table could be compared to each other. Therefore, highest values of contribution from ground water occurred in the plots of 25.8 cm ground water depth irrigated at 70 or 85% depletion of available soil water before maximum flowering and at 85% afterwards i.e. in plots of shallowest water table irrigated least frequent. Whereas minimum contribution occured in plots of deepest water table irrigated at 25% depletion of soil available water i.e. irrigated most frequent.

Table 2 shows that grain yield did not differ in plots of different ground water depths on average condition of irrigation regime, but differed significantly with different irrigation regime either before or after maximum flowering stage. Higher grain yields were obtained as the depletion of available water at irrigation, either before or after maximum flowering stage, increased up to 40% then declined with higher depletion. This is on average conditions of the factors included in the experiment. What is of interest, however, is the significant interactions effect revealed in this connection i.e. ground water depth X irrigation regime before maximum flowering, ground water depth X irrigation regime after maximum flowering, irrigation regime before maximum flowering X irrigation regime after maximum flowering and ground water depth X irrigation regime before maximum flowering X irrigation regime after maaximum flowering. The latter interaction effect, i.e. the the second order interaction, would permit an answer to the question what water regime is best for each ground water depth. As obviously shown in Table 2, highest yields were equally obtained from plots of different ground water depths irrigated at 70% depletion of soil available water from sowing to maximum flowering followed by irrigation at 40% depletion till harvest. The number of irrigations received after that of planting differed according to the depth of ground water being 2, 4 and 6 irrigations for the plots of 25.8, 61.2 and 114.4 cm ground water depth, respectively.

Water use efficiency by faba bean crop, as shown in Table 3, varied significantly with all factors involved and with interactions of the first and second order. With the increase in ground water depth, water use efficiency decreased. With irrigation regime uptil maximum flowering it was greatest when irrigation was carried out at 70% depletion of available water. With water regime from maximum flowering onwards greatest value of water use efficiency was obtained when irrigation was applied at 40% depletion of available water. With respect to interactions effect, that of the second order is perhaps the most important to discuss. Here, as obvious from Table 3, highest value of water use efficiency for each of the three depths of ground water was obtained with irrigation at 70% depletion of available water for the period from sowing till maximum fllowering followed by irrigation at 40% depletion until harvest. But efficiency at the

Table 1 : Contribution (mm) of ground water to evapotranspiration by faba bean crop as affected by ground water depth and depletion of available soil water at irrigation.

% Depletion of available soil water at irrigation		Ground water depth in the site		
Sow. to Max. flowr.	Max. flowr to harv.	25.8 cm (site 1)	61.2 cm (site 3)	114.4 cm (site 9)
25	25	183.3	122.9	25.5
	40	188.1	137.8	60.7
	55	210.3	149.4	83.1
	70	216.6	163.7	100.2
40	25	201.0	130.7	51.2
	40	208.6	144.2	68.4
	55	219.4	159.4	93.1
	70	232.6	170.3	104.0
	85	237.8	183.6	133.5
55	25	211.7	146.5	65.4
	40	223.3	160.3	88.2
	55	232.2	167.0	106.2
	70	240.4	181.1	127.8
	85	246.2	192.4	145.0
70	25	226.5	169.1	92.3
	40	243.3	178.2	114.6
	55	252.4	189.5	131.9
	70	256.9	201.1	147.9
	85	271.2	206.3	162.0

Table 1 : Cont.

85	25	238.5	185.4	117.7
	40	246.1	201.2	132.2
	55	254.8	210.8	142.1
	70	264.6	216.7	151.9
	85	273.4	230.9	166.8

L. S. D. (0.05) :

(B) X (A)	=	5.8
Ground water depth (G)	=	4.4
D A W Before M F (B)	=	5.6
D A W After M F (A)	=	3.6
(G) X (B)	=	6.4
(G) X (A)	=	6.6
(B) X (A)		
(G) X (B) X (A)	=	7.6

Table 2 : Grain yield (Kg/plot) of faba bean as affected by ground water depth and depletion of soil available water at irrigation.

% Depletion of available soil water at irrigation		Ground water depth in the site		
Sow. to Max. flowr.	**Max. flowr to harv.**	**25.3 cm (site 1)**	**61.2 cm (site 3)**	**114.4 cm (site 9)**
25	25	2.79	2.82	2.71
	40	2.85	2.95	2.79
	55	2.93	2.88	2.79
	70	2.65	2.47	2.45
	85	2.40	2.24	2.17
40	25	3.13	3.25	3.15
	40	3.28	3.30	3.32
	55	3.27	3.28	3.19
	70	2.84	2.74	2.83
	85	2.68	2.45	2.57
55	25	3.21	3.27	3.32
	40	3.39	3.48	3.37
	55	2.97	2.89	2.95
	70	2.54	2.76	2.61
	85	2.18	2.24	2.10
70	25	3.40	3.32	3.34
	40	3.81	3.74	3.80
	55	2.72	2.64	2.52
	70	2.35	2.28	2.23

Table 2 : Cont.

	85	1.83	1.97	1.87
85	25	2.42	2.63	2.33
	40	2.39	2.48	2.24
	55	2.01	2.15	2.05
	70	1.91	1.87	1.79
	85	1.67	1.55	1.45

L. S. D. (0.05) :

Ground water depth (G)	= n.s.
D A W Before M F (B)	= 0.16
D A W After M F (A)	= 0.12
(G) X (B)	= 0.18
(G) X (A)	= 0.19
(B) X (A)	= 0.17
(G) X (B) X (A)	= 0.21

Table 3 : Water use efficiency (kg. grain/m³ moisture depleted) for faba bean crop as affected by ground water depth and depletion of available soil water at irrigation.

% Depletion of available soil water at irrigation		Ground water depth in the site		
Sow. to Max. flowr.	Max. flowr to harv.	25.8 cm (site 1)	61.2 cm (site 3)	114.4 cm (site 9)
25	25	1.560	1.164	0.787
	40	1.640	1.302	0.907
	55	1.947	1.343	0.982
	70	1.842	1.239	0.921
	85	1.752	1.198	0.867
40	25	1.954	1.401	0.992
	40	2.155	1.500	1.109
	55	2.321	1.609	1.166
	70	2.234	1.423	1.080
	85	2.204	1.373	1.112
55	25	2.154	1.504	1.097
	40	2.478	1.715	1.209
	55	2.330	1.475	1.136
	70	2.136	1.524	1.101
	85	1.933	1.323	0.959
70	25	2.549	1.714	1.217
	40	3.290	2.030	1.515
	55	2.559	1.532	1.082

Table 3 : Cont.

	70	2.315	1.424	1.032
	85	2.116	1.273	0.929
85	25	2.002	1.489	0.941
	40	2.117	1.550	0.963
	55	1.938	1.434	0.923
	70	2.045	1.301	0.845
	85	1.983	1.203	0.739

L. S. D. (0.05) :

Ground water depth (G)	= 0.21
D A W Before M F (B)	= 0.12
D A W After M F (A)	= 0.16
(G) X (B)	= 0.17
(G) X (A)	= 0.19
(B) X (A)	= 0.18
(G) X (B) X (A)	= 0.24

25.8 cm ground water depth was greater than that at the 114.4 cm depth. This is of course due to greater contribution of ground water in plots of shallowest ground water than that in plots of deeper ground water levels.

Thes results are parallel to that of a previous experiment in the same farm on faba bean legume (El-Shakweer et al 1982) and confirm previous work on faba bean at different locations of Egypt and Sudan (Saxena and Stewart 1983). Also, these data confirm previous reports on other field crops (Namken et al 1969, Barakat et al 1972, El-Gibali and Badawi 1978 and Wallender et al 1979).

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