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RESPONSE OF FABA BEAN PLANTS TO PHOSPHORUS FERTILIZATION UNDER SALINE CONDITION

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ABSTRACT

Two pot experiments were carried out during the two successive winter seasons of 2005-2006 and 2006-2007 under the greenhouse of Faculty of Agric., Mansoura University to study the effect of salt stress of irrigation water and phosphorus fertilization on faba bean (*Vicia faba L.)*. These experiments were conducted in a spilt plot design the main plots were 4 levels of saline water (360 mg/l (tap water), 1000, 2000 and 3000 mg/l.) and the sub-plots were 4 levels of phosphorus fertilization (0, 13, 26 and 39 kg P.fed^{-1}.) with three replicates ..

The Obtained results could be summarized as follow:

- By increasing salt concentration in irrigation water, number of flowers per plant, the mean value of number of pods per plant, pod setting %, seed index, straw and seed yield, N, P and K uptakes (mg/plant) of straw and seeds of faba bean plant as well as the calculated total uptake (straw + seeds) decreased significantly.
- Soil addition of P-fertilizer at the rates of 13, 26 and 39 kg P.fed$^{-1.}$ significantly increased number of flower/plant, the mean values of number of pods/plant, fruit setting (%), seed index, straw and seed yield, N, P, and K uptakes (mg/plant) of faba bean seeds and total uptake as compared to P0 (without phosphorus fertilization).
- An irrigation of faba bean plant with saline water with an addition of P-fertilizer at the levels of this investigation had no significant effect on number of flowers per plant, number of pods per plant, seed index, straw and seed yield, N and P uptakes (mg/plant) by faba bean seeds. Such effect of interaction significantly increased N, P and K uptakes of straw and K uptake (mg/plant) of faba bean seeds during both seasons.

Keywords: Faba bean. Salinity, phosphorus, and yield

INTRODUCTION

Faba bean (*vicia faba L*.) is one of the important leguminous crops cultivated in Egypt. Its seeds are consumed in our country as a cheep source of protein for human and animal (Abd El-Hameed *et al*., 2003). Therefore, any improvement in the yield and the nutritional values of faba bean seeds is required and one of the most important factors affecting faba bean production is soil and water salinity.

Salt stress has three fold effects: it reduces water potential, causes ion imbalance or disturbance in ion biomeastasis and toxicity. This altered water status leads to intial growth reduction and limitation of plant productivity. Since salt stress involves both osmotic and ionic stress (Hyashi and Murata, 1998; Munns, 2003 and Benlloch-Gonzales *et al.,* 2005). Growth suppression is directly related to total concentration of soluble salts or osmotic potential of soil water. The deterimental effect, as death of plants or decrease in productivity, is observed at the whole-plant level. Suppression of growth occurs in all plants, but their tolerance levels and rates of growth

reduction at lethal concentrations of salts, vary widely among different plant species (Katerji *et al.,* 2005).

Phosphorus is important nutrient for crop production, it plays an important role and release of energy during cellular metabolism and inter in many organic compound (El-Tawil, 2003). Phosphorus is required by plants, but leguminous which contain more protein in the seed need more phosphorus than other plants. So, phosphatic fertilization is very effective on the yield of most legumes under Egyptian conditions. The problem of phosphorus in Egyptian soil is due to the tendency of the pH to be high in soil. Most Egyptian farmers used to add more P-fertilizers to faba bean fields in spite of results showed adversely effects due to heavy P-fertilization (Mater *et al.,* 1987). Adequate phosphorus was found to be vital for effective nodulation of legumes. It is believed that at moderate P-concentration phosphorus plays a role in epidermal osmotic adjustment; possibly explaining the beneficial role of additional phosphorus on salt stress, however, at high level of p with salinity, phosphorus accumulates and causes damage (Salem and Elmasri, 1986).

Therefore, the present work was undertaken to study the effect of water salinity levels, P-fertilization rates and their interactions on faba bean plant to determine the optimum level of phosphorus fertilizer required by faba bean plant grown under irrigation with saline water for obtaining the maximum yield.

MATERIALS AND METHODS

Two pot experiments were carried out during the two successive winter seasons of 2005-2006 and 2006-2007 under the greenhouse of Faculty of Agric., Mansoura university to study the effect of phosphorus fertilization and salt stress of irrigation water on faba bean (*Vicia faba L.)*.

These experiments were conducted in split block design with three replicates .Each experiment included 16 treatments which were arranged as 4 levels of saline water (360 mg/l (tap water), 1000, 2000 and 3000 mg/l.) as main plot and 4 levels of phosphorus fertilization (0, 13, 26 and 39 kg $P.fed^{-1}$.) devoted as split plot as well as their interaction.

48 polyethylene pots 25 cm. in diameter and 30 cm. length were used. Each pot was filled with 10 kg air dried soil which was brought from the surface layer of special farm near El-Mansoura city. The experimental soil was fertile and clayey in texture; some chemical properties of the experimental soil are illustrated at Table (1) as determined according to Jackson (1967) and Chapman and Pratt (1961).

Table 1: Some Chemical properties of the experimental soil during 2005-2006 and 2006-2007 seasons.

Seasons	E.C. $dS.m^{-1}$ (1:5)	pH (1:2.5)	S.P. (%)	O.M. (%)	$CaCO_3$ (%)	Available (mg/l.)		
						N	P	K
1st	0.52	7.85	62	1.83	1.95	45	3.3	310
2nd	0.56	7.92	65	1.79	2.06	49	3.8	322

On 10 and 12 November 2005 and 2006, respectively; 10 seeds of faba bean (C.V. Giza 843) were sown at equal distances in each pot. Two weeks later; plants were thinned to the most five uniform plants per pot.

Plants were irrigated with tap water (360 mg/l) from sowing date tell complete seedling (21 days). Then each treatment was irrigated with the levels of saline water under investigation i.e. (tap water (360 mg/l)), 1000, 2000 and 3000 mg/l.). The irrigation treatments were performed at 50% of soil field capacity for all salinity treatments. The pots were irrigated with tap water (360 mg/l) every 2 weeks in order to prevent the accumulation of salt.

Calcium-superphosphate (7%) was applied at the rates of (0, 13, 26 and 39 kg $P.fed^{-1}$) as side-dressing in two doses; the first dose after 15 days from sowing and the other after 2 weeks later. All other cultural practices were performed as recommended by the Ministry of Agriculture for faba bean plant.

At flowering stage numbers of flowers per plant was calculated and after that number of pods per plant were taken to calculate fruit setting % as follow:

$$\text{Fruit setting (\%)} = \frac{\text{No. of pods per plants}}{\text{No. of flowers per plants}} \times 100$$

At harvesting stage (160 dayes after sowing) representative samples were taken from each treatment to determine: N, P and K concentration and their uptakes of the seed and straw of faba bean plant as well as 100-seed weight. Also seed/straw ratio was calculated as follow:

$$\text{Seed/straw ratio} = \frac{\text{Seed yield (g/plant)}}{\text{Straw yield (g/plant)}} \times 100$$

The oven dry leaves of plant samples were ground and wet digested by sulphuric-perchloric acid mixture as described by Peterburgski (1986).

- Mineral composition of N, P and K were determined in the dry leaves of plant samples and seeds according to Pregle (1945), Jackson (1967) and Black (1965), respectively.

The significant differences among the mean of various treatments were established by the new least significant differences Methods (LSD) according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Effect of water salinity, P-fertilization and their interactions on faba bean yield components during both seasons of the experiment.

Data at Table 2 showed the effect of water salinity levels, P-fertilization and their interactions on number of flowers/plant, number of pods/plant, as well as calculated percentage of fruit setting during both seasons of the experiments.

It is clear from the data of Table 2 that number of pods per plant and number of flowers per plant decreased significantly by increasing salt concentration in irrigation water. Consequently, the same trend was realized for the calculated percentage of fruit setting. Comparing with tap water (S0) the decreases

percentage in fruit setting were 17.92, 39.63 and 31.32 % in the 1st season and 15.48, 32.22 and 32.17 % in the 2nd season for the treatments of S1, S2 and S3, respectively.

From the data at Table 2 it could be noticed that; soil addition of P-fertilizer at the rates of 13, 26 and 39 kg P.fed^{-1}. Significantly increased the mean values of number of pods/plant, number of flower/plant and fruit setting (%) as compared to the P0. In the 1st season , the highest values of number of pods/plant , number of flower/plant and fruit setting % , respectively (8.42, 12.42 and 67.54) were realized for the plant received P-fertilizer at the rates of (P3) , while the lowest one (6.33, 10.33 and 60.24) were obtained from the untrated plants. The same trend was realized in the 2nd season.

Date in Table 2; also reveal that; an irrigation of faba bean plants with saline water combined with an addition of P-fertilization at the levels of this investigation had no significant effect during both seasons of the experiments.

It could be noticed that the reduction in flowers and pods numbers is accompanied by the increase of water salinity levels and it is reflected on the calculated values of fruit setting. This might be due to the increase in shedding flowers and pods. Soil addition of P-fertilizer at the rates of this study has been corrected the bad effect of water salinity as a result of a beneficial effect of phosphorus on stimulating the development of root hairs to absorb more nutrients from the soil solution .

Obtained results are confirmed with those reported by Ahmed and El-Abagy (2007) they found that increasing P-fertilization significantly affected on number of pods, seeds/plant, seed and straw yield per plant.

Abdel-Aal(1992), Ullah et al., (1993) and Atwa et al., (2008), they studied the influence of water salinity on faba bean and found that, salinity levels had a marked decrease in the average number of pods/plant and number of flowers.

Table 2: Effect of water salinity, P-fertilization and their interactions on faba bean yield components during both seasons of the experiment.

Treatments	No. of pods		No. of flowers		%Fruit Setting	
	1 st	2 nd	1 st	1 st	1 st	2 nd
A- Salinity levels						
S_0	9.92	10.92	12.92	13.92	76.52	78.22
S_1	7.50	8.5	11.50	12.50	64.89	67.74
S_2	6.25	7.25	11.25	12.08	54.80	59.16
S_3	5.75	6.75	10.00	11.00	58.27	59.18
LSD. at 5%	**0.92**	**0.92**	**1.09**	**1.09**	**9.05**	**6.99**
B- phosphorus levels						
P_0	6.33	7.33	10.33	11.17	60.24	62.31
P_1	7.25	8.25	11.33	12.33	63.52	66.56
P_2	7.42	8.42	11.58	12.58	63.17	66.18
P_3	8.42	9.42	12.42	13.42	67.54	69.26
LSD. at 5%	**1.09**	**1.09**	**1.14**	**1.06**	**NS.**	**NS**
Interaction A*B	**NS**	**NS**	**NS**	**NS**	**NS.**	**NS.**

2. Effect of water salinity, P-fertilization and their interactions on yield of faba bean and its components during both seasons of the experiment.

Data in Table 3 show the mean values of 100 seed weight, seed index, seed and straw yield (g/plant) as well as the calculated ratio for seed/straw as influenced by water salinity levels, P-fertilization rates and their interactions of faba bean in the two seasons of 2005-2006 and 2006-2007.

Concerning the effect of present treatments on seed index (100-seed weight) data of Table 3 indicate that; The mean value of seed index had no significant effect in the 1st season but seed index were significantly decreased as the level of saline water was increased in the 2nd season the highest value (65.30) was realized for the control treatment (S0) while the lowest one (63.30) were connected with the 3rd level of saline water (S3). On the contrary of this trend; the mean values of seed index were significantly increased as the level of P-fertilization was increased from 0 up to 39 kg P/fed. On the other hand, at any levels of saline water studied an addition of P-fertilizer had no significant effect during both seasons of 2005-2006 and 2006-2007.

As shown from data at Table 3, it can be noticed that, a depressive effect in the values of straw and seed yield of faba bean plant due to an increasing the level of salinity of irrigation water from 1000 up to 3000 mg/l. as compared to the control treatment. The rate of the decreases less than the control treatment in the 1st season were accounted to be 12.93, 26.67 and 56.34% for straw yield and 16.21, 29.76 and 70.48 % for seed yield for the treatments of S1, S2 and S3, respectively. Such effect was reflected on the calculated seed/straw ratios which were 75.07, 73.05, 72.91 and 68.80 for the treatments of S0, S1, S2 and S3, respectively.

Table 3: Effect of water salinity and P-fertilization and their interactions on yield of faba bean and its components during both seasons of the experiment.

Treatments	100-seed weight (g)		Straw yield (g/plant)		seed yield (g/plant)		Seed/straw ratio	
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
A- Salinity levels								
S_0	60.48	65.30	42.79	46.12	32.05	34.54	75.07	74.94
S_1	59.41	63.80	37.94	41.05	27.58	29.84	73.05	72.84
S_2	59.41	64.03	33.78	36.61	24.70	25.85	72.91	70.72
S_3	57.93	63.30	27.37	29.56	18.80	20.31	68.80	68.84
LSD. at 5%	**NS**	**0.80**	**2.18**	**1.21**	**2.01**	**1.34**	**NS**	**NS**
B- phosphorus levels								
P_0	56.31	61.36	32.26	34.97	23.53	25.52	72.75	72.64
P_1	59.17	63.81	34.50	37.23	24.97	26.95	72.19	72.05
P_2	60.31	65.04	36.53	39.24	26.24	28.19	71.59	71.54
P_3	61.43	66.22	38.60	41.88	28.38	29.87	73.29	71.12
LSD. at 5%	**1.56**	**1.03**	**1.13**	**1.12**	**1.91**	**1.15**	**NS**	**NS**
Interaction A*B	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

On the other hand; soil addition of P-rates under study significantly increased the mean values of straw and seed yield of faba bean plant than those obtained for the untreated plants. But, the seed/straw ratios tended to approximately constant around 72±1 for the P-rates of P0, P1, P2, and P3 in the 1st season, respectively. The same trend was realized in the 2nd season of the experiment.

It can be concluded that the reduction in seed and straw yield (g/plant) as influenced by salinity levels might due to the reduction in vegetitive growth. Soil addition of P-fertilization significantly increased seed and straw yield may be due to balance between P and ions in salinity water in leaves.

The present results are in agreement with those obtained by Sorour (1993), and Hamam (1995), they reported that seed and straw yield/fed. Increased due to phosphorus fertilizer application.

Also, Ullah et al. (1993), mentioned that at the highest salt stress level (60 mM) grain yield were reduced by 85% while straw yield decreased by 43% at 60mM.

3. Effect of water salinity, P-fertilization and their interactions on N, P, K-uptakes (mg/plant) by faba bean plant:

Data presented at Tables (4 and 5) reveal the effect of water salinity, P-fertilization and their interactions on N, P and K uptakes by faba bean plant at harvesting stage during both seasons of the experiment.

Concerning the effect of water salinity levels data indicated that; the mean values of N, P and K uptakes by the straw and seeds of faba bean plant as well as the calculated total uptake (straw + seeds) were significantly decreased as the level of water salinity was increased. In the 1st season; the rate of decreases for total uptake less than the control treatment (S0) was calculated to be 17.62, 28.63 and 48.02% for total N-uptake, 22.57%, 37.68 and 53.98% for total P-uptake and 15.47, 27.20 and 47.19 % for total K-uptake for the treatment of S1, S2 and S3 , respectively. The same trend was realized in the 2nd season of the experiment.

Regarding the effect of P-fertilization levels (0, 13, 26 and 39 kg $P.fed^{-1}$.) data at Tables (4 and 5) show that ; in spite of N, P, and K uptakes by faba bean seeds and total uptake were significantly increased as the level of P-fertilization was increased from 0 up to 39 kg P/fed. ; Such effect was happened for N, P and K uptakes by the straw tell the rate of P2. Increasing the rate of P from P2 to P3 significantly decreases the mean values of N, P and K uptakes by the leaves of faba bean plant at harvesting stage. Such effect was true during both seasons of 2006 and 2007.

As for the interaction effect between water salinity levels and P-fertilization rates data at the same Tables (4 and 5) indicated that; at any level of water salinity under investigation an application of P at the rates of 13, 26 and 39 kg $P.fed^{-1}$ significantly increased the mean values of N, P and K uptakes of straw. As for the mean values of N and P uptakes of seed their had no significant during both seasons. While the mean value of K uptake of seed was significantly increased during 2nd season only.

It could be concluded that; phosphorus concentration and uptake by faba bean leaves were highly depresses due to increasing salinity levels of saline water. This depression effect could be explained on the basis of

increasing the osmotic potential of saline substance as well as the competitions existing between ions (chloride and phosphorus). Moreover, the reduction in N, P and K uptakes of the straw and seeds of faba bean plants may be due to the reduction in N, P and K absorption caused by the high concentration of soluble salts in the root medium.

These results are in agreement with those obtained by Kaya et al., (2001), they reported that salinity decreased the uptake of N, P and K.

However, Hanna et al. (1996) mentioned that N, P and K concentration and their uptakes of seeds and straw were increased by phosphorus application.

Table 4: Effect of water salinity, P-fertilization and their interactions on N, P and K-uptakes (mg/plant) by faba bean (seeds + straw) during first season of the experiment.

Treatments	N-uptake (mg/plant)			P-uptake (mg/plant)			K-uptake (mg/plant)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
A- Salinity levels									
S_0	592.48	664.92	1257.39	55.29	102.78	158.07	584.03	633.62	1217.65
S_1	497.03	538.77	1035.81	38.18	84.22	122.40	494.56	534.68	1029.24
S_2	435.45	461.90	897.35	32.84	65.54	98.37	432.15	454.36	886.51
S_3	313.07	340.54	653.61	23.53	49.21	72.74	37.38	335.69	643.06
LSD. at 5%	**47.49**	**21.01**	**31.02**	**17.59**	**4.29**	**17.46**	**35.99**	**27.55**	**17.99**
B- Phosphorus levels									
P_0	358.71	336.60	695.31	26.44	41.78	68.22	346.85	331.17	678.02
P_1	417.58	457.55	875.13	32.18	68.95	101.12	409.40	449.39	858.79
P_2	493.87	619.495	1113.37	47.07	97.53	144.59	488.21	604.99	1093.21
P_3	567.88	592.485	1160.36	44.15	93.49	137.64	573.64	572.79	1146.44
LSD. at 5%	**36.29**	**16.30**	**39.41**	**15.08**	**2.15**	**15.23**	**33.59**	**17.64**	**37.93**
Interaction A*B	**NS**	**4.04**	**6.78**	**NS**	**1.59**	**NS**	**NS**	**4.54**	**6.68**

Table 5: Effect of water salinity, P-fertilization and their interactions on N, P and K-uptakes (mg/plant) by faba bean (seeds + straw) during second season of the experiment.

Treatments	N-uptake (mg/plant)			P-uptake (mg/plant)			K-uptake (mg/plant)		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total
A- Salinity levels									
S_0	696.58	728.55	1425.13	48.23	110.85	159.09	668.26	719.48	1387.74
S_1	585.41	634.79	1220.20	40.75	89.01	129.75	565.67	612.18	1177.85
S_2	494.65	544.94	1039.59	33.44	74.02	107.47	481.56	519.57	1001.13
S_3	368.77	403.63	772.40	25.28	52.89	78.17	349.59	382.63	732.22
LSD. at 5%	19.73	18.34	25.69	2.23	2.20	2.34	24.95	12.42	28.85
B- Phosphorus levels									
P_0	424.85	401.95	826.79	28.40	46.59	74.99	39٩,٥٠	381.34	775.10
P_1	491.64	538.29	1029.94	34.09	73.10	107.19	47٣,٣٥	508.59	983.02
P_2	577.92	690.30	1268.22	39.35	105.99	145.33	558.91	688.47	1247.38
P_3	650.99	681.36	1332.36	45.87	101.10	146.97	637.97	655.47	1293.44
LSD. at 5%	**20.78**	**19.42**	**27.90**	**1.77**	**2.80**	**3.51**	**21.65**	**18.50**	**27.76**
Interaction A*B	**Ns**	**4.32**	**4.21**	**Ns**	**1.94**	**1.81**	**21.61**	**4.26**	**4.33**

4- Effect of P-fertilization on P concentration (%) in seeds and straw of faba bean plant during both seasons:

As shown from Figs 1, 2 and 3 it can be noticed that; P-concentration (%) in the seeds of faba bean plants were significantly decreased as the level of salinity was increased. The highest value was recorded for the plants irrigated with Tap water (360 mg/l), while the lowest one was connected with the plants irrigated with saline water at the rate of 3000 mg/l.

On the contrary of this trend, soil P-fertilization of faba bean plant at the levels of this irrigation significantly increased the average values of P% in faba bean seeds and recorded the highest values for the treatment of 39 kg $P.fed^{-1}$ while the lowest one was realized for the control treatment. Moreover, an irrigation of faba bean plant with saline water at the studied levels in the presence of P-fertilization level significantly increased the mean values of P% for faba bean seeds as compared to the untreated one. In this respect, the highest values were realized for the plants received P at the rate of 39 kg P/fed. at any level of irrigation with saline water.

As shown from Figs 4, 5 and 6 the same trend of P-content % was realized for P-concentration in the straw of faba bean plant during both seasons of the experiment.

Fig1: Effect of water salinity on P concentration (%) in seeds of faba bean plant during both seasons.

Fig2: Effect of P-fertilization on P concentration (%) in seeds of faba bean plant during both seasons.

Fig3: Effect of water salinity and P-fertilization on P concentration (%) in seeds of faba bean plant during both seasons.

Fig4: Effect of water salinity on P concentration (%) in straw of faba bean plant during both seasons.

Fig5: Effect of P-fertilization on P concentration (%) in straw of faba bean plant during both seasons.

Fig6: Effect of water salinity and P-fertilization on P concentration (%) in straw of faba bean plant during both seasons.

Conclusion:

From the results mentioned previously it could be concluded that ; an irrigation of faba bean plant with saline water at the levels of this study had a depressive effect on straw and seed yield as well as chemical composition of faba bean plant. An addition of P-fertilizer tell the rate of 26 Kg P/fed has been corrected the bad effect of water salinity.

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إستجابة الفول البلدي للتسميد الفوسفاتى تحت الظروف الملحيه.

طارق محمد الزهيري وهناء محمد صقارة
قسم علوم الأراضي ، كلية الزراعة ، جامعة المنصورة .

نفذت تجربتي أصص خلال الموسمين الشتويين ٢٠٠٥-٢٠٠٦ ، ٢٠٠٦-٢٠٠٧ في الصوبة الزراعية بكلية الزراعة – جامعة المنصورة بهدف دراسة تأثير الري بالماء الملحي و التسميد الفوسفاتي على نبات الفول البلدي

وقد تم تنفيذ التجربتين في تصميم تجريبى القطع المنشقة مرة واحدة حيث تمثلت القطع الرئيسية فى الرى باربع مستويات ملوحه بمياه الرى (ماء صنبور(٣٦٠ ملجم/لتر) ، ١٠٠٠ ، ٢٠٠٠ ، ٣٠٠٠ ملجم/لتر) بينما كانت القطع المنشقه تحتوى على اربع مستويات من التسميد الفوسفاتى (٠ ، ١٣ ، ٢٦، ٣٩ كجم فو/فدان) وقد تم تكرار كل معامله ثلاثة مرات .

ويمكن تلخيص النتائج التي تم التوصل اليها على النحو التالي :

- أدى الرى بالماء الملحى عند المستويات موضع الدراسه اى حدوث انخفاض معنوى فى كلا من عدد الازهار للنبات، عدد القرون للنبات، النسبه المئويه للعقد و دليل الحصاد ومحصول القش والقرون ، امتصاص النيتروجين والفوسفور والبوتاسيوم (ملجم/نبات) في القش وبذور الفول اضافة الى الامتصاص الكلي (قش + بذور).
- الاضافة الارضية للسماد الفوسفاتي بمعدلات (٠ ، ١٣ ، ٢٦، ٣٩ كجم فو/فدان) أدى لحدوث زيادة معنوية في عدد الازهار/ نبات ، عدد القرون / نبات ، نسبة العقد % ، دليل الحصاد ، محصول القش والبذور ، امتصاص النيتروجين والفوسفور والبوتاسيوم(ملجم/نبات) بواسطة بذور الفول وكذلك الامتصاص الكلي مقارنة بعدم التسميد الفوسفاتى.
- ري نبات الفول بالماء الملحي في وجود التسميد الفوسفاتي عند معدلات هذة الدراسة أدى لعدم وجود معنويه لكل من عدد الازهار / نبات ، عدد القرون / نبات ، دليل الحصاد ، محصول البذور والقش ، معدل امتصاص النيتروجين والفوسفور (ملجم/نبات) بواسطة بذور الفول مع حدوث زياده معنويه لمعدل امتصاص كل من النيتروجين والفوسفور والبوتاسيوم (ملجم/نبات) للقش والبوتاسيوم للبذور في كلا من موسمي النمو.