RESPONSE OF TWO FABA BEAN CULTIVARS TO DIFFERENT LEVELS OF PHOSPHORUS AND SULPHUR FERTILIZERS.

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Abstract

Two field experiments were conducted during the winter seasons of 2001/2002 and 2002/2003 at the experimental farm of Shandaweel Agriculture Research Station to investigate the response of two faba bean cultivars (Giza-40 and Misr-1) to fertilization with phosphorus (0, 15 and 30 kg P_2O_5/fed) and sulphur (0, 30 and 60 kg S/fed). The obtained data could be summarized as follow:

1) Misr-1 cultivar surpassed Giza-40 cultivar in number of pods/plant, weight of seeds/plant, weight of 100 seeds (g), seed yield arad./fed, straw yield ton/fed and protein percentage in seeds. However, Giza-40 cultivar exceeded Misr-1 in plant height (cm) and number of seeds/plant. The differences were more announced and statistically approved in plant height.
2) Applying high levels of phosphorus caused a significant increasing for all studied characters than those found in control in both seasons.
3) Applying high levels of sulphur fertilizer gave significant increases in plant height, number of pods/plant, number of seeds/plant, weight of seeds/plant, seed yield arad./fed, straw yield ton/fed, percentage of protein in seeds and percentage of phosphorus in both seasons.
4) Fertilizing both Giza-40 and Misr-1 cultivars with 30 kg P_2O_5/fed combined with 30 kg S/fed produced the highest seed and straw yields.
5) Appling 30 kg P_2O_5/fed combined with 60 kg S/fed significantly produced the high values of plant height, protein content % and percentage of P in seeds in both Giza-40 and Misr-1 cultivars. Moreover, the interaction between all studied factors significantly affected number of seeds/plant and weight of 100 seeds in both seasons and number of pods/plant only in the first season.

Introduction

Faba bean (*Vicia faba* L.) is one of the most important legume crop as a source of cheap available protein for human and animal consumption in Egypt. Many workers studied the effect of faba bean cultivars, phosphorus and sulphur fertilization on yield. Nigem *et al* (1988) found that faba bean cultivars differed significantly in their yields and its components and this assured by several researchers such as Salih and Khalafalla (1982); Nassib and Hussein (1984); Amer (1986); EL-Shazly and Nassr (1989) and Togun and Daniel (2000).

Phosphorus nutrition is one of the major factors affecting growth, yield and its components of faba bean. It plays an important role in certain essential steps, such as accumulation and release of energy during cellular metabolism. In addition it is a constituent of many organic compounds in plants (Russell, 1950). Many investigators reported that increasing in the levels of phosphorus fertilization significantly increased each of number of pods/plant [EL-Khawaga and Zeiton (1986); EL-Fieshawy and Fayed (1990)]; number of seeds/plant and seed index [Abdel-Aal (1990) and seed yield/fed EL-Fieshawy and Fayed (1990); EL-Zeiny *et al* (1990); EL-Khawaga and Zeiton (1992) and Hussein *et al* (1993)]. Also, Radwan and Rehab (1993) pointed out that plant height, dry weight/plant, seed yield/fed and seed index of faba bean were significantly increased as phosphorus levels increased up to 90 kg P_2O_5/ha. Mwafy (1995) found that increasing phosphorus levels up to 200 kg super phosphate/fed resulted in an increase in plant height, number of branches/plant; number of pods/plant; number of seeds/pod; 100-seeds weight; seed yield/plant; straw yield ton/fed and seed protein content of faba bean. EL-Kalla *et al* (1997) mentioned that raising P_2O_5 to 45 kg/fed increased faba bean plant height; number of branches/plant; number of pods/plant; number of seeds/pod; seed yield/plant; 100-seeds weight; seed yield/fed and seed protein percentage. Mohamed *et al* (1999) showed that increasing phosphorus fertilization increased seed yield/fed and the protein content of faba bean. Nassar *et al* (2000); Saleh *et al* (2000); Abou Hussien *et al* (2002) and Azer Sohair *et al* (2003) found that availability of

phosphorus in the soil significantly increased fruit setting, seed yield and protein content in the seeds of legumes.

Sulphur exerted a positive effect on the soil feature. This effect might be due to the action of acidity produced as a result of sulphur oxidation by microorganisms. EL-Leboudi and Omar (1975) mentioned that the pH values of the soil decreased through oxidation of applied sulphur by soil microorganisms, which are able to produce sulphuric acid in amount enough to lower the pH. Garcia and Carloni (1977) concluded that sulphur promoting the solubilization of apatite-P already present in, or added to the soil. Yousry *et al* (1984) reported that sulphur was generally favourable for available phosphorus particularly when applied at high rates. Omar *et al* (1990) mentioned that the growth and yield of pea plants significantly influenced by sulphur. EL-Saadany and Abd EL-Rasoul (1999) found that application of sulphur improved legume plant biomass, seed and straw yield, N and S uptake. Kanany *et al* (2000) on soybean found that addition sulphur decreased seeds and straw yield as well as 100-seed weight. Also, sulphur affected the protein content in seeds. Togun and Daniel (2000) reported that 30 ppm sulphur or 60 kg/ha sulphur is adequate for improving the growth, yield and seed protein of soybean. Azer Sohair *et al* (2003) reported that there was a significant response in seed yield; crude protein% and P content by addition of sulphur to faba bean.

It is well known that availability and uptake of many plant nutrients is affected by levels of the other nutrients present in the growth medium. In particular the interactions between phosphorus and sulphur in the plants and soils have been reported by many workers, Ahmed *et al* (1986); Nayak and Dwivedi (1990); Kanany *et al* (2000) and Azer Sohair *et al* (2003). The present study aimed to investigate the response of two faba bean cultivars to application of phosphorus, sulphur and all possible combination between all studied factors.

Materials and Methods

Two field experiments were carried out at Shandaweel Agriculture Research Station during the growing seasons of 2001/2002 and 2002/2003. This

experiment included three factors i.e. (1) The Giza-40 and Misr-1 cultivars which were assigned in the main plots. (2) Three levels of phosphorus fertilizers i.e. (0, 15 and 30 kg P_2O_5/fed) were allocated to the sub-plots. (3) Three levels of sulphur application i.e. (0, 30 and 60 kg S/fed) were distributed in sub-sub-plots. These factors consisted 18 treatments combinations, which were tested using split-split-plot design with four replicates.

The experimental unit was 10.5 m^2 consisted of five ridges; 60 cm apart of 3.5 m length. Phosphorus and sulphur treatments were added during soil preparation i.e. before sowing. Phosphorus was used in the form of conc. superphosphate (37% P_2O_5).

Table 1: Soil characterization of the experimental sites.

Analysis / Seasons	Texture	pH	O.M %	Available nutrients (ppm)		
				N	P	K
2001/2002	Clay loam	7.7	1.2	15.0	11.0	315
2002/2003	Clay loam	7.9	1.1	14.0	10.7	300

The experiments were sowed in 15th October in both seasons by sowing two seeds per hill and 20 cm apart. The previous crop was maize in both seasons. All the experimental units received equal amount of nitrogen as recommended at the first irrigation (21 days from sowing). The other cultural practices were done as in common faba bean fields in the district.

At the harvest time, ten guarded plants were taken at randomly from the inner ridges and the following characters were recorded. While, seed yield/fed, straw yield ton/fed and 100-seed weight (g) were determined on the base of a unit area of 10.5 m^2 (3 x 3.5 m).

1- Plant height (cm).
2- Number of pods/plant.
3- Number of seeds/plant.
4- Weight of seeds/plant (g).
5- Weight of 100-seeds (g).
6- Seed yield (ard./fed).
7- Straw yield (ton/fed).

At the time of harvesting, seed samples were ground and kept for chemical analysis. Nitrogen was determined by using modified micro-kjeldahl's method (A.O.A.C. 1980). In addition the protein content in seed was calculated by multiplying the total nitrogen% by a factor of 6.25. Phosphorus was estimated colorimetrically as described by (Jackson, 1976).

All obtained data were statistically analyzed and the least significant differences (L.S.D) were estimated according to Snedecor (1980).

Results and Discussion

1- Plant height (cm):

Data in Table (2) indicated that plant height significantly was affected by cultivars in both seasons. However, cultivar Misr-1 resulted in higher plants than Giza-40 in both seasons.

Table (2): The effect of two faba bean cultivars, phosphorus and sulphur levels, and their interactions on plant height (cm).

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	106.00	110.50	109.00	108.50	108.50	112.50	111.25	110.75
	15	113.25	110.00	115.50	112.92	115.50	112.50	117.50	115.17
	30	108.00	117.50	128.75	118.08	110.50	119.50	132.00	120.67
Average		109.08	112.67	117.75	113.17	111.50	114.83	120.25	115.53
Misr-1	0	105.00	109.00	112.00	111.33	107.00	110.50	121.75	113.08
	15	127.50	118.75	129.25	125.17	130.50	120.75	132.00	127.75
	30	130.50	121.75	134.75	129.00	135.00	123.50	134.00	130.83
Average		121.00	116.50	128.00	121.83	124.17	118.25	129.25	123.89
Average for all P-levels	0	105.50	109.75	114.50	109.92	107.75	111.50	116.50	111.92
	15	120.38	114.38	122.38	119.05	123.00	116.63	124.75	121.46
	30	119.25	119.63	131.75	123.54	122.75	121.50	133.00	125.75
Average		115.04	114.59	122.88	117.50	117.84	116.54	124.75	119.71

LSD 0.05

V	=	4.31	7.76
P	=	3.89	3.55
S	=	3.05	4.11
V x P	=	5.50	5.02
V x S	=	4.32	N.S
P x S	=	5.27	N.S
V x P x S	=	N.S	N.S

Regarding to the effect of phosphorus fertilization levels, data in Table (2) clearly showed that plant height gradually increased with increasing P levels in both seasons. While, the tallest plants were (123.54 & 125.75 cm) resulted from

the highest phosphorus level i.e. (30 kg P_2O_5/fed) in 2001/2002 and 2002/2003 seasons, respectively. These results are in agreement with those reported by Radwan and Rehab (1993); Mwafy (1995) and EL-Kalla *et al* (1999).

According to the addition of sulphur to faba bean plants, the obtained data revealed that plant height significantly influenced by the addition of sulphur in both seasons. Whereas, the tallest plants could be obtained by adding 60 kg S/fed (122.88 and 124.75 cm) in 2001/2002 and 2002/2003 seasons, respectively. On the other hand adding 30 kg S/fed failed to achieved a significant effect as compared to control treatment. These results held good in the two experimental seasons. This positive effect of sulphur on plant height may be due to the effect of sulphur on soil pH and the availability of other nutrients. These results are in harmony with those obtained by Omar *et al* (1990); EL-Saadany and Abd EL-Rasoul (1999) and Togun and Daniel (2000).

Concerning the effect of interaction between cultivars and phosphorus levels (V x P) it is obvious from the data in Table (2) that this interaction significantly affected plant height in both seasons. While, the tallest plants resulted from treatments received 30 kg P_2O_5/fed for the two cultivars in both seasons. In general, the tallest plants resulted from cultivar Misr-1 combined with 30 kg P_2O_5/fed in both seasons.

Regarding to the effect of interaction between cultivars and sulphur (V x S) and the interaction between phosphorus and sulphur (P x S), the data in Table (2) showed that the two abovementioned interactions affected the plant height character, but the differences were more announced and statistically approved in the first season only. The tallest plants for the two cultivars were obtained by applying 30 kg P_2O_5/fed combined with 60 kg S/fed. However, the interaction among the three studied factors failed to show any significant effect in the two experimental seasons.

Number of pods / plant:

Data presented in Table (3) showed that number of pods per plant did not affected significantly by the two cultivars in both seasons, but cultivar Misr-1 achieved higher values of this character. This result held good in the two

experimental seasons. This result was in line with those reported by Amer (1986); EL-Shazly and Nassar (1989) and Togun and Daniel (2000). It is clear from the data in Table (3) that varying the applied phosphorus levels had a significant effect on this trait in both seasons. The highest number of pods were (14.94 and 15.48) achieved by plants fertilized with the highest phosphorus level i.e. (30 kg P_2O_5/fed) during 2001/2002 and 2002/2003 seasons, respectively. The lowest number of pods per plant (12.44 and 12.89) were resulted from control plants in 2001/2002 and 2002/2003 seasons, respectively. The importance of P fertilizer for number of pods in legume had been found by different investigators such as EL-Khawaga and Zeiton (1986); EL-Fieshawy and Fayed (1990); Saleh *et al* (2000) and Azer Sohair *et al* (2003).

Table (3): The effect of two faba bean cultivars, phosphorus and sulphur levels, and their interactions on number of pods/plant.

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	11.40	11.80	13.10	12.10	11.83	12.00	13.60	12.48
	15	13.95	12.55	14.00	13.50	14.53	13.40	14.65	14.19
	30	14.55	14.08	15.15	14.59	14.70	15.35	15.50	15.18
Average		13.30	12.81	14.08	13.40	13.69	13.58	14.58	13.95
Misr-1	0	12.00	12.30	14.05	12.78	12.60	11.55	15.75	13.30
	15	12.15	13.95	16.15	14.08	12.85	14.28	16.80	14.64
	30	15.40	14.90	15.55	15.28	15.43	15.45	16.45	15.78
Average		13.18	13.72	15.25	14.05	13.63	13.78	16.33	14.57
Average for all P-levels	0	11.70	12.05	13.58	12.44	12.22	11.78	14.68	12.89
	15	13.05	13.25	15.08	13.79	13.69	13.84	15.73	14.42
	30	14.98	14.49	15.35	14.94	15.07	15.40	15.98	15.48
Average		13.24	13.27	14.67	13.73	13.66	13.67	15.46	14.26
LSD 0.05									
	V	=	N.S			N.S			
	P	=	0.55			1.01			
	S	=	0.48			0.77			
	V x P	=	N.S			N.S			
	V x S	=	N.S			N.S			
	P x S	=	N.S			N.S			
	V x P x S	=	1.18			N.S			

Regarding the effect of varying the applied amount of sulphur, the results revealed that this factor significantly affected number of pods per plant in both seasons. The number of pods per plant gradually increased up to the highest sulphur levels i.e. (60 kg S/fed) in both seasons. This result could be explained in light of the positive effect of sulphur on promoting the nutritional status of faba

bean plants Togun and Daniel (2000) and Azer Sohair *et al* (2003) came to the same general trend.

The obtained data in Table (3) showed that neither the interaction between cultivars and phosphorus nor the interaction between cultivar and sulphur succeeded to have a significant effect on number of pods per plant in any of the two experimental seasons. Also, the interaction between sulphur and phosphorus had the same trend.

The interaction effect among the three studied factors was only significant in the first season. The highest number of pods/plant (15.55) was obtained by applying 30 kg P_2O_5/fed combined with 60 kg S/fed to Misr/1 cultivar.

Number of seeds / plant:

The results presented in Table (4) indicated that faba bean cultivars did not differ significantly in number of seeds per plant in both seasons. However, Misr-1 cultivar surpassed Giza-40 cultivars in number of seeds per plant in the two experimental seasons. The same general conclusion was found by Amer (1986); EL-Shazly and Nassar (1989) and Tougan and Daniel (2000). Phosphorus fertilization levels significantly affected this trait in both seasons. While, the highest number of seeds per plant (43.69 and 45.91) were resulted from the highest phosphorus level i.e. (30 kg P_2O_5/fed) in 2001/2002 and 2002/2003 seasons, respectively as compared to the lowest number of seeds per plant (35.81 and 37.41) were produced from control plants (unfertilized) during 2001/2002 and 2002/2003 seasons, respectively. Such results may be due to encouraged vegetative growth of faba bean plants, flowering and pod filling by phosphorus fertilization. These results are confirmed with those found by Abdel-Aal (1990); Mwafy (1995) and EL-Kalla *et al* (1999).

Application of sulphur fertilizer to faba bean plants significantly increased number of seeds per plant as compared to unfertilized plants (control) in the two experimental seasons. Also, this character increased gradually up to the highest sulphur level i.e. (60 kg S/fed), which surpassed the control treatment (unfertilized) by 13.6% and 13.8% in the first and second season, respectively.

Table (4): The effect of two faba bean cultivars, phosphorus and sulphur levels, and their interactions on number of seeds/plant.

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	34.65	33.45	35.70	34.60	36.15	35.10	37.40	36.22
	15	36.85	41.70	43.05	40.53	38.95	43.85	45.30	42.70
	30	40.70	43.80	44.65	43.05	42.85	46.15	46.75	45.25
Average		37.40	39.65	41.13	39.39	39.32	41.70	43.15	41.39
Misr-1	0	31.35	35.30	44.40	37.02	32.25	37.05	46.50	38.60
	15	40.85	35.65	51.15	42.55	42.80	37.30	53.70	44.60
	30	43.45	49.50	40.00	44.32	45.65	52.20	41.85	46.57
Average		38.55	40.15	45.18	41.30	40.23	42.18	47.35	43.26
Average for all P-levels	0	33.00	34.38	40.05	35.81	34.20	36.08	41.95	37.41
	15	38.85	38.68	47.10	41.54	40.88	40.58	49.50	43.65
	30	42.08	46.65	42.33	43.69	44.25	49.18	44.30	45.91
Average		37.98	39.90	43.16	40.35	39.78	41.95	45.25	42.32

LSD 0.05

V	=	N.S	N.S
P	=	1.59	1.44
S	=	1.44	2.16
V x P	=	N.S	N.S
V x S	=	N.S	N.S
P x S	=	2.88	3.75
V x P x S	=	3.52	5.31

Regarding to the interactions between both cultivars and phosphorus or sulphur, the results revealed that these interactions failed to affected the number of seed per plant significantly in any of two experimental seasons. Moreover, the highest values of this trait produced from cultivar Misr-1 combined with both the highest level from phosphorus and sulphur in both seasons. On the other hand, the interaction between phosphorus and sulphur significantly affected the number of seeds per plant in the two seasons. Applying 60 kg S/fed combined with 30 P_2O_5/fed to Giza-40 cultivar resulted in the highest number of seeds/plant, however, the highest number of seeds/plant for Misr-1 cultivar were obtained by applying 60 kg S/fed combined with 15 kg P_2O_5/fed.

The interaction among the three studied factors significantly affected the number of seeds/plant in the two seasons, whereas, applying 30 kg P_2O_5/fed combined with 60 kg S/fed to Misr-1 cultivar resulted in the highest number of seeds/plant (51.15 and 53.70 seeds) during 2001/2002 and 2002/2003 seasons, respectively.

Weight of seeds / plant (g):

It is quite clear from data presented in Table (5) that the two studied cultivars did not significantly affect the weight of seeds/plant. However, Misr-1 cultivar surpassed Giza-40 cultivar by 3.4% and 3.4% in the first and second seasons, respectively. This results are confirmed with those obtained by Salih and Khalafalla (1982) and Amir (1986).

Application of phosphorus fertilizer to faba bean plants significantly affected this trait as compared to control plants (unfertilized). Meanwhile, the highest values resulted from the highest phosphorus level i.e. (30 kg P_2O_5/fed) in both seasons. This result could be explained in light of the beneficial effect of the phosphorus fertilizer in increasing number of pods per plant and number of seeds per plant previously discussed. These results are in harmony with those found by Mwafy (1995) and EL-Kalla *et al* (1999). In addition application of sulphur fertilizer to faba bean plants increased the weight of seeds per plant, but the differences were more announced and statistically approved in the first season. The increments induced in the number of pods per plant and number of seeds per plant previously mentioned due to fertilized with sulphur surely reflected on increasing the weight of plant seeds.

The results in Table (5) further showed that most of the interactions between the studied factors were of insignificant effect on the weight of plant seeds in both seasons of the study. The only interaction, which significantly affected this trait was that between phosphorus and sulphur in the first season only. Addition of 15 kg P_2O_5/fed combined with 30 kg S/fed obtained the highest weight of seeds/plant (37.90 and 38.10 g) for Giza-40 and Misr-1 cultivars, respectively.

Table (5): The effect of two faba bean cultivars, phosphorus and suphur levels, and their interactions on weight of seeds/plant.

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	28.95	29.30	30.00	29.42	29.75	30.15	30.65	30.18
	15	31.65	37.90	36.53	35.36	31.80	38.85	37.95	36.20
	30	37.70	35.85	36.00	36.52	37.30	38.95	37.05	37.77
Average		32.77	34.35	34.18	33.77	32.95	35.98	35.22	34.72
Misr-1	0	27.10	31.50	35.80	31.47	27.80	32.05	37.05	32.30
	15	34.90	38.10	37.05	36.68	39.45	35.75	38.25	37.82
	30	37.55	35.55	36.80	36.63	37.40	39.20	36.05	37.55
Average		33.18	35.05	36.55	34.93	34.88	35.67	37.12	35.89
Average for all P-levels	0	28.03	30.40	32.90	30.45	28.78	31.10	33.85	31.24
	15	33.28	38.00	36.79	36.02	35.63	37.30	38.10	37.01
	30	37.63	35.70	36.40	36.58	37.35	39.08	36.55	37.66
Average		32.98	34.70	35.37	34.35	33.92	35.83	36.17	35.30

LSD 0.05

V	=	N.S	N.S
P	=	2.01	2.48
S	=	1.49	N.S
V x P	=	N.S	N.S
V x S	=	N.S	N.S
P x S	=	2.57	N.S
V x P x S	=	N.S	N.S

Weight of 100-seeds (g):

Data listed in Table (6) demonstrated the 100-seeds weight as affected by cultivars, phosphorus, sulphur and their interactions. Data revealed that Giza-40 cultivar gave the heaviest weight as compared to the other cultivar (Misr-1), but this increasing failed to be a significant in the two experimental seasons. Results indicated that phosphorus fertilizer significantly affected that character in both seasons. Whereas, the highest values for weight of 100-seeds were obtained from faba bean plants received 30 kg P_2O_5/fed in both seasons. These results might be attributed to the beneficial effect of phosphorus on encouraging cell division, cell enlargement, the formation and movement of carbohydrates. These results are in accordance with those found by Mwafy (1995) and EL-Kalla *et al* (1999).

Table (6): The effect of two faba bean cultivars, phosphorus and suphur levels, and their interactions on 100-seeds weight (g).

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	77.25	82.00	80.00	79.75	78.75	83.50	82.25	81.50
	15	82.00	80.25	80.00	80.75	84.00	82.75	80.50	82.42
	30	84.00	79.50	85.00	82.83	85.25	80.25	87.00	84.17
Average		81.08	80.58	81.67	81.11	82.67	82.17	83.25	82.70
Misr-1	0	78.00	78.50	81.75	79.42	80.00	79.50	83.75	81.08
	15	80.50	79.00	80.75	80.08	83.50	81.25	80.25	81.67
	30	79.00	83.00	83.50	81.83	78.75	85.75	85.25	83.25
Average		79.17	80.17	82.00	80.45	80.75	82.17	83.08	82.00
Average for all P-levels	0	77.63	80.25	80.88	79.59	79.38	81.50	83.00	81.29
	15	81.25	79.63	80.38	80.42	83.75	82.00	80.38	82.05
	30	81.50	81.25	84.25	82.33	82.00	83.00	86.13	83.71
Average		80.13	80.38	81.84	80.78	81.71	82.17	83.17	82.35

LSD 0.05

V	=	N.S	N.S
P	=	1.78	1.44
S	=	N.S	N.S
V x P	=	N.S	N.S
V x S	=	N.S	N.S
P x S	=	N.S	2.18
V x P x S	=	3.22	2.71

Concerning to the effect of sulphur fertilizer levels on weight of 100-seed, the obtained results in Table (6) showed that this factor did not affect significantly this trait in the two studied seasons. Also, insignificant effects were found for the studied interactions between (cultivars x phosphorus and cultivars x sulphur) in both seasons. However, the differences were more announced and statistically approved in second season for the interaction between phosphorus and sulphur. This interaction recorded the best values for weight of 100-seed when faba bean fertilized with 30 kg P_2O_5/fed combined with 60 kg S/fed in the two seasons of study. On the other hand, the interaction between the three studied factors significantly affected this trait in both seasons.

Seed yield (aradab/fed):

Data presented in Table (7) emphasized that seed yield arad./fed influenced by the two studied faba bean cultivars in the two seasons. While, the cultivar Misr-1 gave higher seed yield than Giza-40. These increments estimated by (3.5% and 2.6%) in the first and second seasons, respectively. The same conclusion was reported by Nigem *et al* (1988); EL-Shazly and Nassr (1989) and

Togun and Daniel (2000). Moreover, data presented in Table (7) obviously revealed that phosphorus fertilizer significantly affected seed yield arad./fed in both seasons. The highest seed yields (13.14 and 13.83 arad./fed) were achieved by applying 30 kg P_2O_5/fed. These values exceeded the control plants (unfertilized) by (26% and 22.6%) in the first and second seasons, respectively. These results might be attributed to that phosphorus are constituent of all important nucleo-proteins and thus increases the efficiency of root system. Consequently the physiological activities of the plant are enhanced leading to better yield. These results are in harmony with those reported by EL-Khawaga and Zeiton (1992); Radwan and Rehab (1993); Mwafy (1995) Mohamed *et al* (1997) Nassar *et al* (2000) and Azer Sohair *et al* (2003).

Application of sulphur fertilizer levels to faba bean plants significantly affected seed yield arad./fed in both seasons. The highest seed yield values were (12.44 and 13.22 arad./fed) obtained from the highest sulphur level i.e. (60 kg S/fed) in the first and second seasons, respectively. These results could be explained in the light of positive effect of sulphur fertilizer in improving plant height, number of pods/plant, number of seeds/plant and weight of seeds/plant. These results are in agreement with those obtained by EL-Saadany and Abd EL-Rasoul (1999) and Togun and Daniel (2000), whose mentioned that 30 or 60 kg/ha sulphur is adequate for improving the growth, seed yield and seed protein of soybean plants.

Data in Table (7) also showed that the interaction effects between cultivar x phosphorus, cultivar x sulphur and between all studied factors were insignificant on seed yield ard./fed character in both seasons of the study. The only interaction, which significantly affected this character was that between phosphorus and sulphur in the first season. Application 30 kg P_2O_5/fed combined with 30 kg S/fed gave the highest seed yield (14.21 and 14.56 ard./fed) for Giza-40 and Misr-1 cultivars, respectively.

Table (7): The effect of two faba bean cultivars, phosphorus and sulphur levels, and their interactions on seed yield (arad./fed).

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	9.60	10.13	11.24	10.32	10.35	11.24	11.77	11.12
	15	11.49	12.06	12.70	12.08	12.32	13.03	13.61	12.99
	30	12.41	13.21	12.79	12.80	13.05	14.21	13.59	13.62
Average		11.17	11.80	12.24	11.73	11.91	12.83	12.99	12.58
Misr-1	0	9.84	10.53	11.23	10.53	10.71	11.46	12.13	11.43
	15	11.63	12.65	13.14	12.47	12.54	13.31	13.96	13.27
	30	12.93	14.00	13.52	13.48	13.32	14.56	14.23	14.04
Average		11.47	12.39	12.63	12.16	12.19	13.11	13.44	12.91
Average for all P-levels	0	9.72	10.33	11.24	10.43	10.53	11.35	11.95	11.28
	15	11.56	12.36	12.92	12.28	12.43	13.17	13.79	13.13
	30	12.67	13.61	13.16	13.14	13.19	14.39	13.91	13.83
Average		11.32	12.10	12.44	11.95	12.05	12.97	13.22	12.75

LSD 0.05

V	=	N.S	N.S
P	=	0.49	0.36
S	=	0.26	0.42
V x P	=	N.S	N.S
V x S	=	N.S	N.S
P x S	=	0.45	N.S
V x P x S	=	N.S	N.S

Straw yield (ton / fed):

Data presented in Table (8) showed that faba bean cultivars influenced straw yield ton/fed in the two seasons, but the differences failed to be a significant in both seasons. Whereas, cultivar Misr-1 produced higher values. Which exceeded the other cultivar (Giza-40) by (5.1% and 6.8%) in the first and second seasons, respectively.

Phosphorus fertilizer significantly increased straw yield ton/fed in both seasons. The highest straw yield (3.179 and 3.379 ton/fed) were achieved by the highest phosphorus level (30 kg P_2O_5/fed) as compared to the lowest values (2.166 and 2.511 ton/fed) were produced by unfertilized treatment in the first and second seasons, respectively. These results are in line with those obtained by Mwafy (1995).

Data in the prementioned Table clearly showed that sulphur significantly increased straw yield ton/fed in both seasons. Meanwhile, the maximum straw yield (12.44 and 13.22 ton/fed) produced by the highest sulphur level (60 kg S/fed) as compared to `the lowest values (11.32 and 12.05 ton/fed) were resulted

from control plants (unfertilized) during the first and second seasons, respectively. These results are in agreement with those obtained by EL-Saadany and Abd EL-Rasoul (1999).

Table (8): The effect of two faba bean cultivars, phosphorus and sulphur levels and their interactions on straw yield (ton/fed).

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	1.978	2.135	2.100	2.071	2.243	2.400	2.393	2.345
	15	2.618	2.885	3.215	2.906	2.920	3.060	3.495	3.158
	30	2.733	3.400	3.168	3.100	2.950	3.550	3.340	3.280
Average		2.443	2.807	2.828	2.692	2.704	3.003	3.076	2.928
Misr-1	0	2.150	2.180	2.450	2.260	2.590	2.680	2.760	2.677
	15	2.633	2.818	3.450	2.967	2.920	3.210	3.550	3.227
	30	2.885	3.650	3.235	3.257	3.140	3.830	3.465	3.478
Average		2.556	2.883	3.045	2.828	2.883	3.240	3.258	3.127
Average for all P-levels	0	2.064	2.158	2.275	2.166	2.417	2.540	2.577	2.511
	15	2.626	2.852	3.333	2.937	2.920	3.135	3.523	3.193
	30	2.809	3.525	3.202	3.179	3.045	3.690	3.403	3.379
Average		2.499	2.845	2.937	2.760	2.794	3.122	3.168	3.028

LSD 0.05

V	=	N.S	N.S
P	=	0.147	0.239
S	=	0.123	0.151
V x P	=	N.S	N.S
V x S	=	N.S	N.S
P x S	=	0.213	0.261
V x P x S	=	N.S	N.S

Concerning the effect of different interactions between the studied factors, data in Table (8) showed that neither the interaction between cultivar x phosphorus nor between cultivar x sulphur as well as the interaction between the three studied factors had a significant effect on straw yield (ton/fed) in both seasons of the study. On the other hand, data in the same Table showed that the only interaction that significantly affected this character was the interaction between phosphorus and sulphur in the two growing seasons. Appling 30 kg P_2O_5/fed combined with 30 kg S/fed produced the high values of straw yield (3.40 and 3.65 ton/fed) in 2001/2002 season for Giza-40 and Misr-1 cultivars, respectively. Also, the same combination produced the highest values of straw yield (3.55 and 3.83 ton/fed) in 2002/2003 season for Giza-40 and Misr-1 cultivars, respectively.

Protein percentage in seeds:

Data illustrated in Table (9) clearly indicated that cultivars significantly affected the abovementioned trait in both seasons. Whereas, the Misr-1 cultivar achieved the highest protein percentage. It exceeded the Giza-40 cultivar by (2.4% and 2.9%) in the first and second seasons, respectively. Also, results in the abovementioned Table indicated that phosphorus fertilizer levels significantly increased protein percentage up to 30 kg P_2O_5/fed. The highest values were 25.98 and 26.18 % protein during 2001/2002 and 2002/2003 seasons, respectively. These results might be due to the beneficial effect of phosphorus fertilizer on leguminous crops due to its role in activation of microbial population in nodules to fix more N_2 that used by plants in protein synthesis (Bhadoria *et al* 1997). These results are in accordance with those achieved by Mwafy (1995); EL-Kalla *et al* (1997) and Mahmoud *et al* (1999) who reported that fertilizing faba bean with 30 kg P_2O_5/fed was sufficient enough to induce stimulation effect on seed yield and protein yield and there is no need to add more phosphorus.

Table (9): The effect of two faba bean cultivars, phosphorus and sulphur levels, and their interactions on protein percentage in seeds.

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	23.63	23.85	24.72	24.07	23.30	23.61	24.50	23.80
	15	24.17	25.48	25.38	25.01	24.28	25.60	25.52	25.13
	30	25.38	26.03	25.71	25.71	25.52	26.00	26.14	25.89
Average		24.39	25.12	25.27	24.93	24.37	25.07	25.39	24.94
Misr-1	0	24.17	24.42	24.54	24.38	23.74	24.47	24.91	24.37
	15	25.59	26.06	26.25	25.97	25.64	26.46	26.33	26.14
	30	25.95	26.17	26.64	26.25	26.16	26.42	26.83	26.47
Average		25.24	25.55	25.81	25.53	25.18	25.78	26.02	25.66
Average for all P-levels	0	23.90	24.14	24.63	24.23	23.52	24.04	24.71	24.09
	15	24.88	25.77	25.82	25.49	24.96	26.03	25.93	25.64
	30	25.67	26.10	26.18	25.98	25.84	26.21	26.49	26.18
Average		24.82	25.38	25.54	25.23	24.78	25.43	25.71	25.30

LSD 0.05

V	=	0.20	0.44
P	=	0.46	0.52
S	=	0.38	0.50
V x P	=	N.S	N.S
V x S	=	N.S	N.S
P x S	=	N.S	N.S
V x P x S	=	N.S	N.S

Regarding to sulphur fertilizer levels the obtained data in Table (9) clearly indicated that sulphur levels significantly affected this character as compared to control plants (unfertilized) in both seasons. Meanwhile, the highest sulphur level 60 kg S/fed surpassed the control by (2.9% and 3.8%) in the first and second seasons, respectively. As in literature, sulphur is a constituent of the amino acids cysteine and methionine, and hence of proteins. These results are in line with those found by Kanany *et al* (2000); Togun and Daniel (2000) and Azer Sohair *et al* (2003).

All possible interactions between the studied factors insignificantly affected this character in the two growing seasons.

Phosphorus percentage in seeds:

Data presented in Table (10) revealed that the two studied cultivars did not differ significantly for this character in both seasons.

Table (10): The effect two faba bean cultivars, phosphorus and sulphur levels, and their interactions on phosphorus percentage in seeds.

Cultivars	P-levels (P_2O_5 kg/fed)	2001/2002 season				2002/2003 season			
		S-levels (S kg/fed)							
		0	30	60	Average	0	30	60	Average
Giza-40	0	0.49	0.53	0.54	0.52	0.48	0.54	0.57	0.53
	15	0.58	0.60	0.62	0.60	0.58	0.62	0.63	0.61
	30	0.59	0.62	0.66	0.62	0.61	0.63	0.66	0.63
Average		0.55	0.58	0.61	0.58	0.56	0.60	0.62	0.59
Misr-1	0	0.47	0.54	0.55	0.52	0.47	0.55	0.55	0.52
	15	0.58	0.61	0.62	0.60	0.60	0.62	0.65	0.62
	30	0.60	0.63	0.67	0.63	0.62	0.64	0.67	0.64
Average		0.55	0.59	0.61	0.58	0.56	0.60	0.62	0.59
Average for all P-levels	0	0.48	0.54	0.55	0.52	0.48	0.55	0.56	0.53
	15	0.58	0.61	0.62	0.60	0.59	0.62	0.64	0.62
	30	0.60	0.63	0.67	0.63	0.62	0.64	0.67	0.64
Average		0.55	0.59	0.61	0.58	0.56	0.60	0.62	0.59

LSD 0.05

V	=	N.S	N.S
P	=	0.05	0.03
S	=	0.03	0.03
V x P	=	N.S	N.S
V x S	=	N.S	N.S
P x S	=	0.05	0.04
V x P x S	=	N.S	N.S

Applying phosphorus fertilizer levels significantly affected phosphorus percentage in seeds in the two growing seasons. However, the highest values (0.63% and 0.64%) were obtained when faba bean plants received the highest

phosphorus level i.e. (30 kg P_2O_5/fed) in the first and second seasons, respectively. Sulphur fertilizer levels significantly increased phosphorus percentage in seeds as compared to unfertilized plants (control) in the two experimental seasons. Concentration of P (%) in plants received highest sulphur levels surpassed P concentration in the control plants by (10.9% and 10.7%) in the first and second seasons, respectively. The pH values of the soil decreased through oxidation of applied sulphur by soil microorganisms, which are able to produce sulphuric acid in amount enough to lower the pH and consequently the availability of phosphorus to plants (EL-Leboudi and Omar 1975). Same conclusion was found by Garcia and Carlani (1977); Yousry *et al* (1984) and Azer Sohair *et al* (2003).

Regarding the interactions effect of between the all studied factors on percentage of phosphorus in seeds of faba bean plants, the obtained results in Table (10) indicated that these studied interactions insignificantly influenced this character, but the differences were more announced and statistically approved to be significant when phosphorus combined with sulphur. A combination of 30 kg P_2O_5/fed and 60 kg S/fed produced the highest concentrations of P in seeds (0.66 and 0.67 %) for Giza-40 and Misr-1 cultivars during the both growing seasons.

In conclusion, it could be recommended that applying 30 kg P_2O_5/fed. combined with 30 kg S/fed. achieved the highest seed and straw yield for both Giza-40 and Misr-1 cultivars under similar conditions.

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إستجابة صنفين من الفول البلدى للتسميد بمستويات مختلفة من سمادى الفوسفور والكبريت

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الملخص

أقيمت تجربتان حقليتان خلال موسمى الزراعة الشتوى 2002/2001 ، 2003/2002م وذلك بهدف دراسة إستجابة صنفين من الفول البلدى لمستويات مختلفة من التسميد الفوسفاتى والكبريتى .. ولقد أستخدمت أصناف جيزة 40 ، مصر1 ، بينما كانت مستويات التسميد الفوسفاتى صفر ، 15 ، 30 كجم فو$_2$أ$_5$ /فدان والتسميد الكبريتى صفر ، 30 ، 60 كجم جبس زراعى /فدان.

وقد أظهرت النتائج ما يلى:

1- تفوق الصنف مصر1 على الصنف جيزة 40 فى كلاً من عدد القرون / نبات ، وزن بذور النبات ، وزن 100 بذرة ، وزن محصول البذور والقش / فدان ، والنسبة المئوية للبروتين فى البذور .. بينما تفوق الصنف جيزة 40 على مصر1 فى صفتى طول النبات وعدد البذور /نبات إلا أن هذه الفروق لم تكن معنوية سوى فى إرتفاع النبات فقط .
2- تسببت المستويات المرتفعة من الفوسفور فى زيادة معنوية لجميع الصفات تحت الدراسة مقارنة بعدم التسميد فى موسمى الزراعة .
3- أدت أيضاً الإضافات المرتفعة للكبريت لزيادة معنوية فى كل من إرتفاع النبات ، عدد القرون / نبات ، عدد البذور /نبات ، وزن بذور النبات ، وزن محصول البذور والقش / فدان ، والنسبة المئوية للبروتين والفوسفور فى البذور خلال الموسمين .
4- إضافة 30 كجم فو$_2$أ$_5$ مع 30 كجم كبريت لكل من الصنفين جيزة 40 ، مصر1 أعطت أعلى القيم لمحصول البذور والقش للفدان .
5- إضافة 30 كجم فو$_2$أ$_5$ مع60 كجم كبريت للفدان لكل من الصنفين أعطت أعلى قيم معنوية فى إرتفاع النبات والنسبة المئوية للبروتين والفوسفور فى البذور ، بالإضافة إلى ذلك التفاعل بين جميع عوامل الدراسة أثر معنوياً فى عدد البذور للنبات ووزن 100 بذرة خلال موسمى الدراسة وعدد البذور لكل نبات فى الموسم الأول فقط .