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EFFECT OF FURROW SPACING AND PHOSPHORUS FERTILIZATION TREATMENTS ON FABA BEAN YIELD, NUTRIENTS CONTENT AND SOME WATER RELATIONSHIPS

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ABSTRACT

Two field trials were carried out at Sakha Agric. Res. St. farm during two successive winter seasons of 2007/2008 and 2008/2009, to assess the effect of planting methods and phosphorus fertilization treatments on faba bean yield, nutrient contents and some water relationships. Faba bean (*Vicia faba* L.) seeds var. Sakha 2 were planted on November in both seasons. Split plot design was used with four replicates. The main plots were assigned by two planting methods i.e. A: 120 cm furrow spacing with 4 planting rows per furrow and B:60 cm furrow spacing with 2 planting rows per furrow. The sub plots were assigned by four phosphorus treatments .e.1- application of 30 kg P_2O_5 fed^{-1} (ha = 2.4 fed.) as superphosphate 15.5% P_2O_5 (P_2O_5 = 2.29 x P) , 2- completing the soil available phosphorus up to 30 kg P_2O_5 fed^{-1} by superphosphate, 3- application of 15 kg P_2O_5 fed^{-1} in addition to inoculating faba bean seeds with phosphate dissolving bacteria and 4-application of 15 kg P_2O_5 + inoculation with phosphate dissolving bacteria + spraying with cyanobacteria extraction.

The obtained results were summarized as follows:

- Planting methods high significantly affected seed yield in both seasons, the higher mean values of 1653.17 and 1766.75 kg fed^{-1} were obtained with 60 cm furrow spacing in the first and second seasons, respectively.
- Planting method of 60 cm furrow spacing had the higher mean values of biomass (6722.5 and 7161.4 kg fed^{-1}), higher 100 seed weight (99.04 and 101.56 g) and the higher N content mean values (56.0 and 61.4 kg fed^{-1}).
- Planting method of 120 cm furrow spacing had the higher protein % mean value in the second season (22.34%), the higher seed P% mean values (0.55 and 0.56%) and the higher seed P content values of 6.87 and 7.39 kg fed^{-1} in the first and second seasons, respectively.
- Treatment of 15 kg P_2O_5 + inoculation with phosphate dissolving bacteria had the highest seed yield, biomass yield, seed N%, N content of the seeds, protein % and P%.
- Treatment of 30 kg P_2O_5 fed^{-1} had the highest 100 seeds weight values and the highest residual available P values in the soil after faba bean harvesting.
- Planting method of 60 cm furrow spacing had the higher water applied mean values (1596 and 1586 m^3 fed^{-1}) and the higher water consumptive use mean values of 1380 and 1359 m^3 fed^{-1}, while, 120 cm furrow spacing had the lower water applied mean values (1314 and 1285 m^3 fed^{-1}) and the lower water consumptive use mean values of 1113 and 1069 m^3 fed^{-1} in the first and second season, respectively.
- The higher values of water productivity (WP) and productivity of irrigation water (PIW) were 1.24 and 1.30 kg m^{-3} and 1.04 and 1.11 kg of seeds m^{-3} were obtained from 60 cm furrow spacing in the 1st and the 2nd season, respectively.

Key words: Faba bean, phosphorus fertilization, irrigation, water productivity.

INTRODUCTION

Legumes usually require large amounts of phosphorus and their ability to utilize soil phosphate is often less pronounced than that of cereals and grasses (Guanawardena *et al.*, 1992).

Shortage of phosphorus element can reduce legumes nodulation, N-fixation and suppress seed yield (Abdel-Reheem *et al.*, 1992).

Knowledge regarding the effects of cropping practices and fertilization management on the fate of P applied to the soil is required to aid in the prediction of how such practices influence the quality and sustainability of the environment. Most Egyptian soils contain considerably high total phosphorus, yet the amount available for plant uptake is low even after fertilization with the super phosphate due to high pH soils, low organic matter content and calcium carbonate. In such case the two possible ways to increase plant available phosphorus are the use of phosphate solubilizing microorganisms or by decreasing soil pH. A great attention has been paid to the use of phosphate dissolving microorganisms (Saber *et al.*, 1983; Ibrahim *et al.*, 1995; Abdul Wahid and Mehana, 1999; Hamissa *et al.*, 2000 and Knany *et al.*, 2004).

Knany *et al.* (2004) stated that, the highest faba bean seed and straw yields were obtained with 15 kg P_2O_5 fed^{-1}. Inoculating faba bean seeds with phosphate dissolving bacteria achieved the highest hundred seeds weight and phosphorus uptake by the seeds and straw. Application of 50% recommended dose of NPK as drip fertigation jointly with biofertigation and humic substances improved nutrient contents in soil (N, P, K, Fe, Mn and Zn), plant growth nodule parameters, seed quality, and fertilize use efficiency (kg seed kg NPK^{-1}) as well as nutritional assimilation (Selim *et al.*, 2009).

Row spacing affect water relationships and faba bean yield and quality. Talal (2006) showed that, higher row spacing (50-70 cm) resulted in the greatest faba bean yield with a reduction at the narrow spacing.

The objectives of the present study are to investigate the effect of the residual soil phosphate, added phosphate, phosphate dissolving microorganisms on faba bean yield and chemical composition. As well as the effect of row spacing on faba bean yield and water relationships.

MATERIALS AND METHODS

Two field experiments were conducted at Sakha Agric. Res. Station farm (30° 56′ N latitude and 31° 05′ E longitude), Kafr El-Sheikh governorate, Egypt, during the two successive winter seasons 2007/2008 and 2008/2009. The recommended seed rate (40 kg fed^{-1}) of faba bean (*Vicia faba* L.) var Sakha-2 was planted on November in both seasons. Split plot design was used with four replicates. The main plots were assigned by two planting methods of A: 120 cm furrow spacing with 4 planting rows per furrow, and B-60 cm furrow spacing with 2 planting rows per furrow. The sub-plots were randomly assigned with four phosphorus fertilization treatments of 1: application of 30 kg P_2O_5 fed^{-1} (P_2O_5= 2.29 x P), 2: completing the soil

available phosphorus up to 30 kg P_2O_5 fed^{-1}, 3: application of 15 kg P_2O_5 fed^{-1} in addition to inoculating faba bean seeds with phosphate dissolving bacteria (effective strain of *Bacillus megatherium* var. *phosphaticum*), and 4: application of 15 kg P_2O_5 fed^{-1} in addition to inoculating faba bean seeds with phosphate dissolving bacteria and spraying the plants (35 days from sowing) with cyanobacteria extract. Phosphorus was added as single superphosphate 15.5% P_2O_5 during plots preparation as one dose. Effective nitrogen dose was added (20 kg N fed^{-1}) as ammonium nitrate 33% N in one dose before the first irrigation. The other recommended agriculture practices were done. Some physical and chemical soil properties of the experimental field are presented in Table 1.

Available soil phosphorus was extracted by Olsen Method and determined colorimetrically by using spectrophotometer according to Jackson (1958). Available soil nitrogen was extracted by 1 normal KCl and determined by Kjeldahl method according to Black *et al.* (1965). Plant samples were fine ground and wet digested. Total nitrogen and total phosphorus were determined in the digested samples according to Jackson (1958). Protein % was calculated by multiplying N% x 6.25, FAO/WHO (1973).

Table 1: Some physical and chemical properties of the experimental field.

Soil depth	Particle size distribution			Texture class	Bulk density kg m^3	Field capacity %	Per-witting point %	Available water %	EC dS m^{-1}	pH	EC of ground water table	EC of irrigation water	Available nutrients mg kg^{-1}		
	Sand %	Silt %	Clay %										N	P	K
0-15	12.30	33.30	54.40	Clay	1260	47.5	25.81	21.69	2.46	7.81	2.3 dSm^{-1}	0.64 dSm^{-1}	22	7	298
15-30	20.20	34.20	45.60	Clay loam	1210	39.87	21.66	16.21	1.89	7.93					
30-45	20.40	41.40	38.20	loam	1290	38.40	20.86	17.54	2.39	7.96					
45-60	21.10	41.50	37.40	Clay loam	1380	36.39	19.78	16.61	2.45	7.92					

EC was determined in soil paste extract and pH was determined in 1:2.5 soil water suspension according to the standard methods reported by Black *et al.* (1965)

Application of irrigation water was controlled by the constructed rectangular weir that furnished the site with steel gates of each plot. Rate of discharge was 16.54 L sec^{-1}. Water consumptive use or so called crop-water consumed (ETc) was calculated as stated by Hansen *et al.* (1979).

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

Where:

SMD = Soil moisture depletion in the effective root zone = 60 cm

CU = Consumptive use of the growing plants

θ_1 = Mean soil moisture percentage (w/w), before irrigation for the 60 cm soil depth.

θ_2 = Mean soil moisture percentage (w/w) for the 60 cm soil depth, 48 hrs after irrigation (field capacity)

Db = Mean soil bulk density, kg m^{-3} for the 60 cm soil depth

D = Soil wetting depth i.e. effective root zone of 60 cm.
A = Irrigated area, m^2 (4200 m^2 i.e. area of 1 feddan)
Water productivity (WP) was calculated according to Ali *et al.*, (2007). WP = GY/ET. Where: WP (kg seeds m^{-3} WCU), GY = grain yield (kg $fed.^{-1}$) and ET = total water consumption of the growing season (m^3 $fed.^{-1}$). Productivity of irrigation water (PIW) was calculated as Ali *et al.*, (2007).
PIW = GY/I Where: GY is grain yield (kg $fed.^{-1}$) and I is irrigation water applied (m^3 $fed.^{-1}$). Statistical analysis was made using MSTATC computer program.

RESULTS AND DISCUSSION

Faba bean yield:
1.Seed yield:

The seed yield is the most important part of faba bean production. Data presented in Table 2 showed that planting methods high significantly affected faba bean seed yield. The planting method of 60 cm furrow spacing with 2 planting row per furrow had the higher seed yield of 1653.17 and 1766.75 kg fed^{-1} in the first and second seasons, respectively. The increase of the seed yield due to planting method equals 31.9 and 32% in the first and second seasons, respectively. This may be due to that the lower furrow spacing led to suitable plant density and vegetative growth. These results are in harmony with those obtained by Talal (2006) who found that the tested row spacing (50-70 cm) resulted in greatest faba bean seed yield.

On the other hand, no significant differences were obtained between the phosphorus treatments in the first season, while in the second season, there was significant effect due to the phosphorus treatments. The highest mean value of 1599.25 kg fed^{-1} was obtained with 15 kg P_2O_5 fed^{-1} + inoculation with phosphate dissolving bacteria + spraying with cyanobacteria. In this respect, no significant differences were detected between completing phosphorus in the soil to 30 kg P_2O_5 fed^{-1}, 15 kg P_2O_5 fed^{-1} + inoculation and 15 kg P_2O_5 fed^{-1} + inoculation + spraying with cyanobacteria. Data showed that the lowest mean values of 1367.44 and 1461.38 kg seeds were obtained with 30 kg P_2O_5 fed^{-1} treatment in the first and second seasons, respectively. These results could be enhanced by those obtained by El-Saady *et al.* (2007) who found that the lowest mean values of faba bean seed yield were recorded with 30 kg P_2O_5 fed^{-1} treatment at Sakha Agricultural Research station farm.

The previous results showed that phosphate dissolving bacteria increased the availability of the soil phosphate which led to increase faba bean seed yield. These results could be confirmed by those reported by Knany *et al.* (2004).

2.Biomass yield:

Data presented in Table (2) showed that furrow spacing, significantly affected faba bean biomass yield in the first season and highly significant in the second season.

Table 2: Effect of planting methods (furrow spacing) and phosphorus fertilization treatments on faba bean seed yield and biomass yield kg fed^{-1}.

Treat.	Season 2007/2008						Season 2008/2009					
	Seed yield			Biomass yield			Seed yield			Biomass yield		
	Planting methods (furrow spacing)						Planting methods (furrow spacing)					
	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean
30 kg P_2O_5	1113.0b	1621.67 ab	1367.44 A	4865.7 b	6139.3 a	5502.5 b	1185.5 c	1737.25 c	1461.38 b	48345 b	69553 a	5894.9 b
Complete to 30 kg P_2O_5	1188.1 ab	1745.67 a	1467.59 A	5289.3 ab	6898.3 a	6093.8 ab	1320.25 b	1874.0 a	1597.13 a	54725 b	72050 a	
15 kg P_2O_5 + inoc.	1395.3 a	1519.0 b	1457.17 A	6410.5 a	7000.0 a	6705.5 a	1465.75 a	1643.75 c	1554.75 a	65175 a		6942.5a
15 kg P_2O_5 + inoc. + cyano	1316.5 ab	1717.34 ab	1516.80 A	5288.6 ab	6852.5 a	6070.5 ab	1378.5 ab	1820.0 ab	1599.25 a	54870 b	71180 a	6302.0ab
Mean	1253.32	1653.17		5462.70	6722.5		1337.50	1766.75		55179	71614	

	Seed yield					
F. test		L.S.D. 0.05	L.S.D. 0.01		L.S.D. 0.05	L.S.D. 0.01
A	**	-	-	**	-	-
B	NS	-	-	*	93.0	-
AB	*	232.03	-	**	130.4	178.6
	Biomass yield					
A	*	-	-	**	-	-
B	*	958.7	-	*	694.5	-
AB	*	1397	-	*	982.2	-

The traditional furrow (60 cm) had the higher biomass yield of 6722.5 and 7161.4 kg fed^{-1} in the first and second seasons, respectively. This may be due to the amount of the irrigation water and nodulation which increased vegetative growth.

Significant differences due to phosphorus fertilization were detected in the first and the second seasons. Highest means values of 6705.25 and 6942.5 kg fed^{-1} were observed with 15 kg P_2O_5 fed^{-1} + inoculation with phosphate dissolving bacteria in the first and the second seasons, respectively. This may be due to, that inoculation increased availability of soil phosphate. These results were in harmony with those reported by Hamissa *et al.*, (2000) and Knany *et al.*, (2004).

3.100-seed weight:

Data in Table 3 showed that furrow spacing high significantly affected 100-seed weight in both seasons. The highest values of 99.04 and 101.56 g were obtained with 60 cm furrow spacing in the first and second seasons, respectively. This may be due to the amount of the irrigation water applied, where in the traditional furrows (60 cm) the irrigation water applied increased fertilizers solubility, nutrients availability, decreased salt concentration in the root zone, and increased plant growth and photosynthes.

Table 3: Effect of furrow spacing and phosphorus fertilization managements on 100-seed weight (g)

Treatments	Season 2007/2008				Season 2008/2009			
	furrow spacing		T. mean	Diff.	furrow spacing		T. mean	Diff.
	120 cm	60 cm			120 cm	60 cm		
30 kg P_2O_5	82.23 ab	104.3 a	93.26 a	-22.07	84.63 a	105.33 a	94.97 a	-20.70
Complete to 30 kg P_2O_5	83.13 ab	94.18 a	88.65 a	-11.05	85.53 a	97.55 b	91.54 a	-12.03
15 kg P_2O_5 + inoc.	87.08 a	98.82 a	92.95 a	-11.75	88.70 a	101.55 ab	95.13 a	-12.85
15 kg P_2O_5 + inoc. + cyano	83.28 b	98.88 a	86.08 a	-25.60	81.60 a	101.80 ab	91.70 a	-20.20
Mean	81.43	99.04			85.11	101.56	93.33	
F. test		L.S.D. 0.05	L.S.D. 0.01			L.S.D. 0.05	L.S.D. 0.01	
A	**	-	-		**	-	-	
B	NS	-	-		NS	-	-	
AB	*	10.8	-		*	7.48	-	

In respect to phosphorus treatments, the highest 100-seed weight mean values 104.3 g in the first season, and 105.33 g in the second season, were obtained with 30 kg P_2O_5 fed^{-1} treatment under 60 cm furrow space. The obtained data showd the importance of phosphorus fertilization to faba bean crop. Similar results were reported by Bolland *et al.*, (2000) who stated that phosphorus is the major nutrient for grain production of faba bean in neutral to alkaline soils.

Chemical analysis of seeds:

Nutrient status of faba bean plants as affected by furrow spacing and P treatments.

N% of seeds:

Data presented in Table 4 showed that no significant effects were detected in N% due to planting methods during both seasons, while, there was

high significant effect in N% due to phosphorus fertilization treatments in the first and the second seasons.

The highest N% mean values of 3.68% were obtained with (15 kg P_2O_5 + inoculating with phosphate solubilizing bacteria) under 60 cm furrow spaces treatment in the two seasons. This may be due to the high soil pH in Egypt, presence of phosphate solubilizing bacteria led to more available phosphorus and the balance between N and P increased N uptake by faba bean. These results are in harmony with those obtained by Nassar *et al.*, (2002) who found that application of some nutrients caused an increase in N, P, K and some micronutrients uptake in seeds and straw of broad bean.

N content of the seeds (kg fed^{-1}):

Data presented in Table 4 showed the nitrogen content of faba bean seeds in both seasons. In general, 60 cm furrow space had the higher N content in both seasons with average 56.0 kg fed^{-1} comparing with 43.50 kg fed^{-1} in the first season and 61.4 kg fed^{-1} comparing with 47.9 kg fed^{-1} in the second season.

Phosphorus treatments,15 kg P_2O_5 + inoculation with phosphorus dissolving bacteria had the highest N content under 120 cm furrow spacing in both seasons 50.9 and 53.6 kg fed^{-1} in the first and second seasons, respectively. Under 60 cm furrow space there was no significant differences between the phosphorus treatments, the highest N content values of 59.3 and 63.6 kg fed^{-1} were observed with completing the soil available phosphorus to 30 kg P_2O_5 fed^{-1}.

The significant response of N content to the high doses of phosphorus treatments under 120 cm furrow space, may be due to the less moisture in the root zone compared to 60 cm furrow space and the main way of phosphorus translocation from the soil to the root surface is by diffusion in presence of adequate moisture. Most of the phosphorus moves to the root by diffusion (Tisdal *et al.*, 1985). Similar results were reported by Selim *et al.* (2009) who stated that application of 50% recommended dose of NPK jointly with biofertilization improved fertilizer use efficiency, as well s nutritional assimilation of cowpea.

Protein % in the seed:

Data in Table 5 showed that furrow spacing had high effects of protein percentage in first and the second seasons, where 120 cm furrow space had the higher values of 21.61 and 22.34% in the first and second seasons, respectively. Under 120 cm furrow space no significant differences in the protein % was found between the phosphorus treatments in both seasons. While, under 60 cm furrow space there was significant difference in the seed protein % between phosphorus treatments in the two seasons. The highest values of 23.02 and 22.99% were obtained with 15 kg P_2O_5 fed^{-1} + inoculating with phosphorus solubilizing bacteria in the first and second seasons, respectively. While, the lowest values of 19.5 and 19.93 were recorded with 15 kg P_2O_5 + inoculating + spraying with cyanobacteria in the first and second seasons, respectively. The difference in protein % under 60 cm furrow space may be due to the effect of water amounts on phosphorus and nitrogen absorption.

Table 4:Effect of furrow spacing and phosphorus fertilization treatments on N% and N-content of the faba bean seeds kg fed^{-1}.

Treatments	Season 2007/2008						Season 2008/2009					
	N%			N-content			N%			N-content		
	Planting methods (furrow spacing)						Planting methods (furrow spacing)					
	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean
30 kg P_2O_5	3.30 a	3.46 ab	3.38ab	36.6 c	55.2 a	45.9 b	3.58 a	3.56 a	3.57 ab	42.5 c	63.5 a	53 b
Complete to 30 kg P_2O_5	3.50 a	3.38 ab	3.44ab	41.5 bc	59.3 a	50.4 ab	3.56 a	3.40 b	3.48 bc	47.1 bc	63.6 a	55.3 ab
15 kg P_2O_5 + inoc.	3.66 a	3.68 a	3.67a	50.9 a	56.0 a	53.4 a	3.66 a	3.68 a	3.67 a	53.6 a	60.5 a	57.1 a
15 kg P_2O_5 + inoc. + cyano	3.40 a	3.12 b	3.26b	45.0 ab	53.6 a	49.3 ab	3.50 a	3.19 b	3.35 c	48.3 b	58.1 a	53.2 b
Mean	3.46	3.41		43.5	56.0		3.57	3.48		47.9	61.4	
	N %											
F. test			L.S.D. 0.05		L.S.D. 0.01				L.S.D. 0.05		L.S.D. 0.01	
A	NS		-		-		NS		-		-	
B	*		0.34		-		**		0.172		0.236	
AB	NS		-		-		NS		-		-	
	N- content											
A	**		-		-		**		-		-	
B	*		5.80		-		*		3.68		-	
AB	NS		-		-		**		5.21		7.15	

Table 5: Protein % in the seed as affected by furrow spacing and phosphorus treatments.

Treatments	Season 2007/2008				Season 2008/2009			
	Planting methods		T. mean	Diff.	Planting methods		T. mean	Diff.
	120 cm	60 cm			120 cm	60 cm		
30 kg P_2O_5	20.60 a	21.63 ab	21.11 ab	-1.03	22.40 a	22.86 a	22.63 ab	-0.46
Complete to 30 kg P_2O_5	21.90 a	21.13 ab	21.51 ab	0.77	22.22 a	21.22 b	21.72 bc	01.00
15 kg P_2O_5 + inoc.	22.73 a	23.02 a	22.87 a	-0.29	22.86 a	22.99 a	22.93 a	-0.06
15 kg P_2O_5 + inoc. + cyano	21.24 a	19.50 b	20.37 b	1.74	21.90 a	19.93 b	20.91 c	1.97
Mean	21.61	21.32			22.34	21.75		
F. test		L.S.D. 0.05		L.S.D. 0.01		L.S.D. 0.05		L.S.D. 0.01
A	NS	-		-	NS	-		-
B	*	2.14		-	**	1.077		1.48
AB	NS	-		-	NS	-		-

Phosphorus % and phosphorus content:

Data in Table 6 showed that there were significant differences in P% due to planting methods in both seasons. 120 cm furrow space had the higher P% of 0.55 and 0.56% in the first and second seasons, respectively. Phosphorus content in faba bean seed had the same trend in the first season, where 120 cm furrow space had the higher P-content values of 6.87 in the first season and the higher value of 7.69 kg fed^{-1} was obtained with 60 cm space, in the second season.

In respect to phosphorus treatments, and its effects on P% and P-content. Under 120 cm furrow space, there were highly significantly effects of phosphorus treatments on P% and P-content in both seasons. the highest P% values of 0.68 and 0.63% were obtained with 15 kg P_2O_5 fed^{-1} + inoculating with phosphorus solubilizing bacteria in the first and second seasons, respectively. Phosphorus content had the same trend in the first season, where the highest values of 9.5 was recorded with the same treatment. Under 60 cm furrow space, no significant differences were detected between the phosphorus treatments in both seasons except P % in the second season, where, there was highly significant effect and the highest value of 0.5% was observed with the same treatment. Similar results on cowpea were reported by Knany *et al.*(2002) who stated that phosphorus placement increased phosphorus percentage of cowpea seeds up to 15 kg P_2O_5 fed^{-1}, but no clear increase was due to increasing phosphorus placement from 15 to 30 kg P_2O_5 fed^{-1}, and Masoud *et al.* (2007) stated that the narrow spaces between plants (15 cm) had the lowest phosphorus percentage in faba bean seeds.

Residual N and P in the soil:

Data in Table 7 showed that planting methods had no significant effects of available nitrogen in the soil after faba bean harvesting in both seasons. While phosphorus treatments highly significant affected the residual available-N in the soil after faba bean harvesting under 60 cm furrow space, only in both seasons.

The highest available N value of 35 and 35.25 mg kg^{-1} in the first and second seasons, respectively, were obtained with completing the available phosphorus in the soil to 30 kg P_2O_5 fed^{-1} treatment. Residual available phosphorus high significantly affected by planting methods. The higher residual phosphorus values of 15.68 and 15.23 mg kg^{-1} were obtained with 60 cm furrow space in the first and second seasons, respectively.

Table 6 : Phosphorus % and phosphorus content kg fed^{-1} of faba bean seeds as affected by furrow spacing and phosphorus treatments

Treatments	Season 2007/2008						Season 2008/2009					
	P%			P-content			P%			P-content		
	Planting methods (furrow spacing)						Planting methods (furrow spacing)					
	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean
30 kg P_2O_5	0.54 b	0.39 a	0.47 b	5.94 b	6.25 a	6.10 b	0.56 ab	0.44 ab	0.50 b	6.64 b	7.61 a	7.13 b
Complete to 30 kg P_2O_5	0.48 b	0.36 a	0.42 b	5.63 b	6.24 a	5.94 b	0.52 b	0.40 b	0.46 b	6.64 b	7.48 a	7.06 b
15 kg P_2O_5 + inoc.	0.68 a	0.48 a	0.58 a	9.50 a	7.27 a	8.39 a	0.63 a	0.50 a	0.57 a	9.14 a	8.22 a	8.68 a
15 kg P_2O_5 + inoc. + cyano	0.49 b	0.39 a	0.70 b	6.43 b	6.64 a	6.54 b	0.52 b	0.41 b	0.47 b	7.14 b	7.43 a	7.29 b
Mean	0.55	0.40		6.87	6.60		0.56	0.44		7.39	7.69	
	Phosphorus %											
F. test			L.S.D. 0.05		L.S.D. 0.01				L.S.D. 0.05		L.S.D. 0.01	
A	*		-		-		*		-		-	
B	*		0.102		-		**		0.57		0.079	
AB	NS		-		-		NS		-		-	
	Phosphorus content											
A	NS		-		-		NS		-		-	
B	*		1.62		-		**		0.979		1.34	
AB	NS		-		-		NS		-		-	

Table 7:Residual available N and P in the soil mg kg^{-1} after faba bean harvesting

Treatments	Season 2007/2008						Season 2008/2009					
	Available N			Available P			Available N			Available P		
	Planting methods (furrow spacing)						Planting methods (furrow spacing)					
	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean.	120 cm	60 cm	Mean
30 kg P_2O_5	26.25 a	22.75 b	24.50b	16.25 a	17.40 a	16.83	27.13 a	22.75 b	24.94b	16.60 a	16.80 a	16.70
Complete to 30 kg P_2O_5	25.25 a	35.00 a	30.13a	16.00 a	15.50 a	15.75	26.25 a	33.25 a	29.75a	15.70 b	13.80 b	14.75
15 kg P_2O_5 + inoc.	21.00 a	22.75 b	21.88b	15.40 a	16.80 a	16.10	26.25 a	25.38 b	25.82b	14.3 bc	16.00 a	15.15
15 kg P_2O_5 + inoc. + cyano	22.75 a	28.00 b	25.38b	13.20 a	13.00b	13.10	28.00 a	29.75 a	28.88a	12.80 c	14.30 a	13.55
Mean	23.81	27.13		15.21	15.68		26.91	27.78		14.85	15.23	
	Available N											
F. test			L.S.D. 0.05		L.S.D. 0.01				L.S.D. 0.05		L.S.D. 0.01	
A	NS		-		-		NS		-		-	
B	**		4.98		8.19		**		2.69		5.21	
AB	*		5.98				*		3.80		-	
	Available P											
A	NS		-		-		**		-		-	
B	*		7.4		-		**		2.67		5.17	
AB	NS		-		-		*		2.78		-	

In respect to phosphorus treatments and its effects on the residual available phosphorus, the highest residual available phosphorus of 16.25, 17.4, 16.6 and 16.8 mg kg^{-1} soil were obtained with 30 kg P_2O_5 fed^{-1} under the two planting methods in the first and second seasons, respectively. This may be due to the huge amount of 30 kg P_2O_5 rather than the crop needs, some of this amount still available in the soil specially in presence of different species of the microorganisms in the rhizosphere and the root zone. These results are in harmony with those obtained by Knany *et al.* (2002). Water relationships:

a- Water applied:

Data presented in Table 8 showed that furrow spacing clearly affected the water applied. 120 cm furrow space had the lower water applied values of 1314 and 1285 m^3 fed^{-1} in the first and second seasons, respectively. The water saving values were 17.63 and 18.95% in the first and second seasons, respectively. Phosphorus treatments had no significant effects on water applied in both seasons, except the second season under 120 cm furrow space as a planting method. The highest value of 1291 m^3 fed^{-1} was recorded with 15 kg P_2O_5 fed^{-1} + inoculation + cyanobacteria spraying. While the lowest value of 1281 m^3 fed^{-1} was obtained with 30 kg P_2O_5 fed^{-1}. This may be due to the differences of the vegetative growth and faba bean biomass which affected evapotranspiration.

Table 8: Effect of furrow spacing and phosphorus treatments on water applied and water consumptive use by faba bean (m^3 fed^{-1})

Treatments	Season 2007/2008						Season 2008/2009					
	Water applied			Water consumptive use			Water applied			Water consumptive use		
	Planting methods (furrow spacing)						Planting methods (furrow spacing)					
	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean
30 kg P_2O_5	1311 a	1596a	1454a	1114 a	1385 a	1249 a	1281 b	1586 a	1434 a	1077 a	1363 a	1220 a
Complete to 30 kg P_2O_5	1312 a	1595 a	1453a	1111 a	1380 a	1246 a	1285ab	1586 a	1436 a	1072 a	1353 a	1212 a
15 kg P_2O_5 + inoc.	1317a	1595 a	1456a	1113 a	1375 a	1244 a	1284ab	1585 a	1434 a	1053 a	1368 a	1210 a
15 kg P_2O_5 + inoc. + cyano	1317 a	1597 a	1457a	1113 a	1380 a	1247a	1291 a	1586 a	1439 a	1072 a	1355 a	1214 a
Mean	1314	1596		1113	1380		1285	1586		1069	1359	

b- Water consumptive use:

Water consumptive use had the same trend of water applied, where there was clear effect of planting methods on water consumptive use during both seasons. The higher values were recorded with 60 cm furrow space in both seasons (1380 and 1359 m^3 fed^{-1}). No significant effects were detected on water consumptive use due to phosphorus treatments.

c. Water productivity (WP)

Water productivity expressed in kg of seeds for m^{-3} of water consumed and productivity of irrigation water(PIW) in Kg seed m^{-3} of irrigation water applied are presented in Table 9.

The obtained results showed that WP was increased as the irrigation water applied increased, 60 cm furrow space had the higher values of WP to be 1.24 and 1.30 kg of seeds m^{-3} of water consumed, while the lower one was 1.13 and 1.25 kg seed yield m^{-3} of water consumed, resulted from 120 cm furrow space in the 1st and 2nd season, respectively.

Table 9:Water productivity (WP) in Kg seeds m^{-3} of water consumptive use and productivity of irrigation water (PIW) in Kg m^{-3} of irrigation water applied in 2009and 2010 seasons.

Treatments	Water productivity						productivity of irrigation water					
	Planting methods (furrow spacing)						Planting methods (furrow spacing)					
	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean	120 cm	60 cm	Mean
	2007/2008 season			2008/2009 season			2007/2008 season			2008/2009 season		
30 kg P_2O_5	1.00	1.17	1.10	1.10	1.27	1.20	0.849	1.02	0.94	0.93	1.10	1.02
Complete to 30 kg P_2O_5	1.07	1.26	1.18	1.23	1.39	1.32	0.91	1.09	1.01	1.03	1.18	1.11
15 kg P_2O_5 + inoc.	1.25	1.10	1.17	1.39	1.20	1.28	1.06	0.95	1.00	1.14	1.04	1.08
15 kg P_2O_5 + inoc. + cyano	1.18	1.24	1.22	1.29	1.34	1.32	1.00	1.08	1.04	1.07b	1.15	1.11
Mean	1.13	1.24		1.25	1.30		0.96	1.04		1.04	1.11	

.Productivity of irrigation water (PIW)

Results presented in Table 9 indicated that PIW was increased as the irrigation water applied increased, 60 cm furrow space had the higher values of WP to be 1.04 and 1.11 kg of seeds m^{-3} of water consumed, while the lower one was 0.96 and 1.04 kg seed yield m^{-3} of water consumed, resulted from 120 cm furrow space in the 1st and 2nd season, respectively.

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تأثير طرق الزراعة ومعاملات التسميد الفوسفاتي على محصول الفول البلدي ومحتواه من المغذيات وبعض العلاقات المائية

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نفذت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بسخا خلال الموسمين الشتويين ٢٠٠٧/٢٠٠٨م و ٢٠٠٨/٢٠٠٩م لدراسة تأثير بعض طرق الزراعة ومعاملات التسميد الفوسفاتي على محصول الفول البلدي ومحتواه من بعض العناصر وبعض العلاقات المائية. تم زراعة بذور الفول البلدي صنف سخا ٢ في نوفمبر خلال الموسمين. واستخدم تصميم القطع المنشقة في أربع مكررات. شغلت القطع الرئيسية بطريقتين للزراعة:

أ- الزراعة على خطوط عرضها ١٢٠سم حيث تم زراعة أربعة صفوف نباتية عليها.
ب- الزراعة على خطوط بعرض ٦٠سم حيث تم زراعة صفين من النباتات عليها.

وشغلت القطع الشقية بأربع معاملات للتسميد الفوسفاتي:

١- إضافة ٣٠كجم فو٢أه للفدان (هكتار = ٢.٤ فدان) ١٥.٥% فو٢أه (فو٢أه =٢.٢٩ فو) في صورة السوبر فوسفات.
٢- تكملة الفوسفور الميسر بالأرض إلى ٣٠كجم فو٢أه للفدان بإضافة السوبر فوسفات.
٣- إضافة ١٥ كجم فو٢أه للفدان في صورة السوبر فوسفات بالإضافة إلى تلقيح البذور بسلالة نشطة من البكتريا المذيبة للفوسفات.
٤- إضافة ١٥كجم فو٢أه للفدان + التلقيح بالبكتريا المذيبة للفوسفات + الرش بمستخلص السيانوبكتريا

ويمكن تلخيص النتائج المتحصل عليها كالأتي:

- أعطت طرق الزراعة فروقا عالية المعنوية في محصول البذور في الموسمين حيث كانت أعلى قيما للمحصول ١٦٥٣.١٧ ، ١٧٦٦.٧٥كجم للفدان مع الزراعة على الخطوط ذات العرض ٦٠سم في الموسم الأول والثاني على التوالي.
- كما أعطت هذه المعاملة (٦٠سم عرض الخط) أعلى قيما للمحصول الحيوي وهى ٦٧٢٢.٥ ، ٧١٦١.٤ كجم للفدان وأعلى قيما لوزن المائة بذرة وهى ٩٩.٠٤ ، ١٠١.٥٦ جرام وأعلى قيما لمتوسط محتوى الحبوب من النيتروجين وهو ٥٦.٠١ ، ٦١.٤ كجم للفدان في الموسمين الأول والثاني على التوالي.
- أدت طريقة الزراعة على خطوط ١٢٠سم إلى الحصول على أعلى قيم للبروتين في البذور % في الموسم الثاني فقط وهى ٢٢.٣٤% وأعلى نسبة مئوية للفوسفور في البذور وهى: ٠.٥٥ ، ٠.٥٦% وأعلى قيم لمحتوى البذور من الفوسفور ٦.٨٧ ، ٧.٣٩ كجم للفدان في الموسمين الأول والثاني على التوالي.
- أعطت المعاملة ١٥كجم فو٢أه للفدان بالإضافة إلى التلقيح بالبكتريا المذيبة للفوسفات أعلى محصولا للبذور وأعلى محصولا حيويا وأعلى نسبة مئوية للنيتروجين في البذور وأعلى محتوى للنيتروجين في محصول البذور للفدان وأعلى نسبة مئوية للبروتين والفوسفور في البذور.
- أعطت المعاملة ٣٠ كجم فو٢أه للفدان أعلى قيما لوزن مائة بذرة وأعلى قيما للفوسفور الميسر المتبقي بالأرض بعد حصاد الفول.
- أعطت المعاملة (٦٠سم عرض الخط) أكبر كمية من الماء المستهلك بواسطة محصول الفول (١٣٨٠، ١٣٥٩م^3) وأكبر كمية مياه مضافة (١٥٩٦، ١٥٨٦م^3) في موسمي الزراعة على الترتيب، بينما أعطت المعاملة (١٢٠سم عرض الخط) ١١١٣، ١٠٦٩م^3 من الماء المستهلك بواسطة محصول الفول و١٣١٤، ١٢٨٥م٣ ماء مضافا في موسمي الزراعة على الترتيب.
- أعطت المعاملة (٦٠سم عرض الخط) أعلى كفاءة إنتاجية للمتر المكعب من مياه الري المستهلكة بواسطة نباتات الفول البلدي (١.٢٤ و ١.٣٠ كجم بذرة لكل م$^{-3}$ ماء مستهلك وكذلك الكفاءة الإنتاجية لمياه الري المضافة (١.٠٤ و١.١١ كجم بذرة لكل م$^{-3}$ ماء مضاف) في موسمي الزراعة على التوالي.

قام بتحكيم البحث

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