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SCHEDULING IRRIGATION USING PAN EVAPORATION UNDER SOME POTASSIUM LEVELS IN *VICIA FABA L.*

El- Ganayani. A.A.
Agron. Dept., Fac. of Agric., Cairo Univ., Giza, Egypt .

ABSTRACT

Class "A" Pan method was used for scheduling faba, cv. Gz 402, irrigation, under some potassium levels, through 1997/1998 and 1998/1999 seasons, In both seasons, a split plot design with four replications was used, where three irrigation levels (0.7 , 1.0 and 1.3 accumulative pan evaporation using Class "A" Pan, A.P.E.) were allotted at the main plots, meanwhile three levels of K (48,60 and 72 Kg / fed) occupied the sub-plots . A combined analysis was performed

The obtained data showed that most of important studied traits were significantly affected by both irrigation and potassium as well as their interaction . The sounded seed yield / fed, i.e. 1507 Kg was produced by the combination (1.3 A.P.E. X K_{72}), without significant difference with the combination (1.0 A.P.E. X K_{72}). The replacement between each irrigation and potassium levels was reported .

For achieving highest seed yield , faba could be irrigated by 1861.8 m^3 / fed, allotted on five irrigations, of 21, 46, 39, 34 and 19 day intervals, at 250.0, 283.5, 371.7, 451.5 and 505.1 m^3 / fed, respectively The lowest values of both ETp and Kc were estimated by the use of modified Penman method , while the use of Blaney and Criddle method gave the highest values. The general mean of K_c was 0.67. The highest W.U.E., among treatments of both irrigation and K was the same, i.e. 0.93 Kg / m^3. Such value was shown on the highest level of both irrigation and potassium. The highest W. U.E. allover the study, i.e. 1.02 Kg / m^3 was resulted by applying the combination (1.3 A.P.E. X K_{72}) .

Key words : faba, vicia faba, irrigation, pan evaporation, potassium, k fertilization.

INTRODUCTION

Faba bean (*vicia faba L.*) is the most important seed legumes in Egypt. In the few last decades , Egypt was forced to import about 20.0% of the total local faba consumption . Thereafter, no surprise that agronomists are dealing with increasing faba yield through improving crop management, including the different recommended cultural practices, which are mainly bordered by the proper use of watering and fertilization.

Some opinions are going to neglect faba irrigation, depending upon that faba is a winter crop, which usually does not use relative higher water quantities . On the other hand, many authors sharpened the value of irrigation and declared the negative effect of water deficit on faba growth and yield. However, Zoromba (1983) reported that plant height decreased by skipping one irrigation at any stage, while at setting, branches / plant tended to increase by skipping one irrigation. Amer (1986) added no. of pods plant, no. seeds / plant and seed yield / plant as reduced traits by skipping one irrigation. Ainer *et al (1993)* concluded that irrigation every 20-25 days can be recommended for higher faba seed yield. Tawadros *et al* (1993a) adviced to irrigate faba at three times; pre-flowering, flowering and pod filling .

The need of Egyptian soil to potassium (k) fertilization becomes a problem under question, because of its continuos depletion as a result of more intensive cropping , the relative absence of the compensatory effect of Nile flow after building the High Dam and for producing new crop varieties having high yield potential. Thereafter, no surprise that some crops , including faba bean, were formerly regarded as needing little support from K, have now K requirements equaling or nearing those of the traditional K – hungry. crops. In addition, potassium was considered, for a near time, in the Egyptian consideration, as a neglector fertilizer, in special in the old land. Nowadays, potassium reflects particular problem, which lies in its yearly depletion by some field crop including faba bean which depletes about (75.6 kg/fed., Abd El-Hadi, 1988) . Such consumption of K will cause tragic problem if it will not be compensated by K fertilization . Many investigators found that K addition produced significant increments in yield and some of its components of then Aly (1970), Bochniarz *et al* (1987), Pocsai (1987) and Tallarico and Orsi (1989). El–Deeb (1990) found value for K addition up to 24 kg. / fed, mean while both Abd El-Hadi (1988) and Salwa E. Soliman (1992) successfully used higher K amounts up to 48 kg/fed.

Regarding the above mentioned considerations, the present study was planned to estimate the actual Et_a of faba bean under some k amounts in Aga site, Dakhalia governorate. Such study could be helpful for scheduling faba irrigation as quantities and intervals, under K application which becomes recommended in the present time.

MATERIALS AND METHODS

A two- year study was carried out at a private farm, at Aga site, Dakhalia governorate , during the two successive seasons 1997/1998 and 1998/1999. The soil was clay loam, containing 200 p.p.m available k . The main features concering soil-water relation are summarized in Table (1) . In both seasons, each experiment was conducted in a split plot design with four replicates. Three levels of k, viz. 48, 60 and 72 kg/fed, on the form of potassium sulphate 48%, were rondomly alloted at the sub plots, at once during seed bed preperation. The sub plot area was 42 m^2. The main plots were devoted to irrigation treatments. The borders among main plots were wided to 2.0m. to reduce the effect of lateral movement of ground water as possible. The irrigation treatments were:

1- Irrigation at 0.7 accumulative pan evaporation (0.7 A.P.E.)
2- Irrigation at 1.0 accumulative class A pan evaporation (1.0 A.P.E.)
3- Irrigation at 1.3 accumulative class A pan evaporation (1.3 A.P.E.)

In both seasons, The preceding crop was corn. seeding with commercial seeds of Giza 402 cv. was carried on November 15^{th},at hills on ridges 15 and 60 cm apart, respectively. The first irrigation was applied as the same for all main plots after only 3 weeks. Then, the tested irrigation treatments were applied, when water balance reached zero. However, the available water in the soil profile till 60 cm has been convernted to units of water depth and was found to be 100.0 mm, for an interval differed according to accumulative pan evaporation. Table (2) gives the obtained estimations with this respect .

Table (1): values of field capicity (F.C.) wilting point (W.P.) , available moisture (A.M.) and bulk density (B.d.) for the experimental plots at different depths, over the two seasons.

Depth cm	F.C. %	W.P. %	A.M. %	B.d, gm/cm^3
0-15	33.50	18.21	15.29	1.26
16-30	31.20	17.00	14.20	1.25
31-45	28.00	15.22	12.78	1.18
46-60	27.50	15.00	12.50	1.20
Mean	30.05	16.36	13.69	1.22

Table (2): Treatments, number of irrigations, excluding first irrigation, and irrigation intervals in the two studied seasons.

Treatments		1997 / 1998					1998 / 1999				
P. E. Coef.	K Kg. /fed	Irrigations					Irrigations				
		No.	Intervals, days				No.	Intervals, days			
			1	2	3	4		1	2	3	4
0.7	48	2	83	58	-	-	2	80	43	-	-
	60	2	81	56	-	-	2	76	44	-	-
	72	2	79	54	-	-	2	74	44	-	-
1.0	48	3	64	52	23	-	3	60	45	28	-
	60	3	59	50	22	-	3	57	45	31	-
	72	4	53	48	16	11	3	53	45	34	-
1.3	48	3	50	46	41	-	3	49	39	29	-
	60	4	44	40	32	18	4	54	36	31	20
	72	4	43	40	34	15	4	40	33	32	21

Harvest was on April 30. Ten guarded plants were randomaly taken from the two inner ridges of each sub-plot . Plants were handly harvest and threshed, where some yield components and yield were measured as follows:

1-Plan height (Pl.H),cm. 2- No. of branches/ plant (Br/ Pl).
3- No. of pods/plant (Po./Pl.). 4- No. of seeds/ plant (S/Pl).
5- Seed weight / pod. , S.W. / Po. , gm. 6- No. of seed / plant (S.P1).
7- The 100 seed weight (100-S.W.), gm. 8- No. of stands/fed. (Sta/fed).
9- Seed yield/ plant (SY/Pl), gm.
8- Seed yield / fed. (S.Y./fed), Kg. Both Sta. fed. and S.Y./fed. were estimated on polt basis. All other agricultural practics were done as usuall. Statistical analysis was carried out according to Snedecor and Cochran (1981), however analysis of variance for each season as well as for a combined one over the two seasons were performed. L.S.D. test was used for comparing means, at the 0.05 level of significance.

Water relations :

1-Actual evapotranspiration (Eta)

soil samples were taken with an uger just 48 hours before and after irrigation up to harvest, to determine soil moisture content . At each sampling date, duplicate soil samples were taken from 0-15, 16- 30 , 31 45 and 46 –60 cm depth, then moisture content was gravimetrically determined.

Actual evopotranspiration, or actual consumptive use was calculated for 60cm soil depth and for an area of one feddan, for all treatments from planting until harvest, according to Hansen *et al*. (1979)

$$u = \frac{\theta_2 - \theta_1}{100} \text{ x } \frac{60}{100} \text{ xBd } \text{ x } 420$$ Where:

U= Actual consumptive use in m^3,

θ_1 = soil moisture percentage after irrigation,

θ_2 = soil moisture percentage before irrigation B=Bulk density in g/cm^{3}θ

2- Potential evapotranspiration (ET_p)

Potential evapotranspiration (ET_p) was estimated using meterological data from Aga Station (Table,3) by the following methods :

1er. Penman (1956) method described by Doorenbos and Pruitt (1977) :

Etp = W.Rn + (1-w) . F(u). (ea-ed), where :

Etp = potential evapotranspiration (mm).

W = temperature – related weighty factor.

Rn = Net radiation in equivalent evaporation mm/ period.

F(u) = wind relation function

ea-ed= Difference between the saturation vapor pressure at mean air temperature and the mean actual pressure of the aire both in mbar.

B. Class A pan evaporation:

The FAO Class A Pan method , as described by Doorenbos and Pruitt, (1977) was used as follows:

ETp = E x K p,where :

ETp= Potential evapotranspiration in mm/ day.

E= evaporation Pan in mm/ day

Kp = Pan coefficient

C. Blaney and criddle (1962) method :

The method was used as recommended by Doorenbos and pruitt (1977) in the following relationship:

ETp= a + b [p)0.46 T + 8.13)] mm/ day,Where

ETp= potential evapotranspiration in mm/ day.

a and b = Two coefficients which depend on minimum relative humidity, sunshine hours and day time wind speed.

P= percentage of total annual daylight hours

T= Mean air temperature in °c

3- crop coefficient (Kc):

The crop coefficient (Kc) for faba bean was calculated as follows:

$$Kc = \frac{ET\,a}{ETp}$$

4- water use efficienty (W.U.E.)

Water use efficiency was calculated for different treatments according to the formula of Vites (1965)

Water use efficiency (W.U.E.) = Seed yield, Kg / fed. ÷ Water consumptive use m^3 / fed. The relative climatic data are presented in tables (3-a) and (3-b):

Table (3-a): The average daily values of air temperature (C°) , relative humidity (%) and pan evaporation (mm/day), at Aga Station, during the two studied seasons.

Season	1997/1998			1998/1999		
Climate Period (week)	M., air Temp. C°	M.R.H %	P. E. mm/day	M.. air Temp.C°	M.R.H %	P. E.mm/day
1/12 – 7/12	17.17	57.00	1.8	16.27	56.14	2.1
8/12 - 14/12	16.80	57.14	1.9	16.16	68.71	1.7
15/12-21/12	14.70	64.14	1.7	14.07	64.57	1.7
22/12-28/12	13.80	64.00	1.5	14.70	66.86	1.7
29/12-4/1	13.50	64.14	1.4	14.91	74.57	1.3
5/1-11/1	14.60	65.00	1.8	13.33	66.43	1.5
12/1-18/1	13.17	62.29	1.5	15.5	68.71	1.9
19/1-25/1	14.30	58.29	2.0	18.26	69.71	2.1
26/1-1/2	14.50	61.71	1.8	18.56	65.71	2.3
2/2-8/2	15.54	59.00	2.2	16.68	73.57	2.0
9/2-15/2	13.09	65.29	1.7	16.81	63.57	2.3
16/2-22/2	13.77	62.43	1.5	14.27	66.86	1.9
23/2-1/3	13.43	60.67	2.4	14.57	64.86	2.3
2/3-8/3	14.00	63.00	2.5	15.63	63.57	2.6
9/3-15/3	14.4	64.20	2.6	15.36	62.57	2.4
16/3-22/3	14.8	64.3	2.8	17.23	57.29	2.5
23/3-29/3	14.9	64.8	2.9	18.31	62.71	2.9
30/3-5/4	16.00	67.86	3.1	19.36	57.14	3.6
6/4-12/4	21.09	64.57	5.1	16.53	64.14	3.7
13/4-19/4	24.60	66.14	4.8	21.24	59.57	3.8
20/4-26/4	19.07	66.71	3.4	20.17	61.29	4.5
Total	269.13	1073.23	39.6	350.92	1358.55	50.8

Table (3-b) : 10 day interval, monthly and seasonal accumulative Pan evaporation (A.P.E.), as affected by irrigation treatments in the tow studied seasons .

Seasons	1997 / 1998				1998 / 1999			
	A.P.E.	Irrigation at A.P.E. of			A.P.E.	Irrigation at A.P.E. of		
Intervals	mm/inter val	0.7	1.0	1.3	mm interval	0.7	1.0	1.3
1-10 / 12	18.8	13.2	18.8	24.4	20.6	14.4	20.6	26.8
11-20/12	18.1	12.7	18.1	23.5	16.0	11.2	16.0	20.8
21/31/12	16.4	11.5	16.4	21.3	17.7	12.4	17.7	23.0
December	53.4	37.4	53.3	69.2	54.3	38.0	54.3	70.6
1- 10 / 1	16.5	11.6	16.5	21.5	14.3	10.0	14.0	18.6
11-20 /1	15.5	10.9	15.5	20.2	18.7	31.1	18.7	24.3
21/31 /1	21.6	15.1	21.6	28.1	24.8	17.4	24.8	32.2
January	53.6	37.6	53.6	69.8	57.8	40.5	57.8	75.1
1 - 10 / 2	19.8	13.9	19.8	25.7	20.5	14.4	20.5	26.7
11- 20 / 2	17.3	21.1	17.3	22.5	20.9	14.6	20.9	27.2
21 – 28 / 2	16.7	11.7	16.7	21.7	18.0	12.6	18.0	23.4
Febuary	53.8	37.7	53.8	69.9	59.4	41.6	59.4	77.3
1 - 10 /3	22.4	15.7	22.4	29.1	29.1	16.9	24.2	31.5
11-20 /3	18.9	13.2	18.9	24.6	19.2	16.9	24.1	31.1
21.31 /3	27.3	19.1	27.3	35.5	32.3	22.6	32.3	42.0
March	68.6	48.0	68.6	89.2	80.6	56.4	80.6	104.6
1 - 10 /4	33.3	23.3	33.3	43.3	37.9	26.5	37.9	49.3
11-20 /4	53.5	37.5	53.5	69.6	42.9	30.0	42.9	55.8
21-30 /4	35.6	24.9	35.6	46.3	48.9	34.2	48.9	63.6
April	122.4	85.7	122.4	159.2	129.7	90.7	129.7	168.7
Seasonal	351.8	246.4	351.8	457.3	381.8	267.3	381.8	496.3

RESULTS AND DISCUSSION

The effect of year and its interactions are excluding in the pressent study, to be discussed in another one.

Irrigation effect :

Data given in table (4 - a) show that the insignificant effects were only detected on weight seeds / pod and 100 - seed weight absence of significancy herein may be accepted since weight seeds / pod is one of the good inherited traits. Amer (1986) concluded the same both traits, mean while, Khalil (1995) found different results .On the other hand, irrigation by the highest rate, i.e. (1.3 A.P.E.) significantly exceeded that of the middle rate (1.0 A.P.E) which also surpassed the lowest one (0.8 A.P.E) with respect to plant height . the significant reduction in plant height, as a result of water shortage, may probably be due to retarding cell division, cell expansion and cell enlargement, the present findings are in line with those of Tawards *et al* (l993a). It seemed that water shortage effect on plant height was reflected in no. of branches / plant. In other words, it appeared that higher watering allow building more branches due to physiology process and merestimatic activity in growing plants . Zoromba (1983) found similar results.

With respect to no. of pods / plant, significancy was detected only when comparing 0.7 with both 1.0 and 1.3 A.P.E. treatments, which themselves did not significantly differed to each other. This means that watering enhanced no. pods / plant up to 1.0 A.P.E. It seemed that the above mentioned progressive plant height and no . of branches / plant were turned in no. of pods/ plant. The present results agreed with those reported by Amer (1986) who found that reducing water supply or skipping one irrigation significantly reduced no. of pods/plant. Gradual and significant increments were detected on no. of seeds/pod by any increase in water supplies, probably due to that enough soil moisture, through high irrigation quantities may be helpful for increasing fertilization in faba flowers which resulted increases in no. of seeds / pod. Although El - Maghraby (1980) found different results, Amer's results in (1986) agreed with our ones.

Number of seeds / plant typically trended as no, of seeds / plant and partly as no. of pods / plant .Thereafter all progressive effects previously. mentioned on both traits were turned in no . of seeds / plant. Number of stands / fed, the second main component of seed yield / fed tended to be increased as irrigation increased up to 1.0 A.P.E. This means that sufficient watering may promoted stands / fed , might be through raising germination and producing stronger plants which were able to tolerate the harmful effect of competition among plants . Superior seed yield / plant were obtained where irrigation was increased . Such superior seed yield may be attained by the corresponding excesses in term of no. of seeds / plant. The present findings confirmed those of Khalil (1995).

Table (4-a): Means of the studied traits as affected by irrigation treatment, and potassium levels , over the tow studied seasons.

Treatment Traits	Irrigation at A.P.E. of			Potassium levels Kg/fed		
	0.7	**1.0**	**1.3**	**48**	**60**	**72**
P1.H.	104.1 a	107.5 b	110.1 c	104.1 a	107.7 b	109.9 b
Br. / P1	3.7 a	3.8 b	3.8 c	3.7	3.8	3.8
Po. / P1	16.5 a	21.3 b	23.3 b	20.0	20.3	20.7
S / Po.	2.8 a	2.9 b	3.2 c	2.9	3.0	3.0
S.W./ Po.	2.0	2.0	2.1	1.8 a	2.1 b	2.3 c
S / P1	50.1 a	55.7 b	60.2 c	55.1	55.5	55.4
100 – S.W.	52.7	58.5	64.6	52.8 a	59.8 b	63.3 c
Sta / fed.	73.1 a	74.2 b	74.2 b	73.0 a	74.0 b	74.5 b
S.Y. / P1	30.2 a	43.3 b	50.3 c	37.5 a	41.1 ab	45.3 b
S.Y. / fed.	1340.0 a	1445.0 b	1485.0 b	1346.0a	1417.0 ab	1507.0 b

Means followed the some letters are insignificanily different according to L.S.D. test at L 0.05

Seed yield / fed, as the final result of all the above mentioned findings, showed that higher irrigation resulted in higher yield, however the difference between the seed yield of irrigation at 1.0 and 1.3 A.P.E. insignificant The latter two treatments surpassed that of 0.7 A.P.E. by 7.8 and 10.7 % , respectively. This means that higher irrigation may promoted different aspects of faba growth, which in turn translocated to be stored in seeds and consequently increased their yield . Moreover, the favorable effect of irrigation on stands / fed had also a marked role for increasing seed yield / fed The present results are in full agreement with many researchers of them ; Amer *et al.* (1994)

Potassium effect:

Table (4-a) gives the means of studied traits as affected by the three studied levels of potassium, over the two seasons. Obviously, no. significant differences were detected on four traits including no. of branches / plant no. of pods / plant, number of seeds / pod and no. of seeds / plant . These results declare that such traits did not effectively benefit the simulative effect of K on the other traits which significantly responded to K addition. These results may show the relative difficult of K translocation within faba plant and consequently the formation of pods / plant and seeds either per pod or plant**,** Salwa E. Soliman (1992) On the other hand, it was observed that plant height was increased by K addition, however such increase was insignificant when comparing the addition K_{60} with K_{72}, indicating that K may promotes such trait. El-Deeb (1990) found similar results. Gradual and significant increments were detected on seed weight / plant and 100 - seed weight as K level was increased, assuring the positive role of K for good filling of seeds . El- Deeb (1990) found different results meanwhile Salwa E. Soliman (1992) agreed with the present results . Concerning stands / fed , it was found that significant increase disappeared by addition K level over 60 kg/ fed . This means that low and medium of levels of K might be necessary for growing higher population of faba been up to harvest , might be due that plants were more stronger and healthy by K addition, Salwa E. Soliman(1992) came to similar conclusion. Similar trends was shown on seed yield / plant . excesses herein may be contributed to the corresponding ones obtained on the terms of plant height, seed weight / plant and 100 - seed weight . Such results supported those of Bochniarz *et al* (1987)**,** El- Deeb (1990) and Salwa E. Soliman (1992).

Seed yield / fed, was significantly increased when comparing K_{72} with K_{48} . Superior seed yield / fed was mainly formed as the previous better growth features, good accumulation, storage of dry matter and the higher stands / fed. Seed yield / fed. were 1346.0, 1417.0 and 1507.0 kg for K additions of 48, 60 and 72 kg / fed, respectively, indicating that percentage of increases for the medium and higher levels over the lower one were about 5.27 and 12.0%, respectively. It is proper that such increases may be attributed to the promoting influence of K on bacteria in the nodules attached to the root . Also it may be due to K performance in plant metabolism and conserving water, Gething (1986). Zeiger and Hepler (1977) indicated that opening of stomates, which is mainly controlled by K, increases CO_2 uptake by plants, through gas exchange, and hence increases the rate of photosynthesis. Bhaddal and Malik (1988) added that the role of K as such inorganic element is an activator of many enzymes that are essential for photosynthesis, respiration and activates enzymes needed to form starch and protein

Interaction effect :

Table (4–b) indicates that traits of 100–seed weight, stands/fed, seed yield/plant and seed yield/fed., showed significant difference under interaction treatments. Such results suggest that irrigation and K fertilizer may had successfully interacted. In other expression, faba bean may be one of field crops which are able to benefit the combination among irrigation and K levels. Clearly, the yield of the combination (1.3 A.P.E. X K_{72}), i.e.1590.0 kg/fed. , significantly out yielded the remainder combinations except (1.0 A.P.E. X K_{60}) , i.e.1530.0 kg/fed., where the difference was insignificant. In addition, such superior seed yield / fed. was affected by the progressive effects of both stands / fed. and seed yield / plant , (table 4–b). Obviously , no significant differences were detected among combinations (0.7 A.P.E. X K_{60}) and (1.0 A.P.E. X K_{48}) as well as between (1.0 A.P.E. X K_{72}) and (1.3 A.P.E X K_{60}). Such results and similar ones would be helpful with respect to the replacement of each combination instead of others , depending upon , the availability of watering and potassium from the economic view . At final, for high seed yield of faba bean under Aga site and similar sites the combinations (1 .0 or 1.3 A.P.E. X K_{72})could be recommended .

Table (4-b) : Means of the studied traits as affacted by interaction combinations over the two studied seasons.

Treatments	0.7 A.P.E.			1.0 A.P.E.			1.3 A.P.E.		
Traits	K_{48}	K_{60}	K_{72}	K_{48}	K_{60}	K_{72}	K_{48}	K_{60}	K_{72}
P1.H	100.2	105.3	106.9	104.8	107.9	109.9	107.2	110.0	113.0
Br. / P1	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.9	3.8
Pod / P1	16.3	16.5	16.6	20.9	21.5	21.6	22.8	23.0	24.0
S / Po	2.8	2.8	2.8	2.9	3.0	3.0	3.0	3.2	3.3
S.W. / Po	1.8	2.0	2.2	1.8	2.1	2.2	1.8	2.1	2.4
S / Po	50.0	50.2	50.1	55.0	56.0	56.0	60.2	60.3	60.0
100-S.W.	50.3	53.2	54.7	50.3	60.1	65.1	57.7	63.6	70.0
Sta / fed.	72.5	73.3	73.5	73.2	74.6	74.9	73.3	74.2	75.1
S.Y. / P1	28.4	30.2	32.1	39.1	43.0	47.9	45.0	50.0	56.0
S.Y. / fed	1253.0	1367.0	1402.0	1389.0	1415.0	1530.0	1395.0	1469.0	1590.0

L. S. D. for 100-S. W. = 5.8, Sta/fed = 1.3, Sy/pl = 6.1 and S. Y./fed = 62.0.

Water relatioins :

1- Actual evapotranspriation (ET_a) .

The knowledge of water consumptive use (W.C.U.) or (Et_a) is a pre requisite for proper scheduling irrigation and improving irrigation practices, the relative data are given in table (5) . It was found that ET_a was gradually increased by increasing irrigation . Such gradual increments could be attributed to the different number of irrigations, since such number is the minimum at 0.7 and maximum at 1.3 A.P.E. In other expression it may be stated herein that ET_a increased as the available soil moisture increased in the root zone by frequent irrigation at short intervals irrigation at (1.3 A.P.E.) Moreover, Doorenbos and Pruitt (1977) reported that after irrigation the soil water content would be reduced primarily by evaporation. As the soil dries the rate of water transmitted through the soil will be reduced. The present results are in line with many researchers of them, Ainer *et al* (1993) .

Also, it was observed that ET_a was increased from 333.7 to 352.3 and 372.0 mm for treatments of K_{48}, K_{60} and K_{72}, respectively. This means that additional potassium may promote water uptake and consequently ET_a. Zeiger and Helper (1977) stated in that K accumulates in the guarded cells of stomates during day time to cause their opening which is accompanied by increasing the rate of transpirtation and consequently increasing water uptake. Similar trends were observed when considering the interaction of irrigation with all potassium levels.

Data in table (5) demonstrate that the general mean of ET_a over the two seasons was 352.7 mm, where the estimated ET_a was 344.4 and 360.9 mm for the first and second seasons, respectively. Such findings might be attributed to prevailing climatic factors, in special air temperature and relative humidity, which were somewhat higher in the second season. Table (3-a), these results confirmed those were reported by Salwa E. Soliman (1979) who found that ET_a was greatly affected by air temperature and relative humidity .

Table (5) : Seasonal actual evapotranspriation (ET_a in mm) , as affected by irrigation and potassium levels in the two season.

Irrigation / K (Kg / fed)	at A.P.E. of			
	0.7	1.0	1.3	Mean
K_{48} Season1	296.0	328.5	355.0	326.5
K_{48} Season 2	309.7	343.0	370.0	340.9
Mean	302.9	335.8	362.5	333.7
K_{60} Season1	312.6	340.7	375.0	342.8
K_{60} Season 2	326.2	363.5	395.6	361.8
Mean	319.4	352.1	385.3	352.3
K_{72} Season1	330.0	368.2	393.6	363.9
K_{72} Season 2	349.0	381.0	410.2	380.1
Mean	339.5	374.5	401.9	372.0
Total Season 1	312.9	345.8	374.5	344.4
Total Season 2	328.3	362.5	391.9	360.9
Total Mean	320.6	354.2	383.2	352.7

Water consumptive use (m^3 / fed) and scheduling of irrigation :

Table(6) represents the seasonally water consumptive use (W.C.U.) (m^3/ fed), as affected by irrigation treatments (over K levels) in the two seasons. It was calculated over the two seasons. It was calculated that treatment of 0.7 A.P.E. used an average of 1595.9 m^3 / fed , distributed at three irrigations, firstly (El- Mohay) at 250 m^3 / fed , 21 days after seeding , secondly at 478.6 m^3 / fed., 79 days after the first one, thirdly at 867.3 m^3 / fed., 50 days after the second irrigation . The treatment of 1.0 A.P.E. consumed 1715.2 m^3 / fed., allotted at four times, viz. 21 days after seeding (250 m^3 / fed.) , 58 days after the first (367.9 m^3 / fed.) , 48 days after the second (493.5 m^3 / fed.) and 30 days after the third 603.8 m^3 / fed. Treatment of 1.3 A.P.E. required 1861.8 m^3/fed. as a mean over all respects.

Such water amount was applied at four times of five intervals of 21 , 46 , 39 , 34 and 19 days . The corresponding consumed amounts were 250.0 , 283.5 , 371.7 , 451.5 and 505.1 m^3 / fed. , respectively. The above mentioned results indicate that , in general , irrigation at 1.3 A.P.E. reflected the greatest water quantity , highest number of irrigation and shorter interval between irrigations. The opposite was quite true with respect to treatment of 0.7 A.P.E. Moreover , the first irrigation (El Mohay) was the same for the three treatments , i.e. 250 m^3 / fed., and 21 days after seeding . This means that scheduling of irrigation started after applying the first one , which was quickly applied to serve the delayed seed germination . In addition, it was observed that quantity of watering gradually increased by time . This is a natural phenomenon , since faba plants developed in growth, giving bigger vegetative canopy and doing several biological and physiological processes which consumed , at final , greater water quantity. On the other hand, however , winter is the growing season herein, where air temperature is usually lowered during the first periods and gradually increases towards the end of season , hence water consumption will clearly follow the change pattern in air temperature as previously mentioned .

Table (6) : Seasonally water consumptive use (m^3/fed), including El – Mohay irrigation, as affected by irrigation treatments, over K levels, in the two seasons 1997 / 1998 and 1998 /1999 .

Irrigation		At A.P.E. of					
Irrigations		0.7		1.0		1.3	
		W.C.U. m^3/fed	Interval Day	W.C.U. m^3/fed	Interval day	W.C.U. m^3/fed	Interval day
Firstly (El- Mohaya)	Season1	250.0	21	250.0	21	250.0	21
	Season2	250.0	21	250.0	21	250.0	21
Mean		250.0	21	250.0	21	250.0	21
Secondly	Season1	474.2	81	357.8	59	273.0	46
	Season2	483.0	77	378.0	57	294.0	45
Mean		478.6	79	367.9	58	283.5	46
Thirdly	Season1	840.0	56	483.0	50	357.0	42
	Season2	896.6	44	504.0	45	386.4	36
Mean		867.3	50	493.5	48	371.7	39
Fourthly	Season1	------	-----	509.0	20	441	36
	Season2	------	-----	598.5	31	462.0	31
Mean		----	----	603.8	30	451.5	34
Fifthy	Season1	-----	-----	-----	-----	501.9	17
	Season2	-----	-----	-----	-----	508.2	21
Mean		-----	-----	-----	-----	505.1	19
Total		1595.9		1715.2		1861.8	

2- Potential evapotranspiration (ET_p) :

Seasonal evaporation. (ET_p) values were estimated by three methods, viz. modified *Penman, Blany and Criddle* and Class "A" Pan evaporation. Their estimation averages over the two seasons were 621.3, 480.0 and 513.8 mm, respectively for the same respective methods. The corresponding values were 440.8 and 468.3 mm in the first season and 631.3, 519.2 and 559.3 mm in the second one. These results mean that the equation of *Blany and Criddle* gave the lowest estimation among the three methods, meanwhile the modified Penman method was overestimating than them, in both seasons. The lowered values estimated by *Blany and Criddle* method may be contributed to the few climatic factors involved in this method, viz. air temperature and sunshine hours. For sure, these two factors are not enough for reflecting the impact of climate on evapotranspiration. The results herein assured the pervious ones mentioned by Miseha (1983) and Khalil (1995). The former author pointed out that Blany and Criddle method is undependable when calculated in short and long time basis. It was shown that ETp values estimated by the Class "A" Pan evaporation were in-between the two other methods. In this respect. Jensen (1968) stated that most of field crops need less amount of water than those estimated by ETp even through adequate soil moisture is provided. Thereafter, it may be stated that as low ET_p as good method. Thereafter, it was generalized, in the present study, that Class "A" Pan offers a good and reliable method of ETp estimation, in special it is simple, inexpensive, easily operated and need no more of climatic data. Upon the previous explanation it may be concluded that Class "A" Pan can be successfully used for scheduling crop irrigation as well as for estimation ET_p of the short – term fluctuation.

3- Crop coefficient (K_c) :

Table (7) gives Kc values according to studied irrigation treatments (ET_a) and methods of estimating (ET_p). However, crop coefficient is calculated by dividing ET_a by ET_p. Thereafter, K_c would be as greater as ET_a greater or as ET_p lower or the both together. When K_c = 1.0, means that ET_p was estimated with the high reliability and confidence. The general mean of Kc values was 0.67. Thereafter, it may be stated that Kc values depends upon ET_a and ET_p, including all factors affecting these two values, *Doorenbos and* Pruitt (1977) considered climatic factories with this respect. The present findings are in harmony with the results of *Serry et al (1980)* and *Tawadros et al* (1993b) who reported that the seasonal Kc for faba bean was 0.65. In addition, *Khalil (1995)* agreed with the present results, however the use of Blany and Criddle method gave the highest K_c, meanwhile Class "A" Pan evaporation did the opposite.

Table (7) : Means of coefficient of faba bean (Kc), as affected by irrigation treatments and methods for ETp estimation.

Treatments / Method of ET_p	Irrigation at A.P.E. of :			
	0.7	1.0	1.3	Mean
Modified Penman	0.52	0.57	0.62	0.57
Class "A" Plan	0.62	0.69	0.75	0.69
Blany and Criddle	0.67	0.74	0.80	0.74
Mean	0.60	0.67	0.72	0.67

4- Water use efficiency (W.U.E.) :

Water use efficiency is expressed as K_g seeds per one m^3 of water cosumed. Data obtained are given Table (8). It is clear that (W.U.E.) was gained when irrigated at 1.3 A.P.E. (0.93 Kg / m^3), meanwhile the two other irrigation regimes produced lesser (W.U.E.), where the middle irrigation treatment surpassed the lowest one. This mean that higher or highest values of (W.U.E.) of faba bean would be resulted from medium irrigation (4 times of total = 1715.2 m3 / fed) or higher irrigation (5 times of total = 1861.8 m3 / fed). In other words, the prolonged irrigation intervals at 0.7 A.P.E. resulted in reduction in (W.U.E.). Ritchie (1974) stated that plants roots extract more soil water from greater depth at moderate stress, such as 1.0 – 1.3 A.P.E., than plants irrigated at wet level, consequently the stored water can be used more efficiency. Thereafter, it may concluded that faba irrigation at 1.0 - 1.3 A.P.E. through 4 – 5 irrigation with quantities ranged between 1715.2 – 1861.8 m^3 / fed. Could achieve the best seed yield as well as water consumptive use. The present findings are consistent with some researches of them Ainer *et al* (1993) and Khalil (1995).

As regards data concerning potassium effect, (W.U.E.) tended to be gradually increased as K level increased, however the increment was too minimized when K level was increased from 60 to 72 Kg / fed. These results mean that the addition of K up to 60 Kg may enhanced faba growth and increased seed yield and consequently (W.U.E.). In this occasion, it may be important to state that the combination between the highest levels of irrigation and potassium produced the highest (W.U.E.) value in the study, i.e. 1.02 Kg / m^3, which may be recommended.

Table (8) : Water use eff\iciency (W.U.E.), Kg / m^3 , as affected by irrigation treatments and K levels, over the two studied seasons

Irrigation K., Kg / fed.	at A.P.E. of			
	0.7	1.0	1.3	Mean
K_{48}	0.74	0.72	0.78	0.75
K_{60}	0.80	0.96	0.99	0.92
K_{72}	0.79	0.97	1.02	0.93
Mean	0.78	0.89	0.93	0.87

From the above mentioned resulted the following may be concluded :

- Most of studied traits were significantly affected by irrigation treatments, while most of the important ones showed significant response to K additions. Generally, all traits were positively response to higher levels of both irrigation and potassium. It seemed that enough watering enhanced numeral traits, while potassium promoted the weighable ones. The greatest yields. Produced by highest levels of both irrigation and potassium were close to each other.
- Irrigation and potassium had successfully interacted with respect to most of important traits, Increases were always observed by any excess either in irrigation or k in the combination. Any increase in the level of each factor increased the positive effect of the another one. The possibility of the alternative replacement between the two factors was found. The relative reduction in any level of one factor would be compensated by additional supplies in the second one. The sounded seed yield fed. i.e. 1507.0 Kg was produced by the combination (1.3 A.P.E. X K_{72}),
- For attaining such superior seed yield, faba bean would be irrigated by about 1861.8 m^3 / fed, allotted on 5 irrigations, 21, 46, 39, 34 and 19 days intervals at 250.0, 283.5, 371.7, 451.5 and 505.1 m^3/fed, respectively.
- The lowest value of both ETa and Kc. were estimated by modified Penman method, while the use of Blaney and Criddle method gave the highest values. Class “A” Pan method estimations were in-between. The general

mean of Kc was 0.67 . The highest Kc values for irrigation and potassium were close to each other, Viz. 0.72 and 0.74, respectively.

- For W.U.E., the highest value was the same 0.93 Kg / $m^3$for the highest levels of both irrigation and potassium. The greatest W.U.E. in the study, i.e. 1.02 Kg. / m^3. was resulted through applying the combination (1.3 A.P.E. X K_{72}), which could be recommended for optimal seed yield too.

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جدولـة الري بإستخدام وعـاء البخـر القياسـى تحت مستويات مختلفـة مـن التسـميد البوتـاسى فـي الفـول البلـدى

عـادل عبد الحليـم الجنـاينـى
كليـة الزراعـة – جامعـة القاهرة – الجيـزة - جمهوريـة مصر العربيـة

أجريـت تجربتـان حقليتـان بناحيـة أجـا – دقهليـة – و ذلـك خـلال الموسـمين 1997 / 1998 و1999/1998 و ذلك على نبات الفول البلدى صنف جيـزة 402 ، بإستخدام بيانات البخـر التراكمى لوعـاء البخر القياسى بمحطـة الأرصاديـة الجويـة الزراعيـة بالناحيـة ، بإستخدام تصـميم القطع المنشقـة في أربعـة مكررات حيث خصصت القطـع الرئيسيـة لإختبـار ثـلاث معـاملات رى (الري عند 0.7 ، 1.0 و 1.3 من مجموع القيم اليوميـة للبخر من الوعـاء القياسـى) في حين وزعت ثلاث معاملات للتسميد البوتاسـى (48 ، 60 و 72 كجم بوتاسيوم / فدان) على القطع الفرعيـة حيث إضيفت مرة واحدة أثناء تجهيز الأرض للزراعـة و كانت الزراعـة والحصاد في 15 نوفمبر و 30 أبريل على التوالى . و لقد بينت الدراسـة النتائج التاليـة :

- تأثرت معظم الصفات الهامة إيجابيا" و معنويـا" بكل من معـاملات الري و البوتاسيوم والتفاعل المشترك بينهما . و لقد أمكن الحصول على أعلى محصول من البذور وقدره 1507 كجم / فدان عند الري و التسميد البوتاسى بـأعلى مستوياتهما و إن لـم يكن هنـاك فرق معنوى بين المعاملـة العامليـة السابقـة و تلـك المشتملـة على المعدل الأوسط من الري و الأعلـى من التسميد البوتاسـى . و لقد تحققت إمكانيـة إحلال كل عامل من العاملين محل الآخر في بعض التوافيق العامليـة و يبدوا أن التأثير التشجيعى للماء يتضح أكثر على الصفات العدديـة في حين يتضح التأثير المناظـر للبوتاسيم على الصفات الوزنيـة .
- إتضح أن المحصول الأعلى من الفول البلدى يحتاج الى الري بمعدل يتراوح بين 1715.2 الـى 1861.8 م^3 / فدان ، موزعا" على 5 ريات بعد 15 ، 46 ، 39 ، 34 و 19 يومـا" ، حيث كانت الكميات المناظرة 250.0 ، 283.5 ، 371.7 ، 451.5 ، 505.1 م^3 / فدان على التوالى .
- تبين أن إستخدام التقديرات الأقل من ET_p و معامل المحصول قد ظهرت عند إستخدام طريقة Penman في حين أعطت طريقـة Blaney & Criddle التقديرات الأعلى و كانت طريقة Class Pan "A" وسطا" بينهما و قد أوصت الدراسـة بالإعتماد على الطريقـة الأخيرة عند جدولة الري أو تقدير ET_p . و كان المتوسط العام لمعامل المحصول مساويا" 0,67 في حين أعطى كل من الري عند 1.3 من مجموع قيم البخـر التراكمى و التسميد بمعدل 72 كجم بوتاسيوم أعلى معامل للمحصـول و قدره 0.72 و 0.74 علـى التوالى .
- بلغت الكفاءة الإستعماليـة لمياه الري معدلها العالى (0,93 كجم / م^3) عند إستخدام أعلى المعدلات من العاملين (1.3 من مجموع القيم اليومية للبخر من الوعـاء القياسى و72 كجم بوتاسيوم) ، حيث أعطـى الجمع بين هاتين المعاملتين في معاملـة عامليـة واحدة أعلى كفاءة إستعماليـة لمياه الري على الإطلاق و قدرها 1.02 كجم / م^3.
- توصى الدراسـة لإنتاج أعلى محصول من الفول البلدى و تحقيق أفضل كفاءة إستعماليـة لمياه الري و ذلك تحت ظروف أجـا – دقهليـة – و الظروف المماثلـة أن يتم الري بمعدل يتراوح بين 1.0 – 1.3 من مجموع قيم البخر التراكمى لوعاء البخر مع التسميـد بمعدل 72 كجم/ فـدان من البوتاسيوم .