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# FABA BEAN PRODUCTIVITY AS AFFECTED BY NUMBER OF IRRIGATIONS IN NILE DELTA

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## ABSTRACT

A field trail was carried out at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during the two successive winter growing seasons 2008/2009 and 2009/2010. Treatments were: A received 4 irrigations excluding planting irrigation, B received three irrigations after planting watering, C received two irrigations, the first was following sowing and the second was the third as applied for the treatment A, D received two irrigations after the sowing during flowering and maturity stages, E received one irrigation along with sowing irrigation and F was left for rainfall only (without irrigation) after applying the planting watering.

The main target for the current study was to investigate the influence of number of irrigations on faba bean yield, its components and also on some water relations. The main findings of this study could be concluded as follows:

The highest values of water applied [irrigation water (IW) + rainfall (Rf)] were recorded under treatment A (control without stress) which received the high number of irrigations (5 including the sowing) and the seasonal value was 1601.46 $m^3$/fed. (38.13 cm). On the contrary, the lowest value was recorded under the conditions of rainfed treatment (F) of 609.41 $m^3$/fed. (14.51 cm). Also, data clearly illustrated that watering with treatment (B) which received three irrigations excluding the planting one resulted in saving water of about 176.08 $m^3$/fed. (4.19 cm) equivalent to 61 million $m^3$ at the national level. Such saving of water could be used for cultivation new areas.

Regarding crop consumptive use (ETc), data illustrated that with increasing the number of irrigations up to 4.0 excluding the planting one gave the highest seasonal value for crop consumptive use (ETc) comparing with other treatments. The seasonal values for ETc can be arranged in descending order as; 36.93 > 32.60 > 26.60 > 25.05 > 17.09 > 12.37 cm for A, B, D, C, E and F treatments, respectively.

Concerning seed yield (kg/fed.), the highest mean values were recoded under irrigation treatment (B) which received three irrigations following sowing comparing with treatment (A), which received three and four irrigations after sowing, respectively. The mean corresponding values were 1403.33 and 1497.5, kg/fed., respectively. On the contrary, the lowest mean values were recorded under irrigation treatments (E and F) and the mean values were 780.0 and 560.0 kg/fed. in the first and second growing seasons, respectively.

Regarding, all studied parameters such as plant height (cm), 100-seed weight (g), number of pods and number of branches, the highest mean values were recorded under irrigation treatment (A) which received the highest number of waterings. On the other hand, the lowest mean values were recorded under irrigation treatment (F) which left for rainfall during the growing season after planting irrigation.

## INTRODUCTION

In Egypt, there is a great limitation of irrigation water resources which are focused on the river Nile that supplies about 95% or more from fresh water needs. Egypt is the only country over the world that its farming is depending upon irrigation. Knowledge of the optimum quantities and time to

apply irrigation water for obtaining maximum yield of high quality is essential. Shortage of water caused a decrease in most growing characters of broad bean plants (Kozlowski, 1972). Kramer, (1974) added that, soil water deficit led to a disturbance in the most physiological process in plants and this in turn reflected in a decrease of seed yield and quality. In addition, several studies have shown that soil water deficits that occur during the reproductive growth stage are considered to have the most diverse effect on branches number, leaf area, number of flowers on branches and pod setting as compared to the other plant organs affecting the final yield (French, 2009).

Under Saudi Arabia conditions, Al-Suhaibani, (2009) reported that slight decrease in most yield and yield components viz., number of pods/plant, seed weight/plant (g), 100-seed weight (g) was occurred with increasing soil water deficit. He also pointed out that high crude protein and carbohydrate percentage in seeds were associated with low water applied levels.

## MATERIALS AND METHODS

A field experiment was conduced at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, North Nile Delta region during the two growing seasons 2008/2009 and 2009/2010 to study the impact of number of irrigations on faba bean yield and some of its water relations. Soil of the experimental field was clayey in texture (Table 1).

**Table (1):Some physical characteristics for the studied site.**

| Soil depth, (cm). | Physical characteristics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Particle size distribution | | | | Bulk density kg/m$^3$ | Total porosity % | Field capacity % | PWP % | A.W. % |
| | Sand % | Silt % | Clay % | Texture | | | | | |
| 0-15 | 12.2 | 33.3 | 54.5 | Clayey | 1.26 | 52.45 | 47.50 | 25.69 | 21.81 |
| 15-30 | 20.2 | 34.2 | 45.6 | Clayey | 1.30 | 50.94 | 39.87 | 21.66 | 18.21 |
| 30-45 | 20.4 | 41.4 | 38.2 | Clay loam | 1.29 | 51.32 | 38.40 | 20.86 | 17.54 |
| 45-60 | 21.1 | 41.5 | 37.4 | Clay loam | 1.38 | 47.92 | 36.39 | 19.78 | 16.61 |

*** PWP, permanent wilting point, AW; Available water**

Faba bean (*Vicia faba* c.v., Giza 461) was sown on November 10, 2008 and November 5, 2009, harvested on May 5, 2009 and May 3, 2010. While maize, was the previous crop in the two seasons. All the recommended agronomic practices, used in this region were followed except the irrigation treatments which were as follows:

A. Irrigated with 4 watering following the sowing one.
B. Irrigated with 3 waterings following the sowing one.
C. Irrigated with 2 irrigations, the first was following sowing and the second was the third as for treatment A.
D. Irrigated with 2 irrigations; the first one following sowing and the second is as No. 4 as listed with treatment A.
E. Only one irrigation was applied after the sowing.
F. Without irrigation, it was left for rainfall.

So, different treatments could be illustrated in Table (2).

**Table (2): Irrigation for different treatments**

| Irri. No. / Treat. | 0 (Planting) | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| A | + | + | + | + | + |
| B | + | + | + | + | - |
| C | + | + | - | + | - |
| D | + | - | + | - | + |
| E | + | + | - | - | - |
| F | + | - | - | - | - |

It should be notified that irrigation interval for control treatment A was executed as the local farmers irrigate their fields. Irrigation intervals was ranged from 20-25 days as implemented in the area.

**Execution and data collected:**

**Irrigation control**

Application of irrigation water was controlled and measured by rectangular constructed fixed weir upstream with a discharge of 0.01654 $m^3$/sec at 10 cm as effective head over the crest.

**Water-consumptive use (Cu):**

To compute the actual consumed water of the growing plants; soil moisture percentage was determined (on weight basis) before and after each irrigation as well as at harvest. Soil samples were taken from successive layers in the effective root zone, 0-15, 15-30, 30-45 and 45-60 cm. Such method for calculating consumptive use which based on soil moisture depletion (SMD) is defined as actual crop-water consumed (Etc) as stated by Hansen *et al.* (1979).

$$Cu = SMD = \sum_{1=1}^{1=4} \frac{\theta_2 - \theta_1}{100} \times D_{bi} \times D_i$$

**Where:**

Cu = Water consumptive use (cm) in the effective root zone of 60 cm depth, SMD (soil moisture depletion).

i = Number of soil layers (1-4),

$D_i$ = Soil layer thickness (15 cm),

$D_{bi}$ = Bulk density (kg $m^{-3}$) of the layer,

$\theta_1$ = Soil moisture percentage before irrigation, and

$\theta_2$ = Soil moisture percentage, 48 hours after irrigation.

**3. Crop-water use efficiency:**

Crop water use efficiency was calculated according to Doorenbos and Pruitt (1975) as follows:

$$WUsE = \frac{Y}{Cu}$$

$$WUtE = \frac{Y}{Wa}$$

**Where:**

WUsE = Water use efficiency (kg $m^{-3}$),

WUtE = Water utilization efficiency (kg $m^{-3}$),

Y = Seasonal yield kg fed$^{-1}$,
Wa = Seasonal water applied, and
Cu = Crop-Water consumptive use.

**Crop attributes:**

Plant height — Number of branches per plant
Number of pods per plant — 100-seed weight

Data collected were subjected statistical analysis according to Snedecor and Cochran (1980).

## RESULTS AND DISCUSSION

**Amount of applied water (WA, m$^3$/fed.):**

Applied water to faba bean consists of two items; irrigation water (IW) and rainfall (Rf) as clearly are shown in Table 3. Seasonal amounts of rainfall was 34.0 mm and 38.8 mm in the first and second growing seasons, respectively. Seasonal applied water (WA) showed that treatment (A) received the highest applied water of 1601.46 m$^3$/fed. This figure is the summation of 34.49 cm as irrigation water and 3.64 cm as rainfall. On the contrary, the treatment "F" received the lowest average of applied water 609.41 m$^3$/fed., (14.51 cm), 10.87 cm IW and 3.64 cm RF. The values of applied water for all irrigation treatments can be arranged in this descending order: 1601.46 > 1425.58 > 1257.23 > 1182.16 > 843.64 > 609.41 m$^3$/fed. for A, B, D, C, E and F treatments, respectively.

**Table (3): Seasonal water applied; irrigation water (IW) and rainfall (RF) as affected by irrigation regime for faba bean, expressed in m$^3$/fed. and cm.**

| Treatments | Season 2008-2009 | | | | | |
|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** |
| I.W., m$^3$/fed. | 1485.18 | 1311.71 | 1041.29 | 1121.51 | 711.88 | 476.35 |
| I.W., cm | 35.12 | 31.23 | 24.79 | 26.70 | 16.95 | 11.34 |
| RF, m$^3$/fed. | 142.8 | | | | | |
| (mm) | 34.0 | | | | | |
| | **Season 2009-2010** | | | | | |
| I.W., m$^3$/fed. | 1412.35 | 1233.65 | 1017.23 | 1087.15 | 669.6 | 436.66 |
| I.W., cm | 33.63 | 29.37 | 24.22 | 25.88 | 15.94 | 10.40 |
| RF, m$^3$/fed. | 162.96 | | | | | |
| (mm) | 38.8 | | | | | |
| | **Mean of 2 seasons** | | | | | |
| I.W., m$^3$/fed. | 1448.76 | 1272.68 | 1029.26 | 1104.33 | 690.74 | 456.51 |
| I.W., cm | 34.49 | 30.30 | 24.51 | 26.29 | 16.45 | 10.87 |
| RF, m$^3$/fed. | 152.9 | | | | | |
| (mm) | 36.4 | | | | | |

Comparing treatment (A) with other irrigation treatments, average amount of saving water in the two growing seasons were 176.08, 419.50, 344.43, 758.02, and 992.25 m$^3$/fed. or 12.15, 28.96, 23.08, 52.32 and 68.48% for the irrigation treatments B, C, D, E and F, respectively. For

treatment (B) which resulted in the highest yield, saving water was 176.08 $m^3$/fed. under the present shortage of irrigation water such saving of water that obtained from this study is vital in irrigating other crops. Increasing amount of applied water for treatment (A) was due to its high number of irrigations. These results are in a great harmony with those of Al-Shaibani, N.A. (2009).

**Crop consumptive use (Cu):**

Crop consumptive use or crop evapotranspiration (ETc) has the same trend like that of applied irrigation water. Consumptive use is a direct function of the soil water status which already was affected by the amount of applied water. The overall average seasonal consumptive use for faba bean in the two growing seasons, were 36.93 > 32.60 > 26.60 > 25.05 > 17.09 > 12.37 cm for A, B, D, C, E and F irrigation treatments, respectively (Table 4).

Increasing value of consumptive use for treatment (A) which received high number of irrigations in comparison with other treatments was due to increasing amount of applied water which resulted in increasing soil moisture content. These results are in a great harmony with those obtained by El-Maghraby (1980) who reported that water consumptive use for faba bean was decreased by reducing the number of irrigations (i.e. by prolonging irrigation intervals). Also, these results are in a great agreement with those obtained by (French, 2009).

**Table (4):Seasonal consumptive use (Cu) for faba bean, as affected by irrigation regime in the two growing seasons.**

| Treatments | Season 2008-2009 | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| Cu, cm | 37.51 | 33.18 | 24.18 | 26.17 | 17.28 | 12.26 |
| | Season 2009-2010 | | | | | |
| Cu, cm | 36.35 | 32.03 | 25.93 | 27.03 | 16.90 | 12.49 |
| | Means of 2 seasons | | | | | |
| Cu, cm | 36.93 | 32.60 | 25.05 | 26.60 | 17.09 | 12.37 |

**Seed yield (kg/fed.):**

Presented data in Table (5) clearly illustrated that number of waterings has a high significant effect on faba bean seed yield in the two growing seasons. Increasing irrigation period i.e. decreasing number of waterings decreased faba bean seed yield. The lowest mean values were recorded under treatments which received the less number of irrigations (E and F) with corresponding yields of 793.33, 766.67 and 593.33 and 526.67 kg/fed. in the first and second growing seasons, respectively.

Also, as clearly shown in the same table, the high mean values of yield were recorded under treatments which received high number of irrigations (treatments A and B) and the values are 1433.33, 1373.33 and 1528.33 and 1466.67 kg/fed. for treatment (A) and (B) in the first and second growing seasons, respectively. Comparing treatments A and B, the highest mean seed yield was recorded under treatment (B) which received three irrigations, while treatment (A) received four irrigations after sowing.

**Table (5):Faba bean seed yield as affected by irrigation regime in the North Middle Nile Delta region.**

| Irrigation treatments | Seed yield kg/fed. | |
|---|---|---|
| | 2008/2009 | 2009/2010 |
| A | 1433.33 | 1373.33 |
| B | 1528.33 | 1466.67 |
| C | 1266.67 | 1220.00 |
| D | 1146.67 | 1093.33 |
| E | 793.33 | 766.67 |
| F | 593.33 | 526.67 |
| Mean | 1126.94 | 1074.44 |

**All values are significant at 1% level**

Decreasing mean values of faba bean seed yield for treatment (A) which received the highest number of irrigations might be due to increasing amount of applied water besides rainfall that increased availability of soil nutrients and hence, increasing leaching rate of such nutrients. In case of treatments which received the lowest irrigation number and caused decreasing availability of plant nutrients which resulted in decreasing its uptake and therefore, forming small sized seeds with light weight. These results are in a great agreement with those obtained by Abd El-Rahman *et al.* (1980) who reported that irrigation intervals each 20 days proved to be better than irrigation every 15 or 25 days and gave the highest seed yield. Also, French, R.J. (2009), almost found the same results.

**Crop trait:**

**Plant height (cm):**

Data in Table (6) clearly show that the mean values of faba bean plant height was significantly increased by increasing number of irrigations (decreasing irrigation interval). The highest mean values were recorded under treatment (A) which received all irrigations without stress, these values are 140.67 and 138.57 cm in the first and second growing seasons, respectively.

**Table (6):Plant height (cm), 100 seed weight (g), number of pods/plant and number of branches/plant as affected with irrigation regime for faba bean in North Nile Delta region.**

| Trait | Season 2008/2009 | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | Mean |
| Plant height (cm) | 140.67 | 137.07 | 134.13 | 131.03 | 115.3 | 99.37 | 126.26 |
| No. of branches/plant | 4.67 | 4.27 | 3.13 | 2.8 | 2.53 | 2.17 | 3.26 |
| No. of pods/plant | 26.6 | 26.07 | 22.37 | 21.4 | 15.67 | 14.03 | 21.02 |
| 100 seed weight (g) | 72.8 | 72.4 | 63.6 | 62.4 | 55.33 | 50.73 | 62.88 |
| | Season 2009/2010 | | | | | | |
| Plant height (cm) | 138.57 | 136.2 | 132.73 | 128.67 | 113.1 | 97.67 | 124.49 |
| No. of branches/plant | 5.13 | 4.8 | 3.4 | 3.07 | 2.67 | 2.3 | 3.56 |
| No. of pods/plant | 27.7 | 26.73 | 22.93 | 22.3 | 16.53 | 15.1 | 21.88 |
| 100 seed weight (g) | 73.07 | 73.47 | 64.27 | 63.23 | 56.1 | 51.77 | 63.64 |

**All values are significant at 1% level**

On the other hand, the lowest mean values were recorded under the treatments E (one watering following sowing) and F (rainfed treatment).

Increasing mean values of faba bean plant height with increasing number of irrigations might be due to sufficient amount of applied water. So, plants always find their nutritional requirements easily which resulted in well growing and strong plants with a good vegetative growth and tall plant height comparing with treatments received less number of irrigations. These results are in a great harmony with those obtained by El-Beheidi *et al.* (1978), Abd El-Rahman *et al.* (1980), who reported that quantity of irrigation water have a significant effect on the height of faba bean and pea plants. Also, these results are the same with those obtained by Al-Suhaibani, (2009).

**100 seed weight, (g), number of branches/plant and number of pods/plant:**

Data in Table (6) illustrated that irrigation treatments has a significant effect on the abovementioned studied traits, where the highest mean values were recorded under treatments which received the high number of irrigations comparing with other treatments.

Increasing the studied parameters under treatment (A) which received the high number of irrigations) might be due to the conditions of this treatment, availability of soil nutrients which will be more and hence, increasing the amount of nutrients uptake. So, forming strong plants with a good vegetative growth resulted in high 100 seed weight, number of branches and number of pods. These results are in a great harmony with those obtained by Roshdy (1975) and French, (2009).

**Water use and water utilization efficiencies (W.Us.E), W.Ut.E, kg/m$^3$:**

These parameters assess the efficiency exerted by crops in producing yield from water provided for plant. The water use efficiency (WUsE) indicates the amount of yield given from volume unit of water consumed by plant, while the water utilization efficiency (WUtE) indicates the amount of yield given by a volume unit of water applied to field. Results of WUsE show that treatment D have the highest overall value of 1.20 kg/m$^3$ (Table 7). The values of WUsE could be arranged in the descending order as: 1.20, 1.09, 1.08, 1.10, 1.10 and 0.91 kg/m$^3$ for D, E, F, B, C and A treatments, respectively.

**Table (7): Water use efficiency (WUsE) as affected by irrigation regime for faba bean expressed in kg/m$^3$**

| Treatments | Season 2008-2009 | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| WUsE (kg/m$^3$) | 0.91 | 1.10 | 1.25 | 1.43 | 1.10 | 1.15 |
| | Season 2009-2010 | | | | | |
| WUsE (kg/m$^3$) | 0.90 | 1.10 | 1.12 | 0.96 | 1.08 | 1.00 |
| | Mean of 2 seasons | | | | | |
| WUsE (kg/m$^3$) | 0.91 | 1.10 | 1.10 | 1.20 | 1.09 | 1.08 |

Concerning water utilization efficiency (WUtE) results of the effect of number of irrigations on faba bean water utilization efficiency (WUtE) show the same trend like that of the water use efficiency. Meaningfully, treatment F has

the highest overall value of 1.22 kg/m$^3$ (Table 8). Values of WUtE could be arranged in the descending order as; 1.22, 1.17, 1.12, 1.08, 1.01 and 0.96 kg/m$^3$ for F, B, E, C, D and A treatments, respectively.

**Table (8):Water utilization efficiency (WUtE) as affected by irrigation regime for faba bean expressed in kg/m$^3$**

| Treatments | Season 2008-2009 | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| WUtE (kg/m$^3$) | 0.96 | 1.16 | 1.21 | 1.02 | 1.11 | 1.24 |
| | Season 2009-2010 | | | | | |
| WUtE (kg/m$^3$) | 0.97 | 1.18 | 0.96 | 1.00 | 1.14 | 1.20 |
| | Means of 2 seasons | | | | | |
| WUtE (kg/m$^3$) | 0.96 | 1.17 | 1.08 | 1.01 | 1.12 | 1.22 |

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## عدد الريات وإنتاجية الفول البلدى فى منطقة دلتا النيل

**ماهر محمد كساب**
**معهد بحوث الأراضى والمياه والبيئة ـ مركز البحوث الزراعية ـ جيزة**

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا ـ محافظة كفرالشيخ خلال موسمى النمو 2009/2008 ، 2010/2009 وذلك بهدف دراسة تأثير عدد الريات على محصول الفول البلدى ومكوناته وكذلك بعض العلاقات المائية حيث معاملات الرى هى:

A. تروى 4 ريات بعد رية الزراعة.
B. تروى 3 ريات بعد رية الزراعة.
C. تحرم الرية الثانية والرابعة (المضافة إلى المعاملة A ).
D. تروى ريتين تحرم الرية الأولى والثانية (المضافة إلى المعاملة A).
E. تروى الرية الأولى فقط بعد رية الزراعة.
F. معاملة متروكة للمطر بعد رية الزراعة.

**يمكن تلخيص أهم النتائج كالتالى:**

- سجلت أعلى القيم للماء المضاف تحت المعاملة A حيث كانت 1601.46م$^3$/فدان وعلى العكس من ذلك سجلت أقل القيم تحت المعاملة (F) وكانت القيمة 609.41 م$^3$/فدان دلت النتائج كذلك على أن المعاملة B والتى أعطيت 3 ريات بخلاف رية الزراعة أدت إلى توفير كمية من المياه ومقدارها 176.08 م$^3$/فدان مقارنة بالمعاملة A والتى أعطيت 4 ريات + رية الزراعة.
- بالنسبه لقيم الاستهلاك المائى الموسمى دلت النتائج على زيادة القيم تحت ظروف المعاملة A مقارنة ببـاقى المعـاملات والقـيم يمكنـه ترتيبهـا تنازليـا: 36.93 > 32.60 > 26.60 > 25.30> 17.09 > 12.73 بالنسبه للمعاملات A ، B ، D ، C، E ، F على الترتيب.
- بالنسبه لمحصول الحبوب كجم/فدان سجلت أعلى القيم تحت معاملة الرى (B) والتى أعطيت 3 ريات بعد الزراعة مقارنة بالمعاملة (A) والتى أعطيت 4 ريات وكانت القيم: 1433.33 ، 1373.33 ، 1528.33 ، 1466.67كجم/فدان للمعاملة A و B فى الموسم الأول والثانى على الترتيب. وعلى العكس أقل القيم سجلت تحت المعاملة F ، E حيث القيم كانت: 793.33، 766.67 ، 593.33 ، 526.67كجم/فدان فى الموسم الأول والثانى على الترتيب.
- بالنسبه لمكونات المحصول مثل طول النبات (سم) ، وزن 100 حبة (جرام) ، عدد القرون وكذلك عدد الفروع سجلت أعلى القيم تحت المعاملة A وقد سجلت أقل القيم تحت المعاملة (F) والتى تركت للأمطار بعد رية الزراعة.

**قام بتحكيم البحث**

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