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FABA BEAN RESPONSE TO SURGE IRRIGATION IN CLAY SOIL

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ABSTRACT

This study was conducted during the two seasons of 2001/2002 and 2002/2003 at Sakha Agric. Res. Station, Kafr El-Sheikh Governorate. The aim of this work was to study the effect of the relatively new surface irrigation technique (surge flow irrigation) on consumptive use (CU), water application efficiency (Ea), water use efficiency (WUE), water utilizations efficiency (WUtE) and productivity of faba bean, under clay soil condition. Three water irrigations discharge (D): 4, 6 and 8 L/s as main treatments. Four irrigation treatments were used as a subtreatments and were arranged in split plot design, as following: I_1 continuous irrigation, I_2 = 20 min. with cycle 10 min. On and 10 min. Off, I_3= 25 min. with cycle 10 min. On and 15 min. Off and 30 min. with cycle 10 min. On and 20 min. Off. Data revealed that consumptive use is higher under continuous irrigation than the other surge irrigation treatments. The average values of CU were 41.8, 40.4, 37.5 and 33.4 for treatments I_1, I_2, I_3 and I_4, while it was 36.95, 38.31 and 40.25 for D_1, D_2 and D_3 irrigation discharges, respectively. Values of Ea, WUE, WUtE and seed yield were increased in case of surge flow under similar conditions. The best results regarding to CU, Ea, WUE , WUtE and seed yield were obtained from using I_4 treatment.

INTRODUCTION

Surge irrigation is a tool that can be used to improve the efficiency of water applied by furrow irrigation. In surge irrigation, water is applied to an irrigation furrow, intermittently, during irrigations set, whereas in continuous-flow (or conventional) irrigation, water is applied to the furrow during the entire irrigation set. Total water application can be reduced substantially, with the use of surge irrigation. Previous researches with faba bean, had demonstrated the effectiveness of surge irrigation in reducing water application and at the same time, maintaining crop yield and quality equivalent to conventional furrow irrigation. Surge flow creates series of on and off conditions of constant or variable time spans at furrow in let (Bishop *et al.*, 1981). Zein El-Abedin (1988) stated that water application efficiency (Ea) was over 80% by surge flow, while it was about 40% under continuous flow. Guirgus (1988) found that Ea at inflow rate of 1.45 L/S was 43.9, 87.8, 90.1 and 88.% for continuous flow and surge flow of 5/5, 5/10, 5/15 On/Off min., respectively. Kassab (2003) found that consumptive use for faba bean ranged from 38.9-45.8 and 33.5-39.9 during 1999-2000 and 2000-2001 growing seasons at North Nile Delta. Tawadros *et al.* (1988) reported ranges of seasonal CU for beans grown in Nile Delta, middle Egypt, and Upper Egypt, as follows 24.1-38.6 cm, 32.9-44.8 cm and 39.3-49.2 cm for each region respectively. Therefore, the main objective of the present work, is to show the effect of surge flow irrigation on consumptive use, water application efficiency water utilization efficiency, water use efficiency and productivity of faba bean,

and to compare it with the conventional continuous furrow irrigation in clayey soil at North Nile Delta.

MATERIALS AND METHODS

Two field experiments were conduced during 2001/2002 and 2002-2003 winter seasons, at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, using faba bean crop. Table (1) shows some physical properties of the experimental soils. Dates of sowing (S) and harvesting (H) were as follow:

Season 1: S = 10/11/2001 H = 15/5/2002
Season 2: S = 15/11/2002 H = 20/5/2003

All cultural practices were done as recommended by the Egyptian Ministry of Agricultural and land Reclamation except for the two factors of study i.e. irrigation method and discharge. Area of plot was 3.5 x 80 = 280 m^2. The experimental design was a split plot design with four replicates as follows:

A.Main treatments = discharge (L/S):

D_1 = 4 L/S D_2 = 6 L/S D_3 = 8 L/S

B.Subtreatments (irrigation treatments):

There were 4 treatments:

I_1.Continuous flow.
I_2-Surge 20 min. cycle with 10 min. On and 10 min. Off.
I_3-Surge 25 min. cycle with 10 min. On and 15 min. Off.
I_4-Surge 30 min. cycle with 10 min. On and 20 min. Off.

Irrigation water was applied to furrows, whatever number of surges was needed, until the end of the furrow, for each irrigation treatment through a plastic pipe of 5 cm inner diameter and 70 cm length submerged in the irrigation channel. Two, four and six pipes were used per plot. The average effective water head above each pipe was determined during the On time.

Table (1):Some physical analyses of experimental site.

Soil depth	Particle size distribution			Texture	Bulk density mg/m^3	FC w%	PWP w%	Available water w%
	Sand	Silt	Clay					
0-15	15.18	18.85	65.97	Clay	1.12	47.2	25.28	21.92
15-30	19.90	13.80	66.30	Clay	1.15	40.5	21.85	18.65
30-45	16.59	16.47	66.94	Clay	1.24	39.0	21.19	17.81
45-60	17.65	15.24	67.11	Clay	1.26	38.5	20.81	17.69

1.Consumptive use (CU):

To compute the actual consumed water of the growing plants, soil moisture percentage was determined gravimetrically, on over dry basis before and after each irrigation as well as at harvesting. Soil samples were taken from the successive layers of the effective root zone, 0-15, 15-30, 30-45 and 45-60 cm. This method of computation is considered as one of the direct

methods of consumptive use which based on soil moisture depletion (S.M.D) or so called crop-water consumed (ETc) as stated by Hansen *et al.* (1979).

$$SMD = CU = \frac{\theta_2 - \theta_1}{100} Db \times d \times A \ m^3/fed.$$

Where:

SMD =Soil moisture depletion in the effective root zone = 60 cm
CU =Consumptive use of the growing plants.
θ_1 =Mean soil moisture percentage (w/w), before irrigation for the 60 cm soil depth.
θ_2 =Mean soil moisture percentage (w/w) for the 60 cm soil depth, 48 hrs after irrigation (field capacity).
Db =Mean soil bulk density, gm/cm^3 for the 60 cm soil depth.
d =Soil wetting depth i.e. effective root zone of 60 cm.
A =Irrigated area, m^2 (4200 m^2 i.e. area of 1 feddans).

2.Crop yield:

Yield of the inner furrows of each field plot was recorded at harvest.

3.Water application efficiency:

Water application efficiency (Ea) in percent were obtained by dividing the seasonal consumptive use by the irrigation water applied to the field as follows:

Ea = CU/1w x 100 (3)

(ICID) Bulletin (1978)

Where:

Ea = Water application efficiency %,
CU = Total consumptive use, and
IW = Irrigation water applied.

4.Water use efficiency (WUE):

$$WUsE = \frac{\text{Yield (kg/fed.)}}{\text{Amount of water consumed by crop i.e. consumptive use } (m^3/fed.)}$$

5.Water utilization efficiency (WUtE):

The water utilization efficiency, as a measure to clarify variations in yield due to irrigation water was calculated as follows:

WUtE = Yt/I.W.

Where:

WUtE = Water utilization efficiency kg/m^3
Yt = Total yield produced kg/fed. and
I.W. = Applied water m^3/fed.

RESULTS AND DISCUSSION

Crop water consumptive use (CU):

Tabulated data in Table (2) and the illustrated Fig. 1 reveal that the increase in water discharge was associated with the increase in CU. Mean values on the two seasons of CU for the 3 water discharges are: 36.95, 38.31 and 40.25 for the D_1, D_2 and D_3 water discharge respectively. The increase for D_2 and D_3 discharges over the D_1 discharge are, 5.0 and 9.0%, respectively. The greater CU for D_2 or D_3 over D_1 was occurred with all irrigation treatments. Under continuous irrigation mean CU values over the two seasons are 39.5, 42.5 and 43.5 cm for the D_1, D_2 and D_3 respectively for I_2 surge irrigation with cycle ratio 0.5 i.e. 10 min. On-10 min. Off the comparable values are 38.3, 40.5 and 42.5 cm respectively. With the I_3 treatments values are 36.5, 37.5 and 38.5 cm respectively. In addition the I_4 treatment comparable values are 32.0, 32.75 and 35.5 cm, respectively.

Using surge irrigation was associated with lower values of CU. Mean values of CU for the I_2, I_3 and I_4 treatments are 40.4, 37.5 and 33.4 cm, respectively. The average decrease of CU using the I_2, I_3 and I_4 compared with I_1 (continuous) are 1.4, 4.3 and 7.4 cm, respectively. Surge treatment (I_4) recorded the lowest values of CU, it was 32.0, 32.75 and 35.5 for the D_1, D_2 and D_3, respectively.

Such finding might be attributed to the increase of evaporation component at high moisture content, under continuous treatment. These results are similar to that found by many workers Badawi (1970); El-Maghraby (1980) and Serry *et al.* (1980) who reported such increased CU with increasing application of irrigation water.

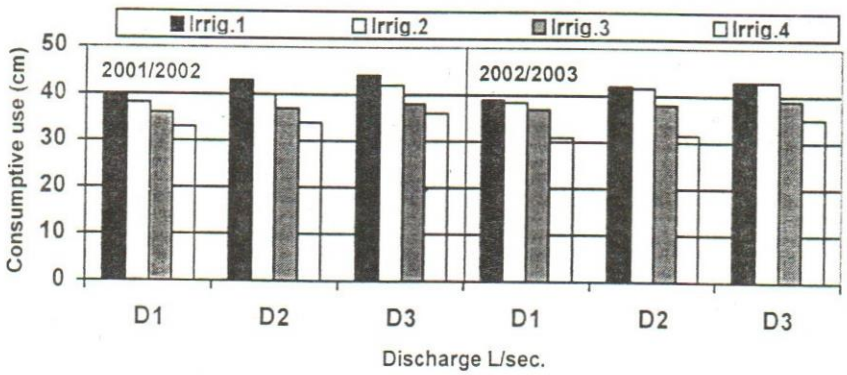

Fig. (1):Seasonal consumptive use (CU) cm for faba bean crop as affected by irrigation treatments and discharge in the two growing seasons.

Table (2):Seasonal consumptive use (CU) cm for faba bean crop as affected by irrigation treatments and discharges in the two growing season.

Treat.	Cycle		Season 2001/2002			Season 2002/2003			Average of two seasons			
			Discharge L/S			Discharge L/S			Discharge L/S			Mean
	On	Off	D_1 4	D_2 6	D_3 8	D_1 4	D_2 6	D_3 8	D_1 4	D_2 6	D_3 8	
I_1	Cont.	Cont.	40.0	43.0	44.0	39.0	42.0	43.0	39.5	42.5	43.5	41.8
I_2	10	10	38.2	40.0	42.0	38.5	41.6	43.0	38.3	40.5	42.5	40.4
I_3	10	15	36.0	37.0	38.0	37.0	38.0	39.0	36.5	37.5	38.5	37.5
I_4	10	20	33.0	34.0	36.0	31.0	31.5	35.0	32.0	32.75	35.5	33.4
Mean			36.8	38.5	40.0	36.4	38.3	40.0	36.95	38.31	40.25	

Seed yield kg/fed.:

Data presented in Table (3) and illustrated in Fig. (2) showed that the increase in water discharge has a slight increase in seed yield, but not to the significancy level. Average values of seed yield for the 3 water discharges are: 1305, 1346 and 1375 kg/fed., respectively. Regarding the effect of surge irrigation, seed yield was highest than the continuos irrigation. I_4 treatment recorded the highest value of seed yield during the two seasons. Mean yields for the 2 seasons due to I_1, I_2, I_3 and I_4 were 1186, 1253, 1373 and 1560 kg/fed., respectively. Thus the I_4 (i.e. 10 min. On and 20 min. Off) gave the highest yield. The mean of surge irrigation treatments I_2, I_3 and I_4 is 1388 kg/fed., it was higher by 17% as compared with I_1 the continuous irrigation. The highest seed yield was obtained using "I_4 D_3 treatment" which gave 1625 kg/fed. The lowest yield was obtained by I_1 D_1 treatment which gave 1155 kg/fed. Therefore, using the surge irrigation I_4 i.e. 10 min. On 20 min. Off, with discharge 8 L/S is the most suitable to get the maximum production of faba bean in north Nile Delta.

These findings are in good agreement with those obtained by El-Zaher *et al.* (1996) and Ghalleb (1987).

Table (3):Faba bean seed yield (kg/fed.) under different irrigation treatments.

Treat.	Cycle		Seasons 2001/2002			Season 2002/2003			Average of two seasons			
	On	Off	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	Mean
I_1	Cont.	Cont.	1150	1200	1220	1120	1190	1200	1155	1195	1210	1186
I_2	10	10	1230	1280	1260	1220	1250	1280	1225	1265	1270	1253
I_3	10	15	1360	1360	1390	1340	1390	1400	1350	1375	1395	1373
I_4	10	20	1520	1550	1610	1500	1550	1640	1510	1550	1625	1561
Mean			1315	1347	1370	1295	1345	1380	1310	1346	1375	

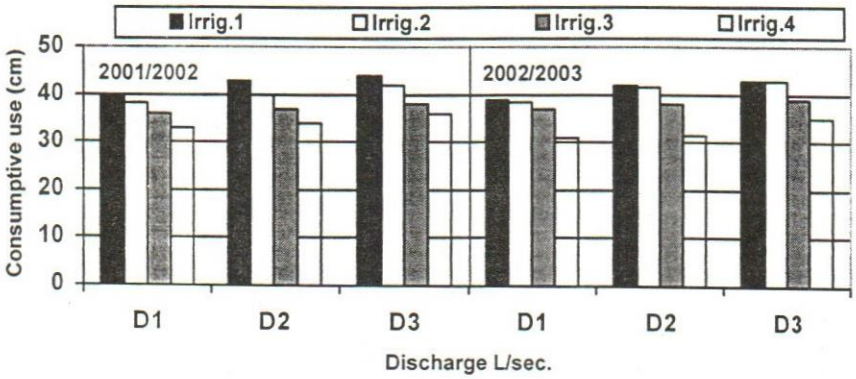

Fig. (2):Effect of surge flow irrigation treatments and discharges on faba bean seed yield (kg/fed) in the two growing seasons.

Water application efficiency (Ea):

Table 4 shows that all tested numbers of surge flow gave high Ea than in continuous one. The highest Ea was obtained by I_4D_2 treatment (which gave 88, 94% during 1st and 2nd season, respectively) and the lowest was obtained by I_1 D_1 which gave 69 and 70.6% during 1st and 2nd season, respectively. The I_4D_2 treatment, was the best treatment due to the doses values of both CU comparing with all other treatments. These results are more or less in close agreement with the results of many workers, Guirgues (1988) found that Ea at inflow rate of 1.4545 was 43.9, 87.8, 90.1 and 88.8 for continuous flow and fore surge flow of 5/5, 5/10 and 5/15 On/Off min., respectively.

Zein El-Abedin (1988) stated that Ea was over 80 percent by surge flow, while it was about 40% for continuous flow.

Water use efficiency WUE:

As water is limiting factor in the expansion of cultivated area in Egypt, the primary management objective in the development of water use program that will provide maximum yield/m^3 of applied water. Values of water use efficiency (kg seed/m^3 of water consumed) for different treatments are presented in Table (5).

It is clear that the highest values of WUE were obtained from surge flow irrigation treatment I_4, under different discharges it was 1.13 kg/m^3 i.e. surge irrigation with cycle ratio 0.33 (10 min. On and 20 min. Off. While the lowest one (0.66 kg seed/m^3) from treatment I_1 (continuous irrigation).

Water utilization efficiency WUtE:

Water utilization efficiency values WUtE for faba bean seed yield for each treatment for total water applied (IW + RF) are shown in Table (6). Data revealed that all tested numbers of surges flow gave high WUtE than in continuos one. The highest values of WUtE were scored from I_4 treatment as

mentioned before (0.97 kg seed/m^3. While the lowest one (0.48 kg seed/m^3 from treatment I_1 (continuous).

Table (4):Water application efficiency values (Ea) as affected by irrigation treatments.

Treat.	Cycle		Seasons 2001/2002			Season 2002/2003			Average of two seasons			
	On	Off	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	Mean
I_1	Cont.	Cont.	69	71	72	74	75	76	71	73	74	72.6
I_2	10	10	73	74	77	83	90	87	78	82	82	806
I_3	10	15	79	77	79	92	94	90	85	85	82	84.0
I_4	10	20	64	88	85	93	94	94	88	91	89	89.5
Mean			71.3	77.5	78.3	85.5	88.3	86.8	80.6	82.7	81.7	

Table (5):Water use efficiency values (WUsE kg/m^3) of faba bean as affected by irrigation treatments.

Treat.	Cycle		Seasons 2001/2002			Season 2002/2003			Average of two seasons			
	On	Off	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	Mean
I_1	Cont.	Cont.	0.68	0.66	0.66	0.68	0.67	0.66	0.68	0.66	0.66	0.66
I_2	10	10	0.76	0.76	0.71	0.75	0.71	0.71	0.76	0.73	0.71	0.73
I_3	10	15	0.89	0.88	0.87	0.86	0.87	0.85	0.87	0.88	0.86	0.87
I_4	10	20	1.09	1.11	1.06	1.15	1.17	1.11	1.13	1.14	1.13	1.13
Mean			0.86	0.85	0.83	0.86	0.86	00.83	0.86	0.85	0.84	

Table (6):Water utilization efficiency values (WUtE kg/m^3) of faba bean as affected by irrigation treatments.

Treat.	Cycle		Seasons 2001/2002			Season 2002/2003			Average of two seasons			
	On	Off	D_1	D_2	D_3	D_1	D_2	D_3	D_1	D_2	D_3	Mean
I_1	Cont.	Cont.	0.47	0.47	0.47	0.50	0.51	0.50	0.48	0.49	0.48	0.48
I_2	10	10	0.56	0.57	0.55	0.63	0.64	0.61	0.59	0.60	0.58	0.59
I_3	10	15	0.71	0.67	0.69	0.79	0.82	0.77	0.75	0.75	0.73	0.74
I_4	10	20	0.92	0.97	0.94	1.0	1.1	1.0	0.96	0.99	0.97	0.97
Mean			0.67	0.67	0.66	0.73	0.77	0.72	0.69	0.70	0.69	0.69

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استجابة الفول البلدى للرى النبضى فى الاراضى الطينية

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أجريت هذه الدراسة خلال موسمى ٢٠٠١/٢٠٠٢ ، ٢٠٠٢/٢٠٠٣ فى محطة البحوث الزرعية بسخا ــ محافظة كفرالشيخ ــ مصر وكان الهدف من هذه الدراسة تأثير الرى النبضى على كل من الاستهلاك المائى وكفاءة الرى وكفاءة استهلاك الماء والكفاءة الاستعمالية لوحدة المياه وانتاجيه الفول البلدى حيث طبق ثلاث تصرفات للمياه ٤ ، ٦ ، ٨ لتر/ث والتى مثلت D_3, D_2, D_1 واربع معاملات رى (ثلاثة للرى النبضى والرابعة للرى المستمر) التى تمثل طريقة الرى التقليدية بالمنطقة وكانت المعاملات كالاتى:

I_1 (رى مستمر) ، I_2 (رى نبضى دورة ٢٠ دقيقة ١٠ دقائق فتح و ١٠ دقائق غلق) ، I_3 رى نبضى دورة ٢٥ دقيقة (١٠ دقائق فتح و ١٥ دقيقة غلق) ، I_4 رى نبضى دورة ٣٠ دقيقة (١٠ دقائق فتح و ٢٠ دقيقة غلق) واجريت هذه المعاملات على محصول الفول البلدى وكانت النتائج كالاتى:

١- الاستهلاك المائى كان اعلى تحت الرى المستمر عن الرى النبضى وكان متوسط الاستهلاك المائى ٤١,٨ ، ٤٠,٤ ، ٣٧,٥ ، ٣٣,٤ سم للمعاملات I_1, I_2, I_3, I_4 على الترتيب بينما كان متوسط الاستهلاك المائى ٣٦,٩٥ ، ٣٨,٣١ ، ٤٠,٢٥ للتصرفات D_1, D_2, D_3.

٢- كانت قيم كفاءة الرى وكفاءة استهلاك الماء والكفاءة الاستعمالية للمياه والمحصول أعلى تحت الرى النبضى عن الرى المستمر.

٣- أحسن النتائج بالنسبة لاستهلاك الماء وكفاءة الرى وكفاءة الاستهلاك والكفاءة الاستعمالية لوحدة المياه ومحصول البذور تحقق بالمعاملة I_4 أى ربى نبضى بدورة ٣٠ دقيقة (١٠ دقائق فتح ، ٢٠ دقيقة غلق).