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RESPONSE OF FABA BEAN TO SOIL MOISTURE STRESS IN EASTERN DELTA

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ABSTRACT: Two field experiments were conducted during the two successive growing seasons 1999/2000 and 2000/2001 to study the effect of soil moisture levels i.e. 25, 50, and 75% of available soil moisture depletion, on growth, yield, and some components of faba bean (Giza 402 CV), water consumptive use, and water use efficiency. The experiments were carried out at Zankalon Water Requirement Research Station, Sharkia Governorate, Egypt. The results indicated that irrigation at 25% of available soil moisture depletion significantly increased plant height, number of branches/plant, number of pods/plant, seed index, seed and straw yields. No significant differences were observed between irrigation at 25% and 50% of available soil moisture depletion regarding grain and straw yields/fed. Seasonal water consumptive use decreased as soil moisture depletion increased. Water use efficiency decreased with decreasing or increasing of soil moisture depletion than treatment (50% of available soil moisture depletion). The results show that irrigation of faba bean at (50% of available soil moisture depletion) seemed to be suitable for increasing water use efficiency without marked decrease in seed and straw yields.

INTRODUCTION

Faba bean (Vicia Faba L.) is one of the most important pulses in Egypt. The strategy of irrigation policy in Egypt aims to optimizing the use of irrigation water. Water management is a very important factor influencing crop yield. Many investigators studied the soil moisture content on faba bean.

Krogman *et al* (1980), studied the response of faba bean to three deficits i.e. irrigation at 40, 60, and 85% available soil moisture

depletion (ASMD). They found that, seed and straw yields were significantly increased with decreasing available soil moisture depth prior to irrigation.

Mohamed (1981), El-Noemani *et al* (1990), Abd El-Haleem (1994), recorded reduction in the faba bean yield and its components due to increasing the soil moisture stress. Moreover, Simpson (1981), reported that water stress resulted in a disturbance in most of the physiological processes i.e. photosynthesis, protein synthesis, enzyme activity.... etc. and hence affected translocation of metabolites to seeds.

Hebbleth Waite (1982), explained that, if evaporation demand exceeds water supply for a prolonged period, the crop is stressed leading to irreversible effects such as reduced photosynthesis and dry matter accumulation, shedding of flowers and pods, ovary abortion and consequently lower yield in faba bean.

Tawadros (1985), noticed that mean seed yield of Vicia faba reached a maximum (2.991 t/ha) with irrigation at 80% of field capacity.

Farah *et al* (1990), indicated that, water shortage greatly affected faba bean production and the lowest biological yield was produced from the dry treatment (70% depletion). Also, Abo El-Kheir (1999), found that, number of both pods and seeds per plant weight of both seeds and straw per plant, and 100 seeds weight were significantly decreased as soil moisture stress increased to 80% (ASMD).

Abd El-Mottaleb and Abbas (1992), reported that the highest yields was obtained when irrigation was given at 2 bars (1497 m^3/fed.) the lowest one was obtained at the 10 bars (874 m^3/fed.) and plant height, number of branches/plant and number of pods/plant, were significantly affected by soil moisture deficit. Also, they found that the highest water use efficiency (1.134 kg/m^3) was obtained when soil, moisture stress reached 10 bars.

Tawadros *et al* (1993), reported that the greatest yield was obtained from frequent irrigation which out yielded the intermediate (65% F.C.) and infrequent irrigation (50% F. C.) treatments.

Wahba *et al* (1993), reported that the wet treatment produced the highest value of seed yield. Also, they found that evapotranspiration by faba bean increased as soil

moisture stress decreased, while the values of water use efficiency increased as soil moisture stress increased.

Fardoas, and Abdel-Nour (2000), studied the effect of different soil moisture levels i.e. 30, 60, and 90% depletion in available water on yield and yield components. They found that soil moisture stress had a significant effect upon growth of faba bean wet condition (30%) depletion in available water which enhanced the growth of faba bean and show the highest values of yield components (plant height, number of branches/plant and number of pods/plant) hence seed and straw yields.

Atta *et al* (2001), reported that under sandy soil, the maximum seed yield (1514 kg/fed.) of faba bean was obtained when 38cm of irrigation water was added and the actual consumptive use 30 cm.

The present study aimed at studying the effect of soil moisture depletion on growth, yield, consumptive use, and water use efficiency of faba bean crop on a clayey soil.

MATERIALS AND METHODS

Two field experiments were conducted at Zankalon Station, water management Research Institute, Sharkia Governorate, Egypt, during the two successive seasons (1999/2000) and (2000/2001). The textural Class of the soil was clay (42.5%) with PH 8.1, and 1.58% organic matter. Soil moisture constants are as shown inTable(1).

Table (1): Soil moisture constants of the experimental site.

Depth (cm)	Field capacity %	Wilting point %	Available water %	Bulk density gm/cm3
0-20	42.70	21.90	20.80	1.27
20-40	39.11	19.41	19.70	1.33
40-60	36.70	16.95	19.75	1.49
Average	39.50	19.42	20.08	1.33

The experiments were performed to study the effect of water depletion levels on growth, yield and some water relations of faba bean (402 cultivar). Planting dates were November 15th and 20th in both seasons, respectively. Seeds were sown in hills 20 cm

apart on both sides of ridges of 60cm apart. Thinning was made before the first irrigation where two plants were left/hill. Each plot (120m2) include 20 ridges of (10m length).

Superphosphate (15.5% p_2O_5) fertilizer was added to all plots at a rate of 15.5kg p_2O_5/fed, and potassium sulphate (48% k_2O) was added at a rate 24.0 kg/fed before sowing. Nitrogen in the form of ammonium nitrate (33.5% N) was added at the rate of 33.5kg N/fed in two equal splits before the first and the third irrigation. The normal practices for growing faba bean were followed as recommended for the region. A randomized complete blocks design with four replicates was used.

Data were statistically analyzed using least significant difference (L.S.D.) test according to Steel and Torri (1980).

The irrigation treatments were based on the available soil moisture depletion (ASMD) as follows:

(T1): Irrigation when 25% of the available soil moisture was depleted (Designed as unstressed or wet).

(T2): Irrigation when 50% of the available soil moisture was depleted (Designed as medium stressed).

(T3): Irrigation when 75% of the available soil moisture was depleted (Designed as stressed or dry).

Irrigation treatments was applied when the moisture content of soil reached the desired available soil moisture in each treatment after faba bean plants received the life watering (30 days after sowing). Soil samples were periodically taken intervals (2 days) to predict the proper time of irrigation.

Harvesting was completed on the last week of April in the two seasons. The following yield attributes were recorded on 10 plants at harvest:

I- Growth yield and some yield components:

1- Plant height.
2- Number of branches/plant.
3- Number of pods/plant.
4- Seed index.

The seed and straw yields were recorded from a central area of $30m^2$ in each plot.

I- Water relations:

For soil moisture determination, soil samples from each plot were taken at 0-20, 20-40, 40-60 cm depth just before and after each irrigation to determine water consumptive use i.e. the actual evapotraspiration (ETa) of faba bean crop. A rectangular weir was used for measuring the amount of irrigation water.

i- Water consumptive use:

The actual evapotraspiration (ETa) (water consumptive use) estimated from the sampling method and was calculated according to the following equation given by Israelson and Hansen (1962):

$$Wc = Db * d * (\theta_2 - \theta_1/100)$$

Where,

WC: Water consumption (Water consumptive use) (cm).

θ_1: Soil moisture content before irrigation (%).

θ_2: Soil moisture content after irrigation (%).

Db: Bulk density (gm/cm^3).

d : Soil depth (cm).

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

(W.U.E.) was calculated for each treatment according to Jensen (1983),

W.U.E. = Seeds yield (kg/fed.)/Water consumptive use (m^3/fed).

RESULTS AND DISCUSSION

I – Faba bean Growth

The results as shown in Table (2) show that the effect of soil moisture stress on the growth of faba bean expressed as plant height, and number of branches/plant. The statistical analysis indicated that soil moisture had a significant effect on the measured growth characters of faba bean. The highest values of plant height, and number of branches/plant were obtained from the wet treatment which was watered at 25% depletion in available soil moisture depletion (ASMD) followed by the medium soil moisture depletion irrigation at 50% of (ASMD), and then followed by the dry treatment (irrigation at 75% ASMD). These results reveal that increasing soil moisture depletion, result in a significant decrease in faba bean growth which was reflected on decreasing plant height, number of branches/plant.

These findings indicate that moisture stress reduces the growth of faba bean plants. Regarding

that, Kramer (1980), showed that plants subjected to water stress, not only show a general reduction in size, but exhibit modification in structure, leaf area, cell size and intercellular volume are usually decreased. Hebbleth-waite (1982), demonstrated that irrigation increases plant height primarily because plants develop larger internodes. As a result, plants have grater stem areas to intercept light.

These results are in line with those reported by Fardoas and Abd El-Nour (2000).

II – Yield components and Yield of Faba bean

i- Yield components

Results in Table (2) indicate that the tested faba bean yield component i.e. number of pods/plant and seed index were significantly affected by soil moisture stress in both seasons and combined.

The wet treatment had the highest values of such yield components followed by the medium treatment. However the dry soil moisture level gave the lowest values. The differences between the results gained from the wet treatment and the other soil moisture stress levels were found to be significant. These results indicate the importance of maintaining soil water at a high level for pod setting of faba bean. Tawadros *et al* (1993), concluded that any or all yield components could be affected by the time of water stress and its degree.

These results are in agreement with those reported by Abd El-Mottaleb and Abbas (1992), Tawadros *et al* (1993), Abo El-Kheir (1999), Fardoas and Abd El-Nour (2000) and Atta *et al* (2001).

ii- Seed and straw yields of faba bean

Seed and straw yields of faba bean as influenced by soil moisture stress is shown in Table (3). Results indicated that the water deficit had a significant effect upon the productivity of faba bean as well as their pooled data. The wet treatment yield the maximum seed yield followed by the medium soil moisture level with no significant differences between them. The lowest seed yield was scored from the dry treatment (irrigation at 75% depletion in available water). This trend can be attributed to the effect of water deficit on faba bean growth, which was reflected on the final yield.

Table (2): Plant height, number of branches per plant, number of pods per plant and seed index affected by soil moisture depletions for faba bean crop in the two seasons and combined.

Treatment	Plant height (cm)			Number of branches/plant			Number of pods/plant			Seed index		
	1999/2000	2000/2001	Combined	1999/2000	2000/2001	Combined	1999/2000	2000/2001	Combined	1999/2000	2000/2001	Combined
T1	118.9	121.5	120.2	4.2	4.40	4.30	17.2	19.0	18.1	62.5	63.9	63.2
T2	115.2	116.5	115.85	3.94	4.26	4.10	14.8	15.7	15.25	60.4	63.2	61.8
T3	111.4	113.0	112.2	3.44	4.08	3.76	11.8	12.48	12.14	58.7	60.3	59.5
L.S.D. 5%	2.88	2.46	1.58	0.50	0.14	0.25	1.71	2.40	1.75	0.59	1.03	0.65
L.S.D. 1%	4.37	3.72	2.29	0.77	0.26	0.37	2.60	3.60	2.53	0.90	1.57	0.94

(T1): Irrigation when 25% of the available soil moisture was depleted (Designed as unstressed or wet).
(T2): Irrigation when 50% of the available soil moisture was depleted (Designed as medium stressed).
(T3): Irrigation when 75% of the available soil moisture was depleted (Designed as stressed or dry).

These results are in line with those reported by Krogman *et al* (1980) who concluded that utilizing the percentage of available water used in the root zone as a measure of start of yield decrease, it ranged from 60 to 70%. Also, Fardoas and Abd El-Nour (2000), found that non-significant differences between water deficit 30 and 60% of (ASMD) on productivity of faba bean.

As for straw yield, similar results to that observed with seed yield were obtained. This trend was the same in both seasons and combined. These results are confirmed by those obtained by Mohamed *et al* (1981), El-Noemani *et al* (1990), Farah *et al* (1990), Wahba *et al* (1993), Abd El-Haleem (1994), and Fardoas and Abd El-Nour (2000).

Table (3): Seeds yield and straw yield as affected by soil moisture depletions for faba bean in the two seasons and combined.

Treatment	Seeds yield (ardab/fed.)*			Straw yield (ton/fed.)		
	1999/ 2000	2000/ 2001	Combined	1999/ 2000	2000/ 2001	Combined
T1	9.85	10.19	10.02	2.95	3.29	3.12
T2	9.12	9.96	9.54	2.87	3.22	3.04
T3	6.43	6.79	6.61	2.36	2.69	2.53
L.S.D. 5%	0.77	0.51	0.57	0.20	0.26	0.14
L.S.D. 1%	1.16	0.77	0.81	0.31	0.40	0.39

* 1 ardab = 155 kg.

III – Water relations

i- Water consumptive use:

Water consumptive use by faba bean for soil moisture depletions are presented in table (4). Results indicated that water consumptive use by faba bean ranged from 45.5 to 26.3 cm as average of the two seasons. The results shown in Table (4) show that water consumptive use increased as soil moisture depletion decreased. The highest water use was brought under wet conditions (irrigation at 25% depletion of available soil moisture depletion) whereas the lowest values of the water consumptive use were attained under dry

conditions (irrigation at 75% depletion of available soil moisture depletion). While, under medium water supply the values of the water consumptive use falls in between. This trend reveals that the increase in water consumptive use depends on the available soil moisture in the root zone. These results are due to the availability of soil moisture to plants as well as to high evaporation opportunity from wet soil surface compared with dry one.

Table (4): Actual consumptive use and Water use efficiency for faba bean crop.

Treatment	Actual consumptive use (cm)			Water use efficiency (Kg/m3)		
	1999/ 2000	2000/ 2001	Average	1999/ 2000	2000/ 2001	Average
T1	51.20	47.78	49.5	0.71	0.79	0.75
T2	37.08	34.12	35.6	0.91	1.09	1.00
T3	26.50	26.10	26.3	0.89	0.96	0.93

In this respect, Miseha (1983), Concluded that evapotranspiration exhibits a great response to changes in soil moisture levels. It is high at low stress and decreased rapidly at severe moisture stress.

The monthly and daily consumptive use values for faba bean crop as affected irrigation treatments as average of the two seasons are presented in Table (5). Monthly consumptive use varied throughout the growing season. Monthly rates were low at the beginning of the growing season and increased gradually with the age of the plant growth till it reach its maximum in March, then it decreased again when plants reached maturity. These results are supported by these obtained by Lemon *et al* (1959).

ii- Water use efficiency (W.U.E.)

The calculated values of (W.U.E) expressed as Kg of faba bean seed per cubic meter of water consumed as affected by different soil moisture depletions in the two seasons are presented in Table (4). Results reveal that the maximum value of (W.U.E.) was higher under medium soil moisture depletions (50% ASMD) while, it was lower under wet and dry soil moisture depletions (25 and 75%

Table (5): Monthly and daily consumptive use (mm) as affected by different irrigation treatments for wheat crop for the two seasons as average.

Treatment	November		December		January		February		March		April		Seasonal consumptive use	
	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily	Monthly	Daily	(mm)	(m3/fed)
T 1	18.3	1.83	57.5	1.85	81.8	2.64	114.7	4.10	137.4	4.43	85.3	2.84	495.0	2079.0
T 2	18.3	1.83	40.3	1.3	63.2	2.03	80.2	2.86	102.3	3.3	51.7	1.67	356.0	1495.2
T 3	18.3	1.83	33.8	1.1	44.5	1.40	55.3	1.97	70.2	2.26	40.9	1.32	263	1104.6

ASMD) in the two seasons, respectively. Water use efficiency (W.U.E.) was increased from 0.75 to 1.0 when 50% of available soil moisture depletion was applied in treatment T2, but was thereafter decreased to 0.93 kg/m^3 when 75% of available soil moisture depletion was given in treatment T3, it decreased with decreasing or increasing of water consumption than that of 50% of ASMD. These results are mainly due to that the seed yield was decreased by only 5.8%, while consumed water was decreased by 28% due to reaching the 50% of ASMD instead 25% of ASMD. Under wet condition (irrigation at 25% of ASMD) faba bean yield was slightly higher than under medium water level but consumed more water compared with medium treatment. However, severe water deficit (irrigation at 75% of ASMD) caused a sharp reduction in faba bean yield more than the reduction in water consumption thereby results in lower values of water use efficiency. It can be concluded that (T2) medium soil moisture level (50% ASMD) seemed to be more efficient in consuming water compared with T1 and T3 (25 and 75% ASMD). The results are supported by these obtained by Fardoas and Abd El Nour (2000).

Conclusion and recommendation

Form the two experiments carried out at Zankalon region (Eastern Delta), it can be concluded that irrigation of faba bean at 50% of available soil moisture depletion, is considered more suitable for increasing water use efficiency without marked decrease in seed and straw yields/fed, where it will lead to the possibility of saving a great amount of irrigation water, and producing as much seed and straw yields/fed. So it could be recommended as more crop per drop of water could be achieved.

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استجابة الفول البلدي لنقص الرطوبة في منطقة شرق الدلتا

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أجريت تجربتان حقليتان بمحطة بحوث و تجارب المقننات المائية بالزنكلون بمحافظة الشرقية خلال الموسمين (١٩٩٩ / ٢٠٠٠) و (٢٠٠٠ / ٢٠٠١) لدراسة تأثير ثلاثة مستويات من الإجهاد الرطوبي عند استنفاذ نسب مختلفة من الماء الميسر و هي ٢٥ % و ٥٠ % و ٧٥ % على النمو و المحصول و بعض مكوناته و كمية الماء المستهلك و كفاءة استخدام المياه لمحصول الفول البلدي لصنف جيزة ٤٠٢ .

يمكن تلخيص أهم النتائج التي تم الحصول عليها على النحو التالي:

- أظهرت النتائج أن الري عند استنفاذ ٢٥ % من الماء الميسر قد أدى إلى زيادة معنوية في كل الصفات تحت الدراسة.
- لم يكن هناك فروق معنوية بين معاملتي الري عند استنفاذ ٢٥ و ٥٠ % من الماء الميسر و ذلك في صفات محصول البذور و القش بالفدان.
- تناقص الاستهلاك المائي الموسمي كلما زاد الإجهاد الرطوبي على النبات.
- تقل كفاءة استخدام المياه بزيادة أو نقص رطوبة التربة عند استنفاذ ٥٠ % من الماء الميسر.
- تشير النتائج إلى أن الري عند استنفاذ ٥٠ % من الماء الميسر تؤدي إلى زيادة كفاءة استخدام المياه بدون نقص معنوي في محصول البذور و القش/الفدان.