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# EFFECT OF IRRIGATIONS NUMBER AND PHOSPHORUS FERTILIZATION ON YIELD AND ITS COMPONENTS OF FABA BEAN IN NORTH NILE DELTA

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## ABSTRACT

Two field experiments were conducted at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate, Egypt during the two successive seasons of 2005/2006 and 2006/2007 to study the effect of irrigations number and phosphorus fertilization levels on faba bean production, consumptive use and water use efficiency. Irrigation was applied at three treatments i.e. 3, 4 and 5 irrigations including sowing irrigation, whereas phosphorus fertilizer was added at three levels i.e. 0, 15 and 30 kg $P_2O_5$/fed. in both seasons.

The main results revealed that increasing number of irrigations caused an increase in yield and yield attributes of faba bean. Also, increasing P-rate caused an increase in all previous characteristics in both seasons. The highest consumptive use values were scored from treatment irrigated with five irrigations. The highest water use efficiency values were obtained from treatment irrigated with four waterings however, the lowest value was obtained from treatment received three watering.

Means values of seasonal water consumptive use of faba bean were 30.0, 34.8 and 42.0 cm/fed. for $I_3$, $I_4$ and $I_5$, respectively.

Seasonal irrigation water applied were 35.2 cm (1482 $m^3$/fed.), 41.2 cm (1732 $m^3$/fed.) and 49.5 cm (2077 $m^3$/fed.) for irrigation treatments $I_3$, $I_4$ and $I_5$, respectively.

Therefore, irrigation of faba bean with 4-waterings including sowing irrigation since the reduction in seeds yield was 5% for 15% of saving irrigation water applied compared with irrigation 5 waterings including sowing irrigation.

## INTRODUCTION

Faba bean (*Vicia faba*) is one of the major winter-sown legume crops grown in the Mediterranean sea region, and has considerable importance as a low coast food rich in proteins and carbohydrates, when carefully managed, it can yield more than 6 t/ha of seed (Saxena *et al.,* 1986). Additionally it helps in restring the fertility of soil in crop rotations through biological nitrogen fixation (Dyke and Prew, 1983). The period during which the crops evaporative demand is high coincides with the end of the rainy reason, thus faba bean experiences considerable soil moisture stress during the reproductive growth stage and often produces poor yields. Moreover, Bond *et al.* (1985) reported that drought is an important factor limiting yield and most faba bean crops in arid climates give a substantial and often economic response to well time irrigation. found that increasing the duration between planting irrigation and the first post planting irrigation form 3 to 8 weeks caused a clear decrease in plant height, 1000 seed weight, seed yield, straw yield and biological yield.

As for phosphorus, is very important nutrient for crop growth and high yield with good quality. It plays a key role in metabolic process such as the conversion of sugar into starch and cellulose. In the context, yield and its

components showed a positive response to phosphorus fertilizer, Soheir Mokhtar (2001), El-Douby and Samia Mouhamed (2002) and Abou Hussien *et al.* (2002). Also, they reported that plant height, number of pods and seeds/plant as well was weight of seed, straw and biological yield/fed. and seed protein percentage were increased due to phosphorus fertilizer applications. Thus, this investigation aimed to optimize faba bean production through better management of water and phosphorus fertilizer.

## MATERIALS AND METHODS

Two field experiments were conducted during the two growing seasons 2005/2006 and 2006/2007 at Sakha Agricultural Research Station, Kafr El-sheikh Governorate, the station is situated at 31$^{o}$C-07N latitude, 30$^{o}$C-75 E longitude. It has elevation of about 6 meters above sea level, it represents conditions and circumstances of middle northern part of the Nile Delta. The experimental site is located near to the main open drain and was served by tile drainage established since 1989. The title drainage system consists of subsurface, 10 cm inner diameter, PVC pipes spacat 20 m apart and buried at 1.65 m depth using faba bean crop. These experiments aimed to study the effect of irrigation regime and phosphorus fertilization on faba bean production. Soil of experimental field was clayey (51.1%, 33.4% silt and 15.3% sand) in texture and non-saline, non alkaline, available nutrients were 21, 5.5 and 200 ppm for N, P and K.

Dates of sowing (S) and harvesting (H) were as follows:

Season 1 (S) 5/11/2005 (H) 5/5/2006

Season 2 (S) 10/11/2006 (H) 7/5/2007

All cultural practices were done as recommended by the Egyptian Ministry of Agricultural and Land Reclamation except the two factors of study i.e. irrigation number and rates of phosphorus fertilizer. Area of plot was 7.5 x 7.5 = 52 m$^2$ = 1/80 fed. The experimental design was a split plot design with four replicates as follows:

**I. Main treatments (irrigations number)**

$I_3$ = 3 irrigation $I_4$ = 4 irrigations $I_5$ = 5 irrigation

**II. Subtreatments (phosphorus fertilizer levels)**

$P_1$ = (0) kg of $P_2O_5$ $P_2$ = (15) kg of $P_2O_5$ $P_3$ = (30) kg of $P_2O_5$

**Irrigation water:**

The quantity of applied irrigation water was measured using the submerged orifice formula, according Hansen *et al.* (1980).

$$q = 0.0226\ D^2\ h^{½}$$

**Where:**

q = discharge of irrigation water (L/sec)

D = Inside diameter of the pip (cm).

h = Average effective head (head causing flow), cm

Soil moisture content was determined gravemetrically as average of two sub-samples of four depths (0-15, 15-30, 30-45, and 45-60 cm) just before and after each irrigation as well as before harvesting for all treatments to determine water consumptive use (Cu) according to Hansen *et al.* (1980).

$$Cu = \sum_{i=1}^{n=4} \frac{\theta_2 - \theta_1}{100} \times D \times Bd$$

**Where:**
Cu = Water consumptive use in cm.
D = Soil depth (cm).
Bd = Bulk density, gm $cm^{-3}$
$\theta_2$ = Soil moisture content after irrigation.
$\theta_1$ = Soil moisture content before irrigation.

$$\text{Field water use efficiency} = \frac{Y}{WR}$$

**Where:**
Y = Seed yield (kg/fed.).
WR = The total amount of water applied in the field ($m^3$/fed.)

Crop water use efficiency: It was calculated as follows (Michael, 1978).

$$\text{Crop water use efficiency} = \frac{Y}{WCU}$$

**Where:**
Y = Seed yield (kg/fed.).
WCU = Actual water consumptive use ($m^3$/fed.).

**Crop parameters:**

At harvest, ten plants were randomly chosen from each plot to measure the following parameters:
Plant height, weight of 100 seeds and seed yield t/fed.

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

## RESULTS AND DISCUSSION

**Water applied:**

Water applied (WA) to faba bean consists of two items. These are (1) irrigation water (IW) and (2) rainfall (RF), as shown in Table (1). Amount of irrigation water (IW) for $I_3$ treatment is the lowest, and the amount for $I_5$ treatment was the highest. Mean values of applied for $I_3$, $I_4$ and $I_5$ treatments were 1482.0 $m^3$/fed., 1732.0 $m^2$/fed. and 2077.0 $m^3$/fed. water applied in the first season more than the second season caused the difference between the rainfall. Sowing irrigation was the same for all irrigation treatments. The average of the effective rainfall was 346 $m^3$ over both growing seasons. It is obvious that amount of irrigation water applied was gradually increased as a result of growing up of a vegetative growth that required higher amount of irrigation to meet its water requirements, and then it decreased again. These findings may be attributed to growth stages, and the availability of soil water content in the root zone. For faba bean growth without stress in North Delta, Egypt, approximately 2077 $m^3$/fed. of water would be required.

**Water consumptive use (Cu):**

Tabulated data in Table (2) reveal that (Cu) increased as the irrigation application increased. Faba bean plants of irrigation treatment of $I_5$ has the highest value of water consumption followed by faba bean plants in the treatments of $I_4$ and $I_3$, respectively. Mean values of seasonal water consumptive use were 30.0, 35.0 and 42.0 cm for $I_3$, $I_4$ and $I_5$ treatments, respectively. While the effect of phosphorus fertilization addition on Cu were 33.2, 35.2 and 36.5 cm for $P_1$, $P_2$ and $P_3$, respectively. The most probably explanation for these results is that more available soil moisture was resulted from more irrigation times giving chance for luxury consumption of water, which ultimately resulted in enhancing transpiration from faba bean plants, in addition to high water evaporation from the soil. These results are in agreement with those obtained by Abd El-Mottaleb and Abbas (1994) and Meleha *et al.* (2004), who pointed out that faba bean plant consumed more water under frequent irrigations. Also, these results are in line with those reported by El-Waraky and Wahb (1999).

**Table (1): Amounts of seasonal irrigation water applied $m^3$/fed. as affected by different irrigation treatments, as well as the amounts of effective rainfall during the two seasons.**

| Seasons | | Date | $I_3$ | $I_4$ | $I_5$ |
|---|---|---|---|---|---|
| 2005/2006 | Sowing irrig. | Nov. 1st | 520 $m^3$/fed. | 520 $m^3$/fed. | 520 $m^3$/fed. |
| | The first irrig. | Dec., 2nd | 390 $m^3$/fed. | 390 $m^3$/fed. | 390 $m^3$/fed. |
| | The second irrig. | Jan., 1st | - | 320 $m^3$/fed. | 320 $m^3$/fed. |
| | The third irrig. | Feb., 2nd | - | 300 $m^3$/fed. | 300 $m^3$/fed. |
| | The fourth irrig | Mar. 2nd | 350 $m^3$/fed. | - | 350 $m^3$/fed. |
| | Irrigation water applied | | 1260 $m^3$/fed. | 1530 $m^3$/fed. | 1880 $m^3$/fed. |
| | Effective rainfall | | 205 $m^3$/fed. | 205 $m^3$/fed. | 205 $m^3$/fed. |
| | Water applied | | 1465 | 1735.0 | 2085 |
| 2006/2007 | Sowing irrig. | Nov. 3rd | 500 | 500 | 500 $m^3$/fed. |
| | The first irrig. | Dec., 3rd | 380 | 380 | 380 $m^3$/fed. |
| | The second irrig. | Jan., 2nd | - | 290 | 290 $m^3$/fed. |
| | The third irrig. | Feb., 1st | - | 280 | 280 $m^3$/fed. |
| | The fourth irrig | Mar. 3rd | 340 | - | 340 $m^3$/fed. |
| | Irrigation water applied | | 1220 $m^3$/fed. | 1450 $m^3$/fed. | 1790 $m^3$/fed. |
| | Effective rainfall | | 279.0$m^3$/fed. | 277.0$m^3$/fed. | 279.0$m^3$/fed. |
| | Water applied | | 1499 $m^3$/fed. | 1729 $m^3$/fed. | 2069 $m^3$/fed. |
| Mean of two seasons | Irrigation water applied | | 1240 $m^3$/fed. | 1490 $m^3$/fed. | 1835 $m^3$/fed. |
| | Effective rainfall | | 242 $m^3$/fed. | 242. $m^3$/fed. | 242.3$m^3$/fed. |
| | Water applied | | 1482 $m^3$/fed. | 1732 $m^3$/fed. | 2077 $m^3$/fed. |

**Effective rainfall = incident rainfall x .7 (Novica, 1979).**

**Table (2): Seasonal consumptive use (Cu) for faba bean crop as affected by number of irrigations and phosphorus fertilizer levels in the two growing seasons.**

| Irrigation | Season 2005/2006 | | | Season 2006/2002 | | | Mean of two seasons | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Number | $P_1$ | $P_2$ | $P_3$ | $P_1$ | $P_2$ | $P_3$ | $P_1$ | $P_2$ | $P_3$ | |
| $I_3$ (3) Irrig. | 22.4 | 29.9 | 31.4 | 28.3 | 30.4 | 37.6 | 27.85 | 30.15 | 32.0 | 30.0 |
| $I_4$ (4) irrig. | 32.6 | 34.0 | 35.4 | 33.6 | 35.4 | 380 | 33.1 | 34.7 | 36.7 | 34.8 |
| $I_5$ (5) irrig. | 39.6 | 41.6 | 42.7 | 39.4 | 43.6 | 45.2 | 39.5 | 42.6 | 43.9 | 42.0 |
| Mean | 33.2 | 35.2 | 36.5 | 33.7 | 36.8 | 38.6 | 33.4 | 35.8 | 37.5 | |

The highest value of Cu was obtained from $I_5$ $P_3$ while the lowest value was found with $I_3P_1$. Also, results revealed that Cu was increased by increasing phosphorus fertilizer level.

**Plant height:**

Regarding the effect of water regime, plant height was the greatest with $I_5$ as compared with the other two water regimes. The means of faba bean plant height for seasons due to $I_3$, $I_4$ and $I_5$ were 111.2, 131.9 and 146.6 cm, respectively, Table (3). The increase due to $I_5$ over $I_3$ was about 30% and the increase, over $I_4$ was 20%.

The greater plant height was given by $I_5$ over the two irrigation treatments occurred with all of phosphorus fertilizer treatments. With 0 kg $P_2O_5$ mean values of faba bean plant height are 123.7, 130.5 and 135.5 cm for $I_3$, $I_4$, and $I_5$ treatments. Concerning the effect of phosphorus fertilizer, faba bean plant height was the greatest with $P_3$. This was true under all water regimes in the two seasons. The means of plant height (over the two seasons) due to $P_1$, $P_2$ and $P_3$ were 123.7, 130.5 and 135.5 cm, respectively. The percentage of increase in plant height was given by this $P_3$ was 3.8% compared to $P_2$ and 9.5% compared to $P_1$. The greater plant height was occurred when irrigated with five irrigations and 30 kg $P_2O_5$ as a phosphorus fertilizer. These results are in a good agreement with those obtained by Hassanein (2000), El-Galfy (2005) and El-Bably and Abo-Mostafa (2008), who reported that quantity of irrigation water have a significant effect on the height of faba bean and pea plants.

**Table (3): Plant height (cm) of faba bean as affected by number of irrigations and phosphorus fertilizer levels in the two growing seasons.**

| No. of irrigations | $P_1$ $P_2O_5$ | $P_2$ $P_2O_5$ | $P_3$ $P_2O_5$ | Mean |
|---|---|---|---|---|
| $I_3$ (3 irrig.) | 107.0 h | 122.5 e | 141.5 c | 111.2 c |
| $I_4$ (4 irrig.) | 111.5 g | 132.8 d | 147.2 b | 131.9 b |
| $I_5$ (5 irrig.) | 115.0 f | 140.5 c | 151.0 a | 146.6 a |
| Mean | 123.7 C | 130.5 B | 135.5 A | |

**The 100 seed weight:**

Mean values of 100 seed weight as affected by no. of irrigations and phosphorus fertilization level in the combined analysis over the two growing seasons due to $I_3$, $I_4$ and $I_5$ were 61.9, 63.6 and 65.6 gm, while they are 62.2, 64.0 and 64.9 for $P_1$, $P_2$ and $P_3$ respectively (Table 4).

**Table (4): 100 seed weight (gm) of faba bean as affected by no. of irrigations and phosphorus fertilizer level in the combined analysis over the two growing seasons.**

| No. of irrigations | $P_1$ $P_2O_5$ | $P_2$ $P_2O_5$ | $P_3$ $P_2O_5$ | Mean |
|---|---|---|---|---|
| $I_3$ (3 irrig.) | 60.08 | 60.8 | 62.4 | 61.9 C |
| $I_4$ (4 irrig.) | 62.3 | 62.3 | 63.6 | 63.6 B |
| $I_5$ (5 irrig.) | 62.8 | 62.8 | 64.8 | 65.6 A |
| Mean | 62.2 B | 64.0 A | 64.9 A | |

Results in Table (4) showed that the highest values of 100 seed weight were resulted from irrigation treatments of $I_5$. The increase due to $I_5$ compared to $I_3$ and $I_4$ were 5% and 3%, respectively.

**Seed yield:**

Data reported in Table (5) revealed that seed yield significantly was increased by increasing no. of irrigations in both seasons. Regarding the main effect of irrigation regimes, seed yield was the highest with $I_5$ compared to either $I_4$ or $I_3$. This occurred in both seasons. The combined analysis over the two growing seasons due to $I_3$, $I_4$ and $I_5$ were 0.925, 1.264 and 1.589 ton/fed., while they are 1.048, 1.286 and 1.444 for $P_1$, $P_2$ an $P_3$, respectively. These results are in harmony with those of Fardos and Abdel-Nour (2000), Hassanin (2000) and El-Galfy (2005) who found that a higher yield and its attributes of faba bean plants was gradually increased as a result of increasing the availability of soil moisture content in root zone, which increased seed yield.

**Table (5): Seed yield (t/fed.) of faba bean as affected by no. of irrigations and phosphorus fertilizer level in the combined analysis over the two growing seasons.**

| No. of irrigations | $P_1$ $P_2O_5$ | $P_2$ $P_2O_5$ | $P_3$ $P_2O_5$ | Mean |
|---|---|---|---|---|
| $I_3$ (3 irrig.) | 0.970 G | 0.915 F | 1.090 E | 0.992 C |
| $I_4$ (4 irrig.) | 1.250 E | 1.313 D | 1.430 C | 1.331 B |
| $I_5$ (5 irrig.) | 1.325 D | 1.430 B | 1.575 A | 1.443 A |
| Mean | 1.181 C | 1.219 B | 1.365 A | 1.255 |

**Crop water use efficiency (CWUE):**

Data of table (6) revaled that irrigation treatment of $I_4$ resulted in the highest value of CWUE to be 38.9 kg of seed yield/cm of water consumed, while the lowest one was 30.3 kg of seed yield/cm of water consumed, resulted from irrigation treatment of $I_3$. These findings could be attributed to the high significant differences between yield of faba bean and differences between water consumptive use.

**Table (6): Seed yield (kg/fed.), consumptive use (Cu) cm/fed, water applied (wa) $m^3$/fed., crop water use efficiency (CUWE) kg/m and field water use efficiency (FWUE) kg/$m^3$ as affected by irrigation treatment and phosphorus fertilizer levels during both growing seasons (2005/2006 and 2006/2007).**

| Treatments | | Seed yield, kg/fed. | Cu, cm/fed. | WA, $m^3$/fed. | CWUF, Kg/cm | FWUE, Kg/$m^3$ |
|---|---|---|---|---|---|---|
| $I_3$ | $P_1$ | 970 | 27.85 | 1482 | 31.2 | 0.58 |
| | $P_2$ | 915 | 30.15 | 1482 | 30.3 | 0.61 |
| | $P_3$ | 1040 | 32.0 | 1482 | 34.1 | 0.73 |
| $I_4$ | $P_1$ | 1250 | 33.1 | 1732 | 37.7 | 0.72 |
| | $P_2$ | 1313 | 34.7 | 1732 | 37.8 | 0.75 |
| | $P_3$ | 1430 | 36.7 | 1732 | 38.9 | 0.82 |
| $I_5$ | $P_1$ | 1325 | 39.3 | 2077 | 33.7 | 0.63 |
| | $P_2$ | 1430 | 42.6 | 2077 | 33.5 | 0.68 |
| | $P_3$ | 1575 | 43.95 | 2077 | 35.8 | 0.77 |

The present results are in line with those reported by Shawky *et al.* (2004), Meleha *et al.* (2004) and Elbably and Abo Mostafa (2008) who reported that the efficiency of water use had decreased as the soil moisture was maintained high by the frequent irrigation.

**Field water use efficiency (FWUE):**

Mean values of field water use efficiency (FWUE) as affected by irrigation number and phosphorus fertilization are shown in Table (6). Irrigation treatment of $I_4$ resulted in highest value of FWUE to be 0.82 kg of seed yield per $m^3$ of water applied, while the lowest one was 0.58 kg yield/$m^3$ of water applied resulted from irrigation treatment of $I_3$. This finding is in agreement with that of El-Bably and Abo-Mostafa (2008).

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**تأثير عدد الريات والتسميد الفوسفاتى على محصول الفول البلدى فى شمال دلتا النيل**

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**معهد بحوث الاراضى والمياه والبيئة - مركز البحوث الزراعية**

اجريت هذه الدراسة بمحطة البحوث الزراعية بسخا محافظة كفرالشيخ - مصر خلال عامى 2006/2005 ، 2007/2006 بهدف دراسة تأثير عدد الريات والتسميد الفوسفاتى على محصول الفول البلدى والاستهلاك المائى والكفاءة الاستعمالية لمياه الرى وكانت معاملات الرى ثلاث ريات واربع ريات وخمس ريات مشتملة على ريه الزراعة وكانت معاملات التسميد الفوسفاتى صفر ، 15 ، 30 كجم ($P_2O_5$). اوضحت النتائج زيادة عدد الريات أدى الى زيادة المحصول ومكوناته وكذلك زيادة معدل التسميد الفوسفاتى ادى الى زيادة المحصول ومكوناته

**ويمكن تلخيص اهم النتائج فى الاتى:**

1. أعلى معدل استهلاك مائى كان للمعاملة 5 ريات.
2. أعلى كفائة استعمالية لمياه الرى كانت للمعاملة اربع ريات.
3. متوسط قيم الاستهلاك المائى كانت 30 ، 34.8 ، 42 سم للفدان.
   للمعاملات $I_3$, $I_4$, $I_5$ على الترتيب.
4. متوسط مياه الرى كانت 35 سم (1482 م$^3$/فدان) ، 41.2 سم (1732 م$^3$/فدان) ، 49.5 سم (2077 م$^3$/فدان) لمعاملات الرى $I_3$, $I_4$, $I_5$ على الترتيب.

وتوصى الدراسى برى الفول البلدى اربع ريات متضمنه ريه الزراعة (معاملة الرى $I_4$) تحت ظروف منطقة الدراسة حيث الانخفاض فى الانتاجية يصل الى 5% مقابل التوفير فى مياه الرى يعادل 15% مقارنة بالرى خمس ريات متضمنة ريه الزراعة (معاملة الرى $I_5$).