Zagazig J. Agric. Res., Vol. 37 No. (5) 2010 1045 -1076

EFFECT OF IRRIGATION INTERVAL, ORGANIC MANURING AND P AND K FERTILIZATION LEVELS ON FABA BEAN SEED QUALITY AND PHOSPHORUS USE EFFICIENCY ATTRIBUTES UNDER SANDY SOIL CONDITIONS

Ahmed A. AbdulGalil[1], A.E.A. Omar[1]*, S.A. Mowafy[1] and T.S. Mokhtar[2]

1 Agron. Dept., Fac. Agric., Zagazig University, Egypt.

2 Ministry of social solidiarity, Egypt.

ABSTRACT

This investigation was carried out during two seasons (2004/2005 and 2005/2006) in a sandy soil of Agricultural Research Station, Faculty of Agriculture, Zagazig University at El-Khattara region. The study aimed to finding out the effect of irrigation interval (7 and 10 days), organic manuring (addition of 30 m^3 FYM/fad compared with a check), P (0, 15.5, 31.0 and 46.5 kg P_2O_5/fad) and K (24 and 48 Kg K_2O/fad) fertilization levels on faba bean seed quality and P uptake and some of its use efficiency attributes.

Shortening the irrigation interval resulted in a significant increase in seed coat percentage but decreased the swelling and hydration coefficient and the seed protein content. In contrary, swelling and hydration coefficients as well as seed protein content were increased due to organic manuring or addition of P up to 31 kg P_2O_5/fad. The increases in these characters due to addition of P fertilizer were on expense of seed coat percentage. Narrowing the irrigation interval or organic manuring increased P uptake and all the P fertilization efficiency attributes. Though, total P uptake was increased significantly with each P increment up to the higher level tested, the last tried increment followed without or with adverse effects on P fertilization efficiency attributes. Doubling the K fertilization level increased most of P fertilization efficiency attributes.

* **Corresponding author :** A.E.A. Omar, Tel. : +20105135701

E-mail address : omaromar1971@yahoo.com, aeomar@zu.edu.eg.

Significant first order interactions were detected, where narrowing the irrigation or the addition of FYM was effective to increase all the P fertilization efficiency attributes and hence decrease the need for phosphorus fertilizer.

Keywords : Faba bean, seed quality, phosphorus efficiency, P and K fertilization, irrigation interval, farmyard manure.

INTRODUCTION

In Egypt, a very wide gap has been observed between the production and the ever growing consumption from faba bean. The competition among faba bean and the other winter crops in the old land, along with the severe attack with rust and satellite weeds particularly Crenate broomrape (*Orobanche crenata* Forsk) all together played negative roles in limiting the faba bean cultivated area. Therefore, attempts should be devoted to expand the cultivation of faba bean in newly cultivated areas. Studies previously undertaken by the Agronomy Department, Zagazig University in sandy soils showed the possibility of raising faba bean yield under these conditions (AbdulGalil *et al.* 2008).

Several authers reported that irrigation had a significant effect on governing seed quality (Gendy *et al.* 1994; Salwau, 1994; Elemery and Elrabie, 1997 and Ahmed, 2004).

Similarly, phosphourus fertilization was found to have a pronounced effect on faba bean production and hence seed quality (El-Bana and Soliman, 1994; Mowafy, 1995; Mohamed *et al,* 1999 and Rifaat, 2002). El-Gizawy and Mehasen (2009) reported that adding 30 kg P_2O_5/fad mixed with PDB (phosphate dissolving bacteria) markedly increased seed protein content and N and P uptake by faba bean.

Under sandy conditions, addition of organic manure was recommended in order to enrich the soil fertility and to improve the soil physical properties.This addition was reported to increase the efficiency of P fertilization (Mahmoud, 1996; Fayed, 1999 and Koreish *et al.,* 2004).

The role of potassium cannot be neglected regarding faba bean production and hence seed quality (Shehata *et al.,* 1991; Soliman *et al.*, 1997 and Koreish *et al.,* 2004). However, El-Bana and Soliman

(1994) reported that seed coat percentage and swelling and hydration coefficients of faba bean were not significantly affected by K fertilization level. Alderfasi and Alghamdi (2010) obtained the highest value of macro and micronutrient uptake by adding irrigation water up to 75% of water holding capacity in the presence of 100 kg P_2O_5/ha and 200 kg K_2O/ha under Saudi Arabia conditions.

Therefore, the present study was carried out to find out the effect of irrigation interval, addition of FYM and different P and K fertilization levels on faba bean seed quality and the efficiency of P fertilization under sandy soil conditions using Nubaria 1 faba bean cultivar.

MATERIALS AND METHODS

This investigation was conducted in the Agricultural Research Station of the Faculty of Agriculture, Zagazig University at El-Khatara, Sharkia Governorate during the two growing seasons of 2004/2005 and 2005/2006. The study aimed to investigate the response of faba bean (Nubaria 1 cultivar) to irrigation interval (7 and 10 days), farmyard manuring (0 and 30 m^3/fad) and P (0,15.5,31.0 and 46.5 kg P_2O_5/fad) and K fertilization levels (24 and 48 kg K_2O/fad) under sandy soil conditions. The soil of the experimental site is sandy in texture, where it had a particle size distribution of 89.1, 6.6 and 4.3% for sand, silt and clay, respectively. The soil had an average pH of 8.1 and organic matter content of 0.28%. The average available soil N, P and K contents were 15.4, 3.5 and 91.7 ppm, respectively.

Farmyard manure (FYM) as delivered from the Agricultural Research Station of the Faculty of Agriculture had the following nutrient contents : 302 ppm N, 440 ppm P, 1131 ppm K, 13.01% organic matter, with a pH of 7.03 in the first season and 311 ppm N, 452 ppm P, 1143 ppm K, 13.52% organic matter, with a pH of 6.89 in the second season. Farmyard manure was soil incorporated before sowing. Flood irrigation was scheduled at seven or ten days intervals after thinning (15 days after planting). Phosphorus as superphosphate (15.5% P_2O_5) and potassium as potassium sulphate (48% K_2O) were mixed and hand band placed below the seeding level in two equal doses at thinning (15 days after planting, DAP) and

7 and 10 days later according to the irrigation interval. Nitrogen as ammonium sulphate (20.5% N) at the rate of 100 kg/fad was applied at planting as activating dose.

A split-split plot design with four replications was used where the main plots were occupied by the irrigation interval and the first order and second order sub-plots were occupied by FYM and P x K levels combinations, respectively. The plot area (14 m^2) included 7 rows of 4 m length and 50 cm apart. The three central rows were devoted for final yield determination. Three seeds of faba bean (Nubaria 1 cultivar) were sown in hills 15 cm apart on the first week of November in both seasons. Faba bean was preceded by a fallow in the two seasons. After 15 days from planting the seedlings were thinned to two plants/hill (112 thousand plants/fad). Seeds were inoculated with the proper inoculum (*Rhyzobium leguminosarum bv. Viceae*) at the rate of 2.5 gm/kg of seeds. All the other cultural practices were kept the same as recommended. Harvest was made in the first week of May in the two seasons.

Recorded Data

Seed quality characters

At harvest, seed and total yields/fad were recorded from the three central rows. Ten pods were randomly taken where the following characters were recorded:

1. Seed coat percentage.
2. Swelling coefficient :

   = Seeds size after soaking for 20 hours/ seeds size before soaking X 100.

3. Hydration coefficient :

   = Seeds weight after soaking for 20 hours/seeds weight before soaking x 100.

Swelling and hydration coefficients were determined as mentioned by Hulse *et al.* (1977).

4. Seed protein content (%).

Total nitrogen was determined using the Micro-kieldahl's method as outlined by Cole and Parks (1946). Protein content was obtained by multiplying seed total N by 6.25.

Phosphorus uptake and efficiency attributes

Phosphorus content in seeds and straw was colorimetrically

determined as described by Jackson (1973). The following P efficiency attributes were calculated:

1. Total phosphorus uptake (TPU) as kg P/fad.
2. Phosphorus apparent recovery efficiency (PARE) :

   $= U_f - U_0$ / added phosphorus x 100 (%).
3. Phosphorus agrophysiological efficiency (PAPE) :

   $= Y_f - Y_0 / U_f - U_0$ (kg seed/kg recovered P).
4. Phosphorus utilization efficiency (PUE):

   $= T_f - T_0$/ added phosphorus
5. Phosphorus agronomic efficiency (PAE) :

   $= Y_f - Y_0$ / added phosphorus (kg seed/kg added P).

Where :

U_f = total P uptake of P fertilized plants (kg).

U_0 = total P uptake of P unfertilized plants (kg).

Y_f = seed yield of P fertilized plants (kg).

Y_0 = seed yield of P unfertilized plants (kg).

T_f = total dry matter yield of P fertilized plants (kg).

T_0 = total dry matter yield of P unfertilized plants (kg).

The aforementioned equations were used according to Fageria *et al.* (1997).

Analysis of variance and combined analysis for the two seasons were carried out as described by Snedecor and Cochran (1981). For comparison between means, Duncan's multiple range test was applied (Duncan, 1955). The response of seed yield and its attributes to phosphorus fertilization levels was also calculated according to Snedecor and Cochran (1981) using the orthogonal polynomial tables for the significant interactions between factors under study. The significancy of the linear and quadratic components of each of these equations was tested, then the response could be described as linear (first order) or quadratic (second order). The maximum predicted average (Ymax) which could have been obtained due to addition of the predicted maximum P level (Xmax) was calculated according to Neter *et al.*, (1990) and AbdulGalil *et al.* (2003). In interaction tables, capital and small

letters were used to compare rows and columns means, respectively. For simple comparison between levels averages of any factor under study, the main effect tables are provided with the percentage change in any character due to prolonging irrigation interval, addition of FYM or the increase of P and K levels.

RESULTS AND DISCUSSION

Seed Quality Characters

Table 1 shows seed coat percentage, swelling coefficient, hydration coefficient and seed protein content of faba bean as affected by irrigation interval, farmyard manure and P and K fertilization and their interactions in the two seasons and their combined.

Irrigation interval effects

It is quite evident from Table 1 that narrowing the irrigation interval from 10 to 7 days resulted in a significant increase in seed coat percentage but, however a highly significant decrease in swelling coefficient, hydration coefficient and seed protein content. These results clearly indicate that the increase of seed coat percentage due to narrowing the irrigation interval was on the expense of weight of cotyledons where starch is accumulated. This was therefore reflected in a significant decrease in each of swelling and hydration coefficients and as well the seed protein content These results are in harmony with those reported by Gendy *et al.* (1994), Elemery and Elrabie(1997) and Ahmed (2004).

Farmyard manure effect

Addition of 30 m^3/fad of FYM resulted in a highly significant increase in swelling coefficient, hydration coefficient and seed protein content in both seasons and their combined. On the other hand, the seed coat percentage was significantly decreased in the first season only, but was not confirmed by the combined of the two seasons (Table 1).

Here again, the negative relationship between seed coat percentage, on one hand, and swelling coefficient, hydration coefficient and seed protein content on the other is clearly observed. These results are in accordance with those reported by Mahmoud (1996), Fayed (1999) and Koreish *et al.*, (2004).

Table 1. Seed coat percentage, swelling coefficient, hydration coefficient and seed protein content of faba bean as affected by irrigation interval, farmyard manure and P and K fertilization levels and their interactions in the two seasons and their combined

Main effects and interactions	Seed coat percentage (%)			Swelling coefficient (%)			Hydration coefficient (%)			Seed protein content (%)		
	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
Irrigation interval effect : (I)												
Every 10 days	9.88	10.04	9.96	210.03	212.28	211.15	192.80	192.96	192.88	28.90	30.83	29.87
Every 7 days	10.16	10.40	10.28	209.31	209.40	209.36	190.18	191.38	190.78	27.47	27.11	27.29
F test	**	**	**	**	**	**	**	**	**	**	**	**
Farmyard manure effect : (M)												
Without	10.07	10.24	10.15	209.22	209.89	209.56	190.75	190.21	190.48	27.48	28.80	28.14
30 m^3/fad	9.97	10.20	10.09	210.12	211.79	210.95	192.23	194.13	193.18	28.89	29.14	29.02
F test	**	N.S	N.S	**	**	**	**	**	**	**	**	**
Phosphorus level effect : (P)												
Zero (Check)	10.51 a	10.57 a	10.54 a	208.96c	210.31c	209.64b	190.18c	191.01b	190.60b	27.14 c	27.80 b	27.47 c
15.5 kg P_2O_5/fad	10.17 a	10.37 a	10.27 a	209.37b	210.55b	209.96b	190.78b	191.24b	191.01b	27.61 b	28.18 b	27.89 b
31.0 kg P_2O_5/fad	9.78 b	10.06 b	9.92 b	210.09a	211.09a	210.59a	192.38a	193.14a	192.76a	28.91 a	29.79 a	29.35 a
46.5 kg P_2O_5/fad	9.62 b	9.88 b	9.75 b	210.26a	211.41a	210.84a	192.61a	193.29a	192.95a	29.09 a	30.12 a	29.60 a
F test	**	**	**	**	**	**	**	**	**	**	**	**
Potassium level effect : (K)												
24.0 kg K_2O/fad	10.02	10.25	10.14	209.61	210.78	210.19	191.43	192.13	191.78	28.16	28.89	28.53
48.0 kg K_2O/fad	10.02	10.19	10.10	209.73	210.90	210.32	191.55	192.22	191.88	28.21	29.05	28.63
F test	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Interaction effects :												
I x M	**	N.S	N.S	N.S	**	**(1-a)	N.S	**	**(1-a)	**	**	**(1-a)
I x P	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	N.S	N.S	**	N.S
I x K	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
M x P	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
M x K	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
P x K	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificancy, respectively.

Phosphorus level effect

In the two seasons and their combined, each P increment up to addition of only 31.0 kg P_2O_5/fad resulted in a significant decrease in seed coat percentage (Table 1). On the other hand, swelling and hydration coefficients and seed protein content were significantly increased due to this addition where the further P increment did not add a further significant increase in these characters. This was true in both seasons and their combined (Table 1).

The present results clearly indicate the favourable effects of phosphorus fertilization on seed quality and all of its attributes as was expressed in a significant decrease in seed coat percentage but, on the other hand, in a significant increase in swelling and hydration coefficients, as well as seed protein content. This quality improvements are expected to improve the nutritive value and cooking properties of seeds as well. Similar results were reported by Mowafy (1995), Mohamed *et al.* (1999), Rifaat (2002) and El-Gizawy and Mehasen (2009).

Potassium level effect

Doubling the level of K fertilization to 48 kg K_2O /fad was without significant influence on all seed quality characters. This was true in both seasons and their combined (Table 1). These results are in agreement with those reported by El-Bana and Soliman (1994). However others reported significant effect to K fertilization on seed quality of faba bean (Shehata *et al.*, 1991; Soliman *et al.*, 1997 ; Koreish *et al.*, 2004 and Alderfasi and Alghamdi , 2010)

Interaction effect

The irrigation interval x manuring significantly affected swelling and hydration coefficients and seed protein content according to the combined analysis (Table 1-a).

Table 1-a shows that swelling and hydration coefficients and seed protein content were significantly decreased due to narrowing the irrigation interval but were increased due to addition of FYM. However, less frequent irrigations were more effective on all these quality attributes in the manured plants than in the un-manured ones, where the highest average were recorded.

These results are quite interesting as they indicate that from seed quality point of view, less frequently irrigated plants when

Table 1-a. Swelling and hydration coefficients and seed protein content of faba bean as affected by irrigation interval x farmyard manure interaction (Comb.)

Irrigation interval	Farmyard manure (m^3/fad)	
	Without	30
	Swelling coefficient (%)	
	B	A
Every 10 days	210.19 a	212.12 a
	B	A
Every 7 days	208.92 b	209.79 b
	Hydration coefficient (%)	
	B	A
Every 10 days	191.70 a	194.06 a
	B	A
Every 7 days	189.26 b	192.30 b
	Seed protein content (%)	
	B	A
Every 10 days	29.27 a	30.46 a
	B	A
Every 7 days	27.01 b	27.57 b

organic manured, produced seeds of higher quality than those frequently irrigated and un-manured. In otherwords, the soil water holding capacity might have had improved, also, the soil fertility level where wide irrigation interval with organic manuring played a complementary roles in sustaining seed quality of faba bean.

Phosphorus Uptake and Efficiency Attributes

This part of the paper deals with the uptake of P by faba bean plants as recorded at harvest. From this uptake and the seed and total yields/fad, a number of P efficiency attributes was calculated and herein are presented.

Total phosphorus uptake /fad

The total phosphorus uptake (TPU) as affected by irrigation interval, farmyard manure and P and K levels in the two seasons and their combined is given in Table 2.

Irrigation interval effect

In both seasons and their combined, narrowing the irrigation interval from 10 to 7 days resulted

Table 2. Total phosphorus uptake (kg P/fad) of faba bean as affected by irrigation interval, farmyard manure and P and K fertilization levels and their interactions in the two seasons and their combined

Main effects and interactions	1st	2nd	Comb.
Irrigation interval effect : (I)			
Every 10 days	4.818	5.120	4.969
Every 7 days	7.106	7.400	7.253
F test	**	**	**
Difference (+)			46.0
Farmyard manure effect : (M)			
Without	4.452	5.260	4.856
30 m^3/fad	7.472	7.260	7.366
F test	**	**	**
Difference (+)			51.7
Phosphorus level effect : (P)			
Zero (Check)	0.836 d	1.010 d	0.923 d
15.5 kg P_2O_5/fad	4.760 c	4.900 c	4.815 c
31.0 kg P_2O_5/fad	8.973 b	8.775 b	8.874 b
46.5 kg P_2O_5/fad	9.309 a	10.357 a	9.833 a
F test	**	**	**
Difference (+)			965.3
Potassium level effect : (K)			
24.0 kg K_2O/fad	5.928	6.110	6.019
48.0 kg K_2O/fad	5.996	6.410	6.203
F test	N.S	N.S	N.S
Difference (+)			--
Interaction effects :			
I x M	**	**	**(2-a)
I x P	**	**	**(2-b)
I x K	N.S	N.S	N.S
M x P	**	**	**(2-c)
M x K	N.S	N.S	N.S
P x K	N.S	N.S	N.S

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

+ Percentage change due to the addition of the highest P level compared with the check P level.

in significant increase in TPU. The average increase was from 4.969 to 7.253 kg P /fad (46.0%).

These results refer to more availability of P for the frequently irrigated plants. The increase of soil moisture content, always, increases the availability of soil and fertilizers added phosphorus (Russel, 1973).

Farmyard manure effect

Addition of 30 m^3/fad of FYM was followed by, a significant increase in TPU in the two seasons and their combined. The average increase was from 4.856 to 7.366 kg P/fad (51.7%).

Tisdale and Nelson (1975) indicated that soil organic matter plays a favourable role regarding the availability of soil phosphorus through the evolution of CO_2 during decomposition along with the release organic anions, which chelate calcium under alkaline soil conditions. Added FYM, which also was rich in phosphorus, increased P uptake.

Phosphorus level effect

Addition of phosphorus and the increase of its level of application up to 46.5 kg P_2O_5/fad was accompanied by a highly significant increase in TPU in the two seasons and their combined. The average increase was from 0.923 to 9.833 kg P/fad (965.3%).

The soil of the experimental site was very poor from available phosphorus (3.5 ppm), therefore, the TPU did not surpass 1 kg P/fad for the check P treatment. This explains the significant increase of P uptake up to the addition of 46.5 kg P_2O_5/fad which amounted to 9.833 kg P /fad (22.5 kg P_2O_5 /fad).

Potassium level effect

Doubling the level of K fertilization to 48 kg K_2O/fad was without significant influence on TPU. This was true in both seasons and their combined (Table 2).

Interaction effect

The irrigation interval x manuring, irrigation interval x P level and manuring x P level interactions affected significantly the TPU according to the combined analysis.

Table 2-a shows that shortening the irrigation interval increased the TPU but with greater magnitude in the manured than in the un-manured plots. Also, addition of FYM increased the TPU with greater magnitude in the frequently

Table 2-a. Total phosphorus uptake (kg P/fad) of faba bean as affected by irrigation interval x farmyard manure interaction (Comb.)

Irrigation interval	Farmyard manure (m^3/fad)		Difference (%)
	Without	30	
	B	A	
Every 10 days	4.519 b	5.420 b	19.9
	B	A	
Every 7 days	5.193 a	9.314 a	79.4
Difference (%)	14.9	71.8	

Table 2-b. Total phosphorus uptake (kg P/fad) of faba bean as affected by irrigation interval x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Irrigation interval	P level (kg P_2O_5/fad)				Response equations	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	Check	15.5	31.0	46.5	$\hat{Y} = a + bx - cx^2$		
	D	C	B	A	$\hat{Y} = 0.488 + 4.397^{**}$		
Every 10 days	0.624 b	3.874 b	7.271 b	8.107 b	$x - 0.604^{**} x^2$	8.490	56.4
	D	C	B	A	$\hat{Y} = 1.031 + 6.162^{**}$		
Every 7 days	1.222 a	5.755 a	10.478a	11.558a	$x - 0.863^{**} x^2$	12.030	55.3

Table 2-c. Total phosphorus uptake (kg P/fad) of faba bean as affected by farmyard manure x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Farmyard manure (m^3/fad)	P level (kg P_2O_5/fad)				Response equations	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	Check	15.5	31.0	46.5	$\hat{Y} = a + bx - cx^2$		
	D	C	B	A	$\hat{Y} = 0.489 + 4.162^{**}$		
Without	0.660 b	3.603 b	7.181 b	7.891 b	$x - 0.536^{**} x^2$	8.568	60.2
	D	C	B	A	$\hat{Y} = 1.031 + 6.396^{**}$		
30	1.187 a	6.027 a	10.567	11.684 a	$x - 0.931^{**} x^2$	12.016	53.2

irrigated than in the less frequently irrigated plots.

Table 2-b shows that TPU was significantly increased due to each increase of P level. The response equations showed that the response was positive and diminishing by the frequently and the less frequently irrigated plants. The TPU could have been maximized to 8.490 kg P/fad if the level of P could have been increased to 56.4 kg P_2O_5/fad in the less frequently irrigated plots, compared with 12.030 kg P/fad if the level of P could have been increased to only 55.3 kg P_2O_5/fad in the frequently irrigated ones.

Table 2-c shows that TPU was significantly increased due to the increase of P level. The response equations showed that the response was positive and diminishing by the manured and the un-manured plants. The TPU could have been maximized to 8.568 kg' P/fad if the level of P could have been increased to 60.2 kg P_2O_5/fad in the un-manured plots, compared with 12.016 kg P/ fad if the level of P could have been increased to only 53.2 kg P_2O_5 /fad in the manured ones.

These interactions, clearly indicate that both the frequent irrigations and the addition of FYM played favourable effects regarding the increase of phosphorus availability and hence the increase of its uptake.

Phosphorus apparent recovery efficiency

The phosphorus apparent recovery efficiency (PARE) expresses the percentage of total P uptake from added P fertilizer. The PARE as affected by irrigation interval, farmyard manure and P and K levels in the two seasons and their combined is given in Table 3.

Irrigation interval effect

Narrowing the irrigation interval to 7 instead of 10 days was followed by a significant increase in PARE in the two seasons and their combined. This recovery was increased from 44.62% to 62.04% according to the combined analysis.

These results clearly indicate that shortening the irrigation interval played a good role in making more of added phosphorus available and hence increased the efficiency of its uptake by faba bean plants.

Table 3. Phosphorus apparent recovery efficiency (%) of faba bean as affected by irrigation interval, farmyard manure and P and K levels fertilization and their interactions in the two seasons and their combined

Main effects and interactions	1st	2nd	Comb.
Irrigation interval effect : (I)			
Every 10 days	44.78	44.46	44.62
Every 7 days	60.81	63.27	62.04
F test	**	**	**
Farmyard manure effect : (M)			
Without	44.33	40.76	42.54
30 m^3/fad	61.26	66.97	64.12
F test	**	**	**
Phosphorus level effect : (P)			
Zero (Check)	--	--	--
15.5 kg P_2O_5/fad	56.99 a	57.97 a	57.48 a
31.0 kg P_2O_5/fad	58.95 a	58.41 a	58.68 a
46.5 kg P_2O_5/fad	42.46 b	45.22 b	43.84 b
F test	**	**	**
Potassium level effect : (K)			
24.0 kg K_2O/fad	50.29	53.68	51.98
48.0 kg K_2O/fad	55.30	54.05	54.68
F test	*	N.S	*
Interaction effects :			
I x M			
I x P	**	**	** (3-a)
I x K	N.S	*	N.S
M x P	N.S	N.S	N.S
M x K	*	**	** (3-b)
P x K	N.S	N.S	* (3-c)
	N.S	N.S	N.S

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

Farmyard manure effect

Addition of FYM significantly increased the PARE in the two seasons and their combined from 42.54% to 64.12%when 30 m^3/fad of FYM were added according to the combined of the two seasons.

It seems evident that FYM addition increased the availability of added phosphorus. The increase of CO_2 evolution and the release of organic anions during organic matter decomposition are known to increase the availability of soil phosphorus (Tisdale and Nelson, 1975).

Phosphorus level effect

In both seasons and their combined, the increase of P level beyond 31.0 kg P_2O_5/fad, was followed by a significant decrease in PARE. These results could be attributed to the noticeable diminishing increase in total P uptake with each increase in P level (Table 3).

Potassium level effect

Doubling the level of K to 48 kg K_2O/fad resulted in a significant increase in PARE in the first season and the combined where it was increased from 51.98% to 54.68% according to the combined.

These results are quite interesting as the increase in the level of added K might have had increased root extension and hence more root surface was served by faba bean plants for P uptake. Potassium plays a role in photosynthates partitioning towards roots as was reported by Mengle *et al.* (1974) in faba bean.

Interaction effect

The irrigation interval x manuring, manuring x P level and manuring x K level interactions affected significantly the PARE according to the combined analysis.

Table 3-a shows that shortening the irrigation interval increased the PARE but with greater magnitude in the manured plots than in the un-manured ones. Also, addition of FYM increased the PARE with greater magnitude in frequently irrigated than in the less frequently irrigated plots. Therefore, addition of FYM along with shortening the irrigation interval maximized the PARE which amounted to 79.78%.

These results clearly indicate that addition of FYM and shortening the irrigation interval played complementary roles regarding the efficiency of faba

Table 3-a. Phosphorus apparent recovery efficiency (%) of faba bean as affected by irrigation interval x farmyard manure interaction (Comb.)

Irrigation interval	Farmyard manure (m^3/fad)	
	Without	30
	B	A
Every 10 days	40.79 b	48.46 b
	B	A
Every 7 days	44.30 a	79.78 a

Table 3-b. Phosphorus apparent recovery efficiency (%) of faba bean as affected by farmyard manure x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Farmyard manure (m^3/fad)	P level (kg P_2O_5/fad)			Response equations $\hat{Y} = a + bx - cx^2$	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	15.5	31.0	46.5			
	A	A	B	$\hat{Y} = 43.47 + 13.04^{**}$		
Without	43.47 b	48.13 b	36.03 a	$x - 8.38^{**} x^2$	48.54	27.6
	A	A	B	$\hat{Y} = 71.48 + 5.39^{**} x$		
30	71.48 a	69.22 a	51.65 a	$- 7.65^{**} x^2$	72.43	21.0

Table 3-c. Phosphorus apparent recovery efficiency (%) of faba bean as affected by farmyard manure x K level interaction (Comb.).

Farmyard manure (m^3/fad)	K level (kg K_2O/fad)	
	24	48
	A	A
Without	42.64 b	42.45 b
	B	A
30	61.32 a	66.92 a

bean plants in uptaking added phosphorus. Added FYM, enhances P uptake through its favourable effect in keeping added P available against fixation, whereas, shortening the irrigation interval, made phosphorus more soluble.

Table 3-b shows that the increase of P level beyond 31.0 kg P_2O_5 / fad, decreased the PARE with greater magnitude in the manured than in the un-manured plots. According to the response equations, the decrease of PARE was diminishing in the manured and un-manured plots. Therefore, addition of 21.0 kg P_2O_5/fad could have been used to maximize the PARE to 72.43% in the manured plots compared with 27.6 kg P_2O_5/fad needed to maximize this efficiency to, only, 48.54% in the un-manured plots.

Table 3-c shows that the increase of K level was without significant effect on PARE in the un-manured plots, whereas it increased it in the manured ones. However, addition of FYM was effective to increase the PARE at the two K levels but with greater magnitude at the high than at the low K level.

According to these interactions, organic manuring played an interacting effect with irrigation interval, P and K levels in affecting the PARE. These interactions clearly indicate that organic manuring was indispensable to maximize the PARE when the irrigation interval was shortened and the P level was adopted around 20 kg P_2O_5 /fad and the K level was doubled to 48 kg K_2O /fad.

It is worth to note that the PARE averages, recorded, herein, are quite high when compared with those reported in the literature by Fageria *et al.* (1997). This could be attributed to a more availability of added P under sandy soil conditions, as well as, a more need of faba bean plants to this addition as the soil of the experimental site was very poor in its fertility level from available phosphorus (3.5 ppm P).

Phosphorus agrophysiological efficiency

The phosphorus agrophysiological efficiency (PAPE) expresses the efficiency of a unit of P uptake from fertilizer phosphorus in building up the seed yield. Therefore, it is expressed as kg seed/kg recovered P.

Table 4. Phosphorus agrophysiological efficiency (kg seed/kg recovered P) of faba bean as affected by irrigation interval, farmyard manure and P and K levels fertilization and their interactions in the two seasons and their combined

Main effects and interactions	1st	2nd	Comb.
Irrigation interval effect : (I)			
Every 10 days	77.74	78.12	77.93
Every 7 days	84.07	85.61	84.84
F test	**	**	**
Difference (+)			8.9
Farmyard manure effect : (M)			
Without	74.23	75.67	74.95
30 m^3/fad	87.58	88.06	87.82
F test	**	**	**
Difference (+)			17.2
Phosphorus level effect : (P)			
Zero (Check)	--	--	--
15.5 kg P_2O_5/fad	67.59 b	68.01 b	67.80 b
31.0 kg P_2O_5/fad	88.13 a	87.97 a	88.05 a
46.5 kg P_2O_5/fad	87.01 a	89.62 a	88.32 a
F test	**	**	**
Difference (+)			30.3
Potassium level effect : (K)			
24.0 kg K_2O/fad	80.29	80.40	80.35
48.0 kg K_2O/fad	81.52	83.33	82.42
F test	N.S	N.S	N.S
Difference (+)			--
Interaction effects :			
I x M	N.S	*	N.S
I x P	**	**	** (4-a)
I x K	N.S	N.S	N.S
M x P	N.S	**	** (4-b)
M x K	N.S	N.S	N.S
P x K	N.S	N.S	N.S

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

+ Percentage change due to the addition of the highest P level compared with the check P level.

The PAPE as affected by irrigation interval, organic manuring and P and K levels in the two seasons and their combined is given in Table 4.

Irrigation interval effect

The PAPE was significantly increased due to shortening the irrigation interval to 7 instead of 10 days. This was true in the two seasons. According to the combined analysis, the PAPE was increased from 77.93 to 84.84 kg seed /kg P due to narrowing the irrigation interval.

These results clearly indicate that the increase of PARE (Table 4) due to narrowing irrigation interval was followed by a significant increase in PAPE. This increase in percentage amounted to 8.9% according to the combined analysis.

Farmyard manure effect

Addition of FYM was accompanied by a significant increase in PAPE in the two seasons and their combined. This increase was 17.2% according to the combined analysis. This indicates that addition of FYM was more effective than narrowing the irrigation interval as far as the beneficial effect on PAPE. This effect was about double of the effect of narrowing the irrigation interval (8.9%). These results are logic as the addition of organic matter plays a role in increasing the availability of soil moisture in addition of its favourble effect on the availability of phosphorus. Therefore, FYM had dual roles, i.e the increase of soil moisture availability as well as the increase of P availability. This in turn increased P uptake and hence increased the PAPE observed herein.

Phosphorus level effect

The increase of P level from 15.5 to 31.0 kg P_2O_5/fad was followed by a significant increase in PAPE in the two seasons and their combined. The further increase of P level was without significant effect on PAPE. These results clearly indicate that 31.0 kg P_2O_5/fad were quite enough to maximize the PAPE as well as the PARE (Table 4).

Potassium level effect

Doubling the level of potassium was without significant effect of PAPE in the two seasons and their combined.

Interaction effect

The irrigation interval x P level and manuring x P level interactions affected significantly the PAPE according to the combined analysis.

Table 4-a. Phosphorus agrophysiological efficiency (kg seed/kg recovered P) of faba bean as affected by irrigation interval x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Irrigation interval	P level (kg P_2O_5/fad)			Response equations $\hat{Y} = a + bx - cx^2$	$\hat{Y}$ max (kg P/fad)	X max (kg P_2O_5/fad)
	15.5	31.0	46.5			
	B	A	A	$\hat{Y} = 59.170 + 36.50^{**}x$		
Every 10 days	59.17 b	85.03 a	89.62 a	$- 10.64^{**} x^2$	90.47	42.1
	B	A	A	$\hat{Y} = 76.43 + 23.98^{**}x -$		
Every 7 days	76.43 a	91.06 a	87.02 a	$9.34^{**} x^2$	91.82	35.4

Table 4-b. Phosphorus agrophysiological efficiency (kg seed/kg recovered P) of faba bean as affected by farmyard manure x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Farmyard manure (m^3/fad)	P level (kg P_2O_5/fad)			Response equations $\hat{Y} = a + bx - cx^2$	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	15.5	31.0	46.5			
	B	A	A	$\hat{Y} = 55.21 + 42.09^{**}$ x		
Without	55.21 b	83.89 a	85.74 a	$- 13.41^{**} x^2$	88.24	39.8
	B	A	A	$\hat{Y} = 80.39 + 18.37^{**}$		
30	80.39 a	92.20 a	90.90 a	$x - 6.56^{**} x^2$	93.25	37.2

It is evident from Table 4-a that the P increment from 15.5 to 31.0 kg P_2O_5/fad was effective to increase significantly the PAPE , but, the further increase of P level did not add a further increase in PAPE. However, the response equations, showed that the effect was of different magnitudes due to varying the irrigation interval. The frequently irrigated faba bean plants were in need for only 35.4 kg P_2O_5 /fad to maximize the PAPE to 91.82 kg /kg P compared with 42.1 kg P_2O_5/fad needed to maximize this efficiency to 90.47 kg /kg P by the less frequently irrigated ones.

These results clearly indicate that keeping the irrigation interval

at 7 days decreased the need for more P in order to maximize the PAPE.

It is evident from Table 4-b that no further significant increase was observed in the PAPE due to the increase of P level beyond 31.0 kg P_2O_5/fad. This was true in the manured and un-manured plots, but with different magnitudes. The response equations of PAPE to the increase of P level were diminishing but a relatively higher response was observed in the manured than in the un-manured plots. However, less P was needed to maximize the PAPE to a higher predicted average in the manured than in the un-manured ones. In the formers PAPE could have been maximized to 93.25 kg seed/kg P compared with 88.24 kg seed/kg P in the latters due to predicted additions of 37.2 and 39.8 kg P_2O_5 /fad in respective order.

Phosphorus utilization efficiency

The phosphorus utilization efficiency (PUE) refers to the efficiency of a unit added P in building up the total faba bean yield. Therefore it is expressed as kg total yield produced by a unit of added P. The PUE as affected by irrigation interval, organic manuring and P and K levels in the two seasons and their combined is given in Table 5.

Irrigation interval effect

Shortening the irrigation interval resulted in a significant increase in the PUE in the two seasons and their combined where the average increase amounted to 53.0%. These results clearly indicate that the utilization of a unit of added P was so much increased due to narrowing the irrigation interval.

Farmyard manure effect

Addition of FYM significantly increased the PUE in the two seasons and their combined Table 5. According to the combined analysis this increase amounted to 65.9% compared to an increase of 53.0% due to shortening the irrigation interval to 7 days. This indicates that organic manuring was more effective than irrigation interval in governing the PUE. Similar effect was observed in PAPE (Table 4) and was attributed to the role of organic matter in maintaining both the soil moisture and phosphorus availabilities.

Table 5. Phosphorus utilization efficiency (kg biomass/kg added P) of faba bean as affected by irrigation interval, farmyard manure and P and K levels fertilization and their interactions in the two seasons and their combined

Main effects and interactions	1st	2nd	Comb.
Irrigation interval effect : (I)			
Every 10 days	63.01	59.97	61.49
Every 7 days	92.47	95.67	94.07
F test	**	**	**
Difference (+)			53.0
Farmyard manure effect : (M)			
Without	58.97	58.04	58.51
30 m^3/fad	96.51	97.60	97.05
F test	**	**	**
Difference (+)			65.9
Phosphorus level effect : (P)			
Zero (Check)	--	--	--
15.5 kg P_2O_5/fad	72.96 b	77.80 b	75.38 b
31.0 kg P_2O_5/fad	90.81 a	92.77 a	91.79 a
46.5 kg P_2O_5/fad	69.46 c	62.89 c	66.18 c
F test	**	**	**
Difference (+)			-12.2
Potassium level effect : (K)			
24.0 kg K_2O/fad	74.00	77.12	75.56
48.0 kg K_2O/fad	81.48	78.52	80.00
F test	*	N.S	*
Difference (+)			5.9
Interaction effects :			
I x M	**	**	** (5-a)
I x P	**	**	** (5-b)
I x K	N.S	N.S	N.S
M x P	*	**	** (5-c)
M x K	N.S	**	** (5-d)
P x K	N.S	N.S	N.S

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

+ Percentage change due to the addition of the highest P level compared with the check P level.

Phosphorus level effect

Doubling the level of P to 31.0 kg P_2O_5/fad was effective to increase significantly the PUE whereas tripling this level to 46.5 kg P_2O_5/fad decreased it. This was true in the two seasons and their combined (Table 5). These results again strengthen the view that PUE was more sensitive than PAPE in expressing the effect of P level on the efficiency of added or recovered phosphorus. The data further indicate that faba bean plants made the best utilization of added P when given at 31.0 kg P_2O_5/fad level.

Potassium level effect

In the first season and the combined of the two seasons, doubling the level of K to 48 kg K_2O/fad was accompanied by a significant increase in PUE. However, this effect was so much limited where it amounted to only 5.9% compared with 53.0% and 65.9% obtained due to narrowing the irrigation interval and addition of FYM. in respective order (Table 5).

Interaction effect

The PUE was significantly affected by all the first order interactions except the I x K and P x K interactions (Table 5).

It is evident from Table 5-a that narrowing the irrigation interval to 7 days was much more effective on PUE in the manured than in the un-manured plots. Therefore, the highest PUE (124.96 kg/kg P) was recorded when FYM was added and irrigation was scheduled at 7 days. However, organic manuring was more effective (97.8%) than irrigation interval (80.7%) in this respect.

It is evident from Table 5-b that the PUE showed diminishing response to the increase of P level at the two irrigation intervals but with different magnitudes. According to the response equations, lower predicted P level (26.9 kg P_2O_5 / fad) could have been used to maximize the PUE to 110.48 kg/kg P with more frequent irrigations than that which could have been used (32.0 kg P_2O_5 /fad) to maximize it to only 74.72 kg/kg P with less frequent irrigations. Therefore, frequent irrigations at 7 days interval afforded faba bean plants the best utilization of added P in building up their total biomass.

Table 5-a. Phosphorus utilization efficiency (kg biomass/kg added P) of faba bean as affected by irrigation interval x farmyard manure interaction (Comb.)

Irrigation interval	Farmyard manure (m^3/fad)		Difference (%)
	Without	30	
	B	A	
Every 10 days	53.84 b	69.16 b	28.5
	B	A	
Every 7 days	63.19 a	124.96 a	97.8
Difference (%)	17.4	80.7	

Table 5-b. Phosphorus utilization efficiency (kg biomass/kg added P) of faba bean as affected by irrigation interval x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Irrigation interval	P level (kg P_2O_5/fad)			Response equations $\hat{Y} = a + bx - cx^2$	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	15.5	31.0	46.5			
	B	A	B	$\hat{Y} = 52.41 + 41.94^{**} x$		
Every 10 days	52.41 b	74.64 b	57.44 a	$- 19.71^{**} x^2$	74.72	32.0
	A	A	B	$\hat{Y} = 98.36 + 32.88^{**} x$		
Every 7 days	98.36 a	108.94 a	74.92 a	$- 22.30^{**} x^2$	110.48	26.9

Table 5-c. Phosphorus utilization efficiency (kg biomass/kg added P) of faba bean as affected by farmyard manure x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Farmyard manure (m^3/fad)	P level (kg P_2O_5/fad)			Response equations $\hat{Y} = a + bx - cx^2$	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	15.5	31.0	46.5			
	B	A	B	$\hat{Y} = 47.95 + 48.08^{**} x -$		
Without	47.95 b	73.52 b	54.06 a	$22.51^{**} x^2$	73.62	32.1
	A	A	B	$\hat{Y} = 102.81 + 26.75^{**} x$		
30	102.81 a	110.06 a	78.30 a	$- 19.50^{**} x^2$	111.98	26.1

Table 5-d. Phosphorus utilization efficiency (kg biomass/kg added P) of faba bean as affected by farmyard manure x K levels interaction (Comb.)

Farmyard manure (m^3/fad)	K level (kg K_2O/fad)		Difference (%)
	24	48	
	A	A	
Without	59.42 b	57.60 b	--
	B	A	
30	91.71 a	102.41 a	11.7
Difference (%)	54.3	77.8	

It is evident from Table 5-c that the response of PUE to the increase of P level was diminishing in the manured and un-manured plots. However, lower predicted P level was needed to maximize PUE to a higher maximum in the manured than in the un-manured plots.

It is evident from Table 5-d that doubling the K level to 48 kg K_2O /fad was without significant effect on PUE of the un-manured faba bean plants. However, this addition increased significantly PUE of the manured faba bean ones. Therefore, the highest PUE (102.41 kg/kg P) was recorded for the manured faba bean plants when fertilized with 48 kg K_2O /fad.

Phosphorus agronomic efficiency

The phosphorus agronomic efficiency (PAE) expresses the efficiency of a unit of added P in building up the seed yield. The PAE as affected by irrigation interval, organic manuring and P and K levels in the two seasons and their combined is given in Table 6.

Irrigation interval effect

Narrowing the irrigation interval to 7 instead of 10, days increased significantly the PAE in the two seasons and their combined where the average increase amounted to 55.5% Table 6. These results confirm those of the PUE where the average increase due to narrowing the irrigation interval amounted to 53%. These clearly indicate that the unit of added P was much more effective in increasing the seed yield as well as the total faba bean biomass, when irrigation interval was shortend.

Farmyard manure effect

Addition of FYM effectively and significantly increased the PAE in both seasons and their combined where the average increase reached 78.6% i.e much more effective than narrowing the irrigation interval (Table 6).

Phosphorus level effect

The increase of P level to 31.0 kg P_2O_5/fad was followed by a significant increase in PAE, but the further increase of P level decreased it significantly in both seasons and their combined.

Similar effect was observed in all P efficiency attributes, particularly the PUE (Table 5). Therefore, the 2nd P fertilization level i.e. 31.0 kg P_2O_5/fad was the optimum level as far as the use of unit of added P in maximizing both the PUE and the PAE.

Table 6. Phosphorus agronomic efficiency (kg seed/kg added P) of faba bean as affected by irrigation interval, farmyard manure and P and K levels fertilization and their interactions in the two seasons and their combined.

Main effects and interactions	1st	2nd	Comb.
Irrigation interval effect : (I)			
Every 10 days	32.33	37.03	34.68
Every 7 days	55.39	52.47	53.93
F test	**	**	**
Difference (+)			55.5
Farmyard manure effect : (M)			
Without	30.27	33.35	31.81
30 m^3/fad	57.45	56.15	56.80
F test	**	**	**
Difference (+)			78.6
Phosphorus level effect : (P)			
Zero (Check)	--	--	--
15.5 kg P_2O_5/fad	43.75 b	40.11 b	41.93 b
31.0 kg P_2O_5/fad	51.88 a	52.90 a	52.39 a
46.5 kg P_2O_5/fad	35.95 c	41.23 b	38.59 b
F test	**	**	**
Difference (+)			-8.0
Potassium level effect : (K)			
24.0 kg K_2O/fad	41.64	42.98	42.31
48.0 kg K_2O/fad	46.08	46.52	46.30
F test	*	N.S	**
Difference (+)			9.4
Interaction effects :			
I x M	**	**	** (6-a)
I x P	**	**	** (6-b)
I x K	*	N.S	N.S
M x P	**	**	** (6-c)
M x K	**	N.S	** (6-d)
P x K	N.S	N.S	N.S

*, ** and N.S. indicate significant at 0.05, 0.01 and insignificant, respectively.

+ Percentage change due to the addition of the highest P level compared with the check P level.

Potassium level effect

Doubling the level of K was effective to increase the PAE significantly in the first season and the combined of the two seasons Table 6. However, this effect was not as much as the effect of either narrowing the irrigation interval or the addition of organic matter.

Interaction effect

It is evident from Table 6-a that narrowing the irrigation interval was much more effective on PAE of the manured than the un-manured plants where the maximum PAE (72.82 kg / kg P) was recorded for the manured faba bean plants when received irrigation at 7 day interval. Here again, organic manuring was much more effective (107.6%) than irrigation interval (78.6%) in this respect.

It is evident from Table 6-b that the PAE could have been maximized to 63.44 kg/kg P with the addition of a predicted P level of 27.9 kg P_2O_5/fad when irrigation was given at 7 day interval. Higher addition of 32.4 kg P_2O_5/fad was needed to maximize it to only 41.95 kg /kg P when the irrigation interval was prolonged to 10 days.

It is evident from Table 6-c that a lower predicted P level of 26.6 kg P_2O_5 /fad could have been used to maximize the PAE to 65.45 kg/kg P for the manured plants compared to a higher level of 33.0 kg P_2O_5/fad needed to maximize PAE to only 40.46 kg/kg P for the un-manured ones.

Finally results in Table 6-d, indicate that the increase in PAE due to the increase of K level was of greater magnitude in the manured than in the un-manured ones where the maximum PAE was recorded (60.84 kg/kg P) when the high K level was used to fertilize the manured faba bean plants. Surprisingly, K fertilization (91.3%) was more effective than organic manuring (15.3%) in this respect. However, this result certained the role of K fertilizer in increasing efficiency of added P unit in building up the seeds with the exposure to water stress late in the season, due to the raise in temperature and the increase in biomass of faba bean plant.

Similar interaction effects were observed in the PUE Table 5-a to 5-c indicating the favourable roles of either narrowing irrigation interval or addition of organic matter in maximizing the efficiency of added P in building up the seed and hence the total yield of faba bean plants. In all cases, organic manuring was more effective than scheduling irrigation in all these respects.

Table 6-a. Phosphorus agronomic efficiency (kg seed/kg added P) of faba bean as affected by irrigation interval x farmyard manure interaction (Comb.)

Irrigation interval	Farmyard manure (m^3/fad)		Difference (%)
	Without	30	
	B	A	
Every 10 days	28.5 b	40.77 b	42.8
	B	A	
Every 7 days	35.08 a	72.82 a	107.6
Difference (%)	23.1	78.6	

Table 6-b. Phosphorus agronomic efficiency (kg seed/kg added P) of faba bean as affected by irrigation interval x P level interaction and the response equations, as well as, predicted maximum ($\hat{Y}_{max}$) and P level (X_{max}) (Comb.)

Irrigation interval	P level (kg P_2O_5/fad)			Response equations $\hat{Y} = a + bx - cx^2$	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	15.5	31.0	46.5			
	B	A	B	$\hat{Y} = 29.11 + 23.52^{**}$		
Every 10 days	29.11 b	41.85 b	33.06 a	$x - 10.77^{**} x^2$	41.95	32.4
	B	A	C	$\hat{Y} = 54.81 + 21.54^{**}$		
Every 7 days	54.81 a	62.91 a	44.13 a	$x - 13.44^{**} x^2$	63.44	27.9

Table 6-c. Phosphorus agronomic efficiency (kg seed/kg added P) of faba bean as affected by farmyard manure x P level interaction and the response equations, as well as, predicted maximum (Y_{max}) and P level (X_{max}) (Comb.)

Farmyard manure (m^3/fad)	P level (kg P_2O_5/fad)			Response equations $\hat{Y} = a + bx - cx^2$	$\hat{Y}$ max	X max (kg P_2O_5/fad)
	15.5	31.0	46.5			
	C	A	B	$\hat{Y} = 24.38 + 28.50^{**} x$		
Without	24.38 b	40.25 b	30.86 a	$- 12.63^{**} x^2$	40.46	33.0
	A	A	B	$\hat{Y} = 59.54 + 16.55^{**} x$		
30	59.54 a	64.51 a	46.33 a	$- 11.58^{**} x^2$	65.45	26.6

Table 6-d. Phosphorus agronomic efficiency (kg seed/kg added P) of faba bean as affected by farmyard manure x K level interaction (Comb.)

Farmyard manure (m^3/fad)	K level (kg K_2O/fad)		Difference (%)
	24	48	
	B	A	
Without	31.86 a	52.75 b	65.6
	B	A	
30	31.80 a	60.84 a	91.3
Difference (%)	--	15.3	

REFERENCES

AbdulGalil, A.A., H.A. Basha, S.A. Mowafy and S.M. Mohamed. 2003. Effect of P addition on the response of four wheat cultivars to N fertilization level under sandy soil conditions. Minufiya J. Agric. Res., 28(1) : 1 – 22.

AbdulGalil, A.A., S.A. Mowafy, A.E. Omar and T.S. Mokhtar. 2008. Nodulation, growth and yield of faba bean as affected by irrigation interval, organic manuring and P and K fertilization levels under sandy soil conditions. Agric. Res. J. Suez Canal Univ., 8(1) : 31 - 48.

Ahmed, E.A.L. 2004. Yield and seed quality of faba bean as affected by some factors. Ph.D. Thesis, Fac. Of Agric., Cairo Univ., Egypt.

Alderfasi, A.A. and S.S. Alghamdi. 2010. Integrated water supply with nutrient requirements on growth, photosynthesis productivity, chemical status and seed yield of faba bean. American – Eurasian J. Agron., 3(1) : 8 – 17.

Cole, J.D. and C.R. Parks. 1946. Simi-microkieldahl procedure for control laboratories. Ind. Egn. Chem. Anal. Ed., 18 : 61 – 62.

Duncan, D.B. 1955. Multiple range and multiple F. test, Biometrics, 11 : 1 – 24.

El-Bana, A.Y.A. and K.G. Soliman. 1994. Yield and yield attributes response of two faba bean (*Vicia faba* L.) cultivars to potassium and phosphorus fertilization under newly cultivated sandy soil conditions. Zagazig J. Agric. Res., 21(5) : 1411 – 1426.

Elemery, M.I. and H.G. Elrabie. 1997. Evaluation of seed quality of selected faba bean (*Vicia faba*, L.) genotype under irrigation and rainfed at Nubaria region. Egypt. J. Appl. Sci., 12(2) : 103 – 115.

El-Gizawy, N.Kh.B. and S.A.S. Mehasen. 2009. Response of faba bean to bio, mineral phosphorus fertilizers and foliar application with zinc. World Applied Sci. J., 6(10) : 1359 – 1365.

Fageria, N.K., V.C. Ballgar and C. Allanjones. 1997. Growth and Mineral Nutrition of Field Crops. New York Basel. Hong Kong.

Fayed, M.N. 1999. Interaction effect of organic matter, heavy metals and root-knot nematode on plant growth and nutrient content of faba bean. Zagazig J. Agric. Res., 26(3B) : 829 – 844.

Gendy, E.N., A.A. Mohamed and S.R. Saleeb. 1994. The effect of number of irrigation and P-fertilization on faba bean. Egypt. J. Appl. Sci., 9(8) : 315 – 322.

Hulse, S.H., K.O. Rachie and O.M. Billingaly. 1977. Nutritional standard and methods of evaluation for food legume breeders. IDRGT. 57e. Ottawa, Canada, pp. 100.

Jackson, M.L. 1973. Soil chemical analysis. Prentice-Hall of India Privat Limited, New Delhi, pp. 183 – 192.

Koreish, E.A., M.E. El-Fayoumy, H.M. Ramadan and W.H. Mohamed. 2004. Interaction effect of organic and mineral fertilization on faba bean and wheat productivity in calcareous soils. Alexanderia J. Agric. Res., 49(2) : 101 – 114.

Mahmoud, M.M. 1996. Natural conditioners effect on some physical and chemical properties of soils. M.Sc. Thesis, Fac. of Agric., Zagazig Univ., Egypt.

Mengel, K., M.R. Haghparast and M. Koch. 1974. The effect of potassium on fixation of molecular nitrogen by roots of faba bean. Plant physiol., 54 : 535 – 538.

Mohamed, E.I., G.A. Zayed and F.A. Khalil. 1999. Effect of different phosphorus sources and levels on the productivity and chemical composition of faba bean (*Vicia faba* L.). Egypt. J. Appl. Sci., 14(7) : 309 – 318.

Mowafy, S.A.E. 1995. Studies on faba bean (*Vicia faba* L.). M.Sc. Thesis, Fac. of Agric., Zagazig Univ., Egypt.

Neter, J., W. Wasserman and M.H. Kutner. 1990. Applied Linear Statistical Model. 3rd Ed. IRWIN, Boston, MA. USA.

Rifaat, M.G.M. 2002. Broad bean response to available soil moisture depletion and phosphorus fertilization in alluvial soil. Egypt. J. Appl. Sci., 17(9) : 334 – 345.

Russel, E.W. 1973. "Soil Conditions and Plant Growth". Language Book Society and Longman, London. pp. 30 – 37.

Salwau, M.I.M. 1994. Effect of irrigation number under different levels of phosphorus and potassium on yield and seed quality of field bean (*Vicia faba,* L.). Egypt. J. Appl. Sci., 9(10) : 1 – 13.

Shehata, H.M.A., H.H. Hatem, M.A. El-Kadi and K.W. Khalil. 1991. Response of faba bean raised on calcareous soil to N and K fertilization. Egypt. J. Appl. Sci., 6(2) : 195 – 207.

Snedecor, G.W. and W.G. Cochran. 1981. Statistical Methods 7th ed., Iowa State Univ., Press, Ames. Iowa U.S.A.

Soliman, K.G., A.E. NasrAlla and Fatma, A.A. Osman. 1997. Effect of source and methods of phosphorus application on broad bean plant under different levels of potassium in a sandy soil. Egypt. J. Appl. Sci., 12(10) : 304 – 321.

Tisdale, S.L. and W.L. Nelson. 1975. "Soil Fertility and Fertilizers". Macmillan Publishing Co., Inc., New York.

تأثير فترة الرى ، التسميد العضوى ومستوى التسميد الفوسفاتى والبوتاسى على صفات الجودة ومؤشرات كفاءة استخدام الفوسفور فى الفول البلدى تحت ظروف الأراضى الرملية

أحمد أنور عبد الجليل[١] – عبد الرحمن السيد أحمد عمر[١]

صـــابر عبد الحميد موافى[١] – تامـــر صـــلاح مختـــار[٢]

١ قسم المحاصيل – كلية الزراعة – جامعة الزقازيق

٢ وزارة التضامن الاجتماعى

أجريت هذه الدراســة لموســمين (٢٠٠٤/٢٠٠٥ و ٢٠٠٥/٢٠٠٦) بــأرض رمليــة بالمزرعة التجريبية لكلية الزراعة – جامعة الزقازيق بمنطقــة الخطــارة وذلــك لدراســة استجابة الفول البلدى (صنف نوبارية ١) لفترتى رى (سبعة وعشرة أيام بــين الريــات) ، التسميد العضوى (إضافة ٣٠ م^{٣}/ فدان بالمقارنة بعدم الإضافة) ، أربعــة مســتويات مــن

الفوسفور (صفر ، ١٥,٥ ، ٣١ ، ٤٦,٥ فو٢أ٥/ فدان) ومستويين من البوتاسيوم (٢٤ و ٤٨ كجم بو٢أ/ فدان) ، وتم تتبع تأثير المعاملات على بعض صفات جودة بذور الفول البلدى ومؤشرات كفاءة استخدام الفوسفور. ويمكن تلخيص أهم النتائج التى تم التحصل عليها كما يلى :

١- أدى تقليل الفترة بين الريات إلى نقص معنوى فى معاملى البلل والهدرجة وكذلك محتوى البذور من البروتين ، وإلى زيادة معنوية فى النسبة المئوية لوزن القصرة.

٢- أدت إضافة السماد العضوى أو زيادة مستويات الفوسفور حتى ٣١ كجم فو٢أ٥/فدان إلى زيادة معاملى البلل والهدرجة ومحتوى البذور من البروتين ، وكانت الزيادة فى هذه الصفات نتيجة إضافة الفوسفور على حساب النسبة المئوية لوزن القصرة الذى إنخفض معنوياً.

٣- لم يؤثر مستوى التسميد البوتاسى على جميع صفات جودة البذور.

٤- أدى تقليل الفترة بين الريات أو إضافة السماد العضوى إلى زيادة الفوسفور الممتص وجميع مؤشرات كفاءة استخدامه.

٥- أدت زيادة مستويات الفوسفور حتى ٤٦,٥ كجم فو٢أ٥/ فدان إلى زيادة الفوسفور الممتص ، وقد كان هذا هو الحال بالنسبة لجميع مؤشرات كفاءة استخدام الفوسفور مع زيادة مستوى الفوسفور حتى ٣١,٠ كجم فو٢أ٥، فى حين زيادة التسميد الفوسفاتى عن ذلك (حتى ٤٦,٥ كجم فو٢أ٥) لم تؤثر على بعض مؤشرات استخدام الفوسفور ، وكان لها أثر عكسى على البعض الآخر.

٦- أدت مضاعفة مستوى البوتاسيوم إلى زيادة معظم مؤشرات كفاءة استخدام الفوسفور.

٧- أوضح تداخل الفعل بين مستويات الفوسفور وفترات الرى أو إضافة السماد العضوى إلى وجود تأثير تكاملى بين عوامل الدراسة ، فقد أوضحت النتائج أنه يمكن معظمة جميع مؤشرات كفاءة استعمال الفوسفور باستخدام مستوى تسميد فوسفاتى أقل عند تقليل الفترة بين الريات أو إضافة السماد العضوى مقارنة بزيادة هذه الفترة أو عدم اضافة السماد العضوى.