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Study The Response of Two Faba Bean Cultivars to Mineral and Bio-Phosphorus Fertilization

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Abstract

Reliance on vegetable protein sources has become an urgent necessity in Egypt due to the high prices of animal protein sources. This research was conducted to study the effect of different rates of mineral phosphate fertilizer with some phosphorous bio-fertilizers (Phosphorine and Microbene) on the productivity and quality of two faba bean cultivars Giza 843 and Masr3 in 2018/2019 and 2019/2020 winter seasons. The results revealed that a significant improvement could be found for most studied traits by the application of 30 kg P_2O_5/fad of phosphate fertilizer. Moreover, Phosphorine as a bio-fertilizer exhibited a significant enhancement on all studied traits, except shelling% and straw yield in the second season. The cultivars exerted different responses to the rates of phosphate fertilization for plant height, shelling% and protein content in the 2018/2019 season; number of branches/plant and 100 seed weight in the 2019/2020 season; as well as a noticeable response in seed and straw yields/fad, husk, and protein percentages in the two seasons. The interaction between cultivars and bio-fertilizers was significant for seeds protein and carbohydrates content in the 2019/2020 season. Furthermore, phosphate fertilizer rates and bi-fertilizers interaction gave a significant influence on seed yield/fad in both seasons and straw yield/fad in the first season. The second order interaction i.e., cultivars × phosphate × bio-fertilizers possessed a significant effect for seed and straw yields/fad, where the highest seed and straw yields were obtained from Masr1 cultivar when received 30 kg P_2O_5/fad and inoculated with Phosphorine biofertilizer in both seasons.

Keywords: Faba bean, phosphorus, biofertilizer, quality.

Introduction

Faba bean (*Vicia faba*, L.) is one of the most important food crops, due to its use as main source of vegetable protein for humans and substituted instead of animal protein. It has been noticed recently that the cultivated area of the faba bean crop has decreased and its prices have increased in the Egyptian market (Kandil, 2022). Furthermore, its seeds provide a cheap and high source of protein, as well as a good source of mineral nutrients, vitamins, and a variety of biologically active compounds. Faba beans also contain a chemical called Levodopa, which is used to control brain neuron diseases (Parkinson's disease) that affect body movement (Holden, 2009). Phosphorus plays an important role in photosynthesis and respiration, also essential for the division and development of meristems (Abdul-Galil et al., 2003; and Abdo, 2003). Many researchers reported that the application of phosphate fertilizer increased the yield and yield components of faba bean (Tageldin and Mehasen, 2004; Tayel and Sabreen, 2011 and Jafar, 2014).

Biofertilization is one of the modern trends in agriculture to preserve the environment from chemical pollution and to obtain an agricultural product free of chemicals that are harmful to human and animal health. Bio-phosphorous fertilizer depends on microbes that can facilitate phosphorus in the soil and provide it in a way that the plant can absorb, as it transforms the alkaline medium in the soil into a neutral medium, thus transforming triple phosphorus into binary and monovalent suitable for absorption. Fertilization is essential for nutrient cycling in the biosphere and the main way to rely on plants for nutrients (Passricha et al., 2020). Biofertilization can increase soil organic matter, improve soil structure and soil buffer capacity (Godara et al., 2012). In addition, bio-fertilization can provide ideal growing conditions for plants by increasing the availability of nutrients in the soil, because of the increase in microbial activity and the decrease in soil pH in the analysis of organic matter (Huang, et al. 2017). The biggest benefits of biofertilizer are that it has the potential to increase the health and productivity of plant life and reduce the need to use synthetic fertilizers. As well as many researchers reported that phosphate-dissolving bacteria can promote crop growth, increase seed, straw yield and nutrient absorption (Hamed 2003, Ahmed and El-Abagy 2007 and, El-Habbasha et al., 2007).

The use of biofertilizers is not new to Egyptian agriculture, but it is not widespread enough. The use of mineral fertilizers has become very expensive due to the global rise in the prices of these fertilizers, in addition to the environmental pollution consequences of their use. Therefore, this research aimed to I) study the response of some growth characteristics, yield components and some quality characteristics of two cultivars (Masr 3 and Giza 843) of faba bean, II) application bio and mineral fertilization, III) Verify the possibility of reducing the use of mineral fertilizers through the use of some bio alternatives to fertilizers, thus reducing production costs and reducing the environmental pollution and IV) overcome the problem of phosphorus fixation in the alkaline lands spread in the New Valley region and the Egyptian lands, in general.

Materials and methods

A field experiment was conducted at the Faculty of Agriculture Farm, New Valley University, during the growing seasons of 2018/2019 and 2019/2020 to study the growth, yield, and seed quality of two faba bean (*Vicia faba* L.) cultivars as a response to phosphorous and bio-phosphate fertilization. Both experiments were laid out in randomized complete block design (RCBD) using a split split-plot arrangement with three replications. Faba bean cultivars were assigned to the main plot, Phosphate fertilizer rates were distributed randomly in the sub plots and Bio-fertilization types were located in the sub -sub plots.

Experiment Factors

A- Cultivars: two local faba bean cultivars (Giza-843 and Misr-3).

B- Phosphate fertilization: three rates of phosphate fertilizers (15, 30 and 45 kg P_2O_5/fad) in the form of Monocalcium superphosphate 15%.

C- Bio-fertilization: two commercial biofertilizer types i.e., Phosphorine and Microbene in addition without inoculation as a control.

Before sowing, the seeds of each cultivar were divided into three equal parts and two parts were inoculated in each with one of the bio-fertilizers (Phosphorine or Microbene) with one part left untreated as control and then planted directly, as recommended. The biofertilizers were produced by the Ministry of Agriculture, Egypt.

The mechanical and chemical properties of the soil at the experimental site were analyzed and presented in Table 1.

Table 1: The mechanical and chemical analyses of soil field experiments.

	Season	
	2018/2019	**2019/2020**
Mechanical analysis		
Sand (%)	80.5	80.0
Silt (%)	18.0	18.5
Clay (%)	1.5	1.5
Soil texture	Sandy loam	Sandy loam
Chemical analysis		
Organic matter (%)	0.64	0.69
Available N (ppm)	56.0	54
Available P (ppm)	1.63	1.87
Available K (ppm)	128	149
Ca CO_3 (g/kg soil)	47	44
pH	8.6	8.5
E.C (dc. m^{-1})	1.67	1.72

The experimental unit comprised five ridges, each 3.5 m long and 0.6 m wide (or 10.5 m^2 in area = 1/400 fad^{-1}). Seeds were sown on October 20th in both seasons, on the two sides of ridges, in hills 25 cm apart and were thinned to one plant/hill. The preceding summer crop was maize in both seasons. All other practices were uniformly applied as recommended for faba bean production in the region.

Agronomic traits:

1. Plant height (cm):it was measured from above ground surface to the top of plant before the harvest directly on five plants.
2. Numbers of branches/plant.
3. 100- seed weight (g).
4. Shelling percentage (%): was calculated on line basis using the following formula:

$$\text{Shelling percentage (\%)} = \frac{\text{weight of seeds /Line}}{\text{weight of pods/Line}} \times 100$$

Plants of three middle lines of each plot were harvested and, were left up to one three days until air dray then seeds, and straw were separated and weighed to estimate the yield traits. The following yield traits were calculated on Faddan (4200 m^2) basis.

5. Seed yield (ton/fad).
6. Straw yield (ton/fad).
7. Husk percentage (%): A sample of 100 grams of seeds was taken from each plot and, husked. The result husk of the sample was weighed and the husk% was calculated according to the following formula:

$$\text{Husk(\%)} = \frac{\text{husk weight (g)}}{\text{Whole seed weight (g)}} \times 100$$

8. Protein content (%): Total nitrogen content in seeds was estimated by using the Micro-Kjeldahl method as described by A.O.A.C. (1980) and the percentage of protein was calculated by multiplying the nitrogen percentage by 6.25.

9. Carbohydrate content (%): carbohydrates content of seeds using phenol-sulfuric acid regent Dubois et al., (1965).

Statistical analysis:

All obtained data were subjected to statistical analysis according to Gomez and Gomez (1984) and treatment effects were compared using Revised Least Significant Differences ($RLSD_{0.05}$). All statistical analysis was performed using the analysis of variance technique by the "MSTAT-C" computer software package 1990. The phenotypic correlation across all treatments between each pairs of studied traits in both seasons was calculated as outlined by Walker (1960).

Results and Discussion

1. Plant height (cm), branches number/plant and, 100-seed weight (g):

Means of faba bean plant height cm, branches number/plant and, 100-seed weight g for Giza 843 and Masr 3 cultivars affected by bio and mineral phosphate fertilization in 2018/2019 and 2019/2020 seasons are presented in Table 2.

Faba bean cultivars differed significantly for plant height and weight of 100 seed in 2018/2019 only, where Masr 3 recorded the tallest plants (112.60 cm) and the heaviest 100 seed (89.08 g) in comparison to Giza 843. These differences may be due to the combination of genetic behavior and environmental factors, which is more suitable for Masr 3 than Giza 843. The previous results are consistent with those obtained by Khattab, et al. (2016) and Negasa, et al. (2019).

Results in **Table 2** exerted that phosphorous fertilizer rates affected significantly plant height (cm), branches number/plant and, 100-seed weight (g) in both seasons. Application of 45 kg P_2O_5/fad. recorded the tallest plants (110.96 cm) in the first season, while the tallest plants (118.36 cm) in the second season was recorded by a rate of 30 P_2O_5/fad. Moreover, the rate of 30 kg P_2O_5/fad. gave the highest branches number/plant of 5.85 and 5.79 branch in the first and second seasons, respectively. Notably, the effect of the two rates 30 and 45 kg P_2O_5/fad on plant height and so, branches number/plant was in statistically par. The increase in plant height and branches/plant may be attributed to the stimulating effect of phosphorus on cell division of apical meristem and vegetative buds during growth period. These results are largely consistent with those reported by Woldekiros, et al. (2018) and Jasim and Alghrebawi (2020). On the other hand, the rate of 45 kg P_2O_5/fad recorded the highest weight of 100 seed (88.97 g) in the first season, while the heaviest 100-seed weight (89.22 g) was recorded by a rate of 15 P_2O_5/fad. in the second season. This increase could be to the negative effect of the higher and lower rates than recommended rate of phosphate fertilizer on seed number/plant which resulted in an increase in the fullness of seeds and thus their weight.

Moreover, data exhibited a significant influence of biofertilizers on plant height, branches number/plant and, 100-seed weight in both seasons. The tallest plants (113.42 and 118.79 cm), the highest number of branches/plant (5.85 and 6.40) as well as the heaviest 100-seed (90.82 and 91.39 g) were recorded when Phosphorine was applied in two consecutive seasons, respectively. This increase could be because that the increase of nutrients availability especially phosphorus element with used biofertilizers which encourages elongation and, cell division leading to an enhancement in each of plant height, no. of branches and seed filling. These results are largely consistent with those reported by Nour El-Din, et al., (2020) and Gebeyehu & Selassie (2021).

The interaction between cultivars and phosphorus fertilizers rates was significant on plant height in the first season, only **(Fig.1)**, where the Masr 3 cultivar recorded the tallest plants (114.04 cm) when receiving the phosphorus fertilizer at a rate of 30 kg P_2O_5/fad. Otherwise, the interaction between cultivars and phosphorus fertilizers rates exhibited a significant effect on branches number/plant and 100-seed weight in the second season, only **(Fig.2&3)**.

Table 2: Means of faba bean plant height cm, branches number/plant and, 100-seed weight g for Giza 843 and Masr 3 cultivars affected by bio and mineral phosphate fertilization in the 2018/2019 and 2019/2020 seasons.

Traits	Plant height (cm)		Branches No./Plant		100-seed weight (g)	
Season	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Cultivars						
Giza 843	107.45	114.85	5.20	5.39	86.31	83.64
Masr 3	112.60	117.16	5.56	5.55	89.08	91.66
F test	*	N.S.	N.S.	N.S.	*	N.S.
Phosphate fertilizer rates						
15 Kg P_2O_5/fad	108.71	113.82	4.58	5.10	85.24	89.22
30 Kg P_2O_5/fad	110.41	118.36	5.85	5.79	88.87	86.84
45 Kg P_2O_5/fad	110.96	115.84	5.71	5.51	88.97	86.90
F test	*	**	*	*	**	**
RLSD.$_{at\ 0.05}$	1.81	1.29	0.49	0.47	2.35	2.34
Biofertilizers						
Control	106.96	112.92	4.66	4.70	85.08	83.90
Phosphorine	113.42	118.79	5.94	6.40	90.82	91.39
Microbene	109.70	116.31	5.53	5.30	87.18	87.66
F test	**	**	*	*	**	*
RLSD.$_{at\ 0.05}$	2.59	3.18	0.35	0.49	2.40	2.92

Where: N.S. * and ** mean non-significant and significant at 5 and 1 % level of probability, respectively.

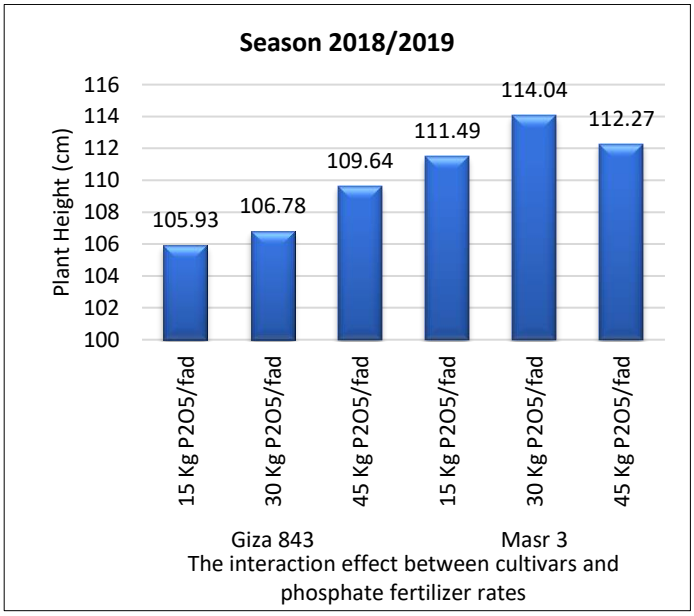

Fig.1: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on plant height (cm) in the 2018/2019 season.

The highest number of branches/plant (5.96) was recorded for Masr 3 cultivar when receiving 30 kg P_2O_5/fad. Furthermore, the heaviest 100-seed weight (95.55 g) was recorded also from Masr 3 cultivar when receiving 15 kg P_2O_5/fad. On the other hand, the rest interactions had an insignificant effect on faba bean plant height in both seasons.

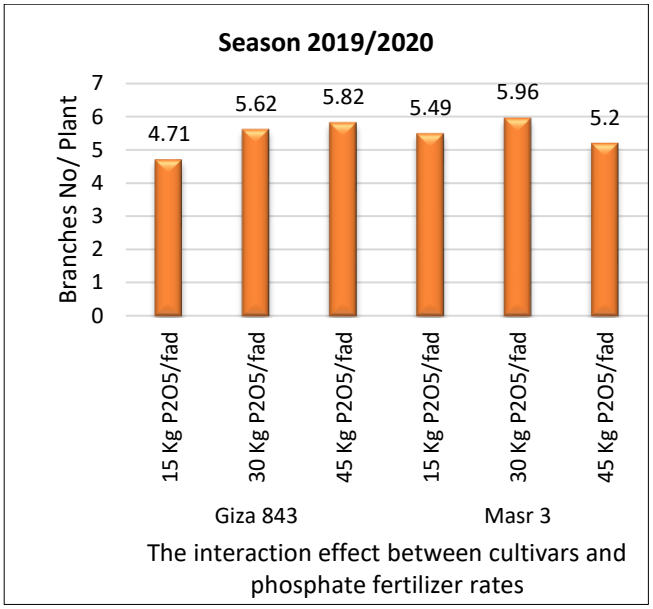

Fig.2: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on branches number/plant in the 2019/2020 season.

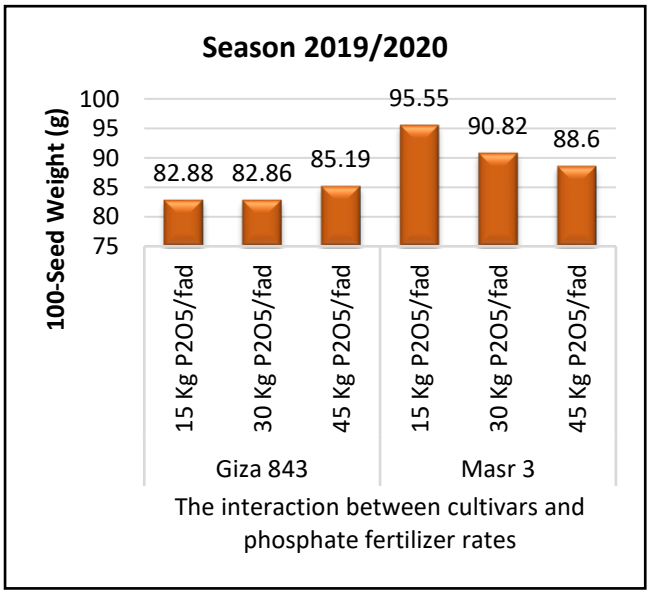

Fig.3: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on 100-seed (g) in the 2019/2020 season.

2- Shelling% and, seed and straw yields (ton/fad):

It is clear from Table 3 that faba bean cultivars were differed significantly in seed and straw yields/fad in the 2019/2020 season, only. Furthermore, data clearly presented that Masr 3 cultivar was surpassed by Giza 843 cultivar in seed and straw yields.

Phosphate fertilizer rates had a significant effect on shelling percentage and straw yield/fad in the first season, only while exerted a highly significant influence on seed yield/fad in both seasons (Table 3). The highest percent of shelling (70.90%) and the highest straw yield (2.16 ton/fad) in the 2019/2018 season, as well as the highest seed yield (1.61 and 1.96 ton/fad in two consecutive seasons, respectively) were obtained when phosphate fertilizer was applied at a rate of 30 kg P_2O_5/fad. These results may be due to the enhancement of the vegetative growth and enhancing the photosynthesis process because of phosphate fertilizer rate increase, encouraging dry matter accumulation and consequently increasing of number of branches. These results are largely consistent with those reported by El-Gizawy and Mehasen (2009) & Shakori and Sharif (2016).

Table 3: Means of faba bean shelling%, seed yield (ton/fad), and straw yield (ton/fad) for Giza 843 and Masr 3 cultivars affect by bio and mineral phosphate fertilization in the 2018/2019 and 2019/2020 seasons.

Traits	Shelling %		Seed Yield (ton/fad)		Straw Yield (ton/fad)	
Season	**2018/2019**	**2019/2020**	**2018/2019**	**2019/2020**	**2018/2019**	**2019/2020**
Cultivars						
Giza 843	68.38	70.40	1.49	1.82	2.03	2.47
Masr 3	68.35	71.53	1.52	1.95	2.12	2.75
F test	N.S.	N.S.	N.S.	*	N.S.	**
Phosphate fertilizer rates						
15 Kg P_2O_5/fad	67.75	70.54	1.46	1.82	1.95	2.61
30 Kg P_2O_5/fad	70.90	70.95	1.61	1.96	2.16	2.74
45 Kg P_2O_5/fad	66.45	71.42	1.44	1.87	2.11	2.47
F test	*	N.S.	**	**	*	N.S.
RLSD.$_{at\ 0.05}$	3.47	--	0.04	0.05	0.17	--
Biofertilizers						
Control	64.06	69.99	1.35	1.74	2.02	2.55
Phosphorine	70.73	73.12	1.60	2.01	2. 20	2.72
Microbene	70.29	69.79	1.56	1.91	2.00	2.55
F test	**	N.S.	**	**	**	N.S.
RLSD$_{at\ 0.05}$	4.21	--	0.05	0.04	0.10	--

Where: N.S., * and ** mean non-significant and significant at 5 and 1 % level of probability, respectively

Furthermore, the showed results pointed out that faba bean inoculation by biofertilizers exerted highly significant influence on shelling percentage and straw yield/fad in the first season, only while exerted a highly significant effect on seed yield/fad in both seasons (Table 3). The largest shelling percentage (70.73%) and straw yield (2.20 ton/fad) in the 2018/2019 season, as well as the highest seed yield (1.60 and 2.01 ton/fad in the first and second seasons, respectively) were recorded when Phosphorine bio-fertilizer was applied. These results are largely consistent with those reported by Ahmed and El-Abagy (2007) and Nour El-Din et al., (2020).

Concerning the interaction effect, the exhibited results in **(Fig.4&5)** focus that cultivars x phosphate fertilizer rates interaction had a significant influence on shelling in the first season and seed yield/fad in both seasons. The highest shelling percentage (73.09 %) and seed yield/fad (1.69 and 2.00 ton/fad in the first and second season, respectively) were recorded to Masr 3 cultivar when phosphate fertilizer was applied at a rate of 30 kg P_2O_5/fad.

On the other hand, the interaction between faba bean cultivars and biofertilizers did not exhibit a significant effect on shelling %, straw and seed yields/fad in both seasons. The interaction between phosphate fertilizer rates and biofertilizers gave a significant effect on seed yield/fad in both seasons and straw yield/fad in the first season, only **(Fig.6&7)**.

The second-order interaction among the studied factors **(Fig.8&9)** exhibited a significant impact on seed and straw yields/fad in the two seasons where, the highest seed yield 1.86 and 2.18 ton/fad, as well as straw yield 2.19 and 3.03 ton/fad were obtained from Masr 1 cultivar when received 30 kg P_2O_5/fad and inoculated with Phosphorine biofertilizer in the first and second season, respectively.

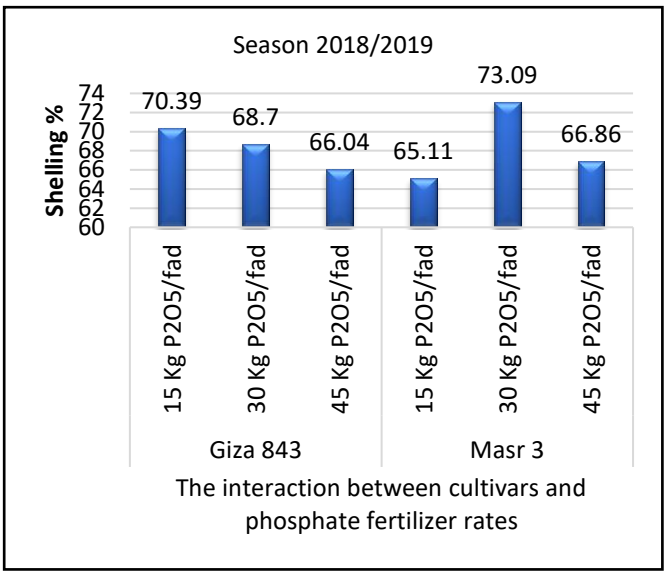

Fig.4: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on shelling (%) in the 2018/2019 season.

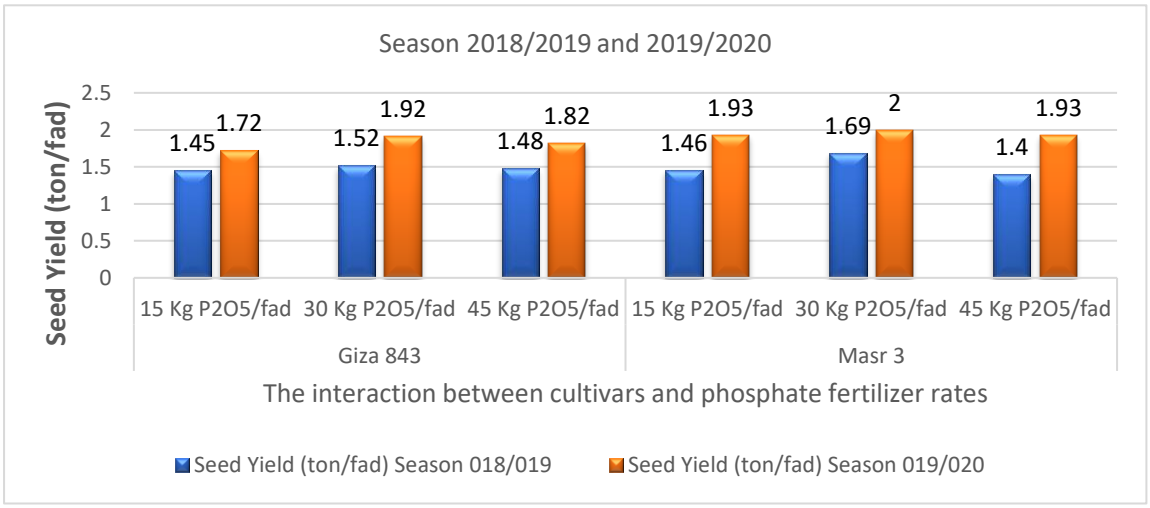

Fig.5: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on seed yield (ton/fad) in the 2018/2019 and 2019/2020 seasons.

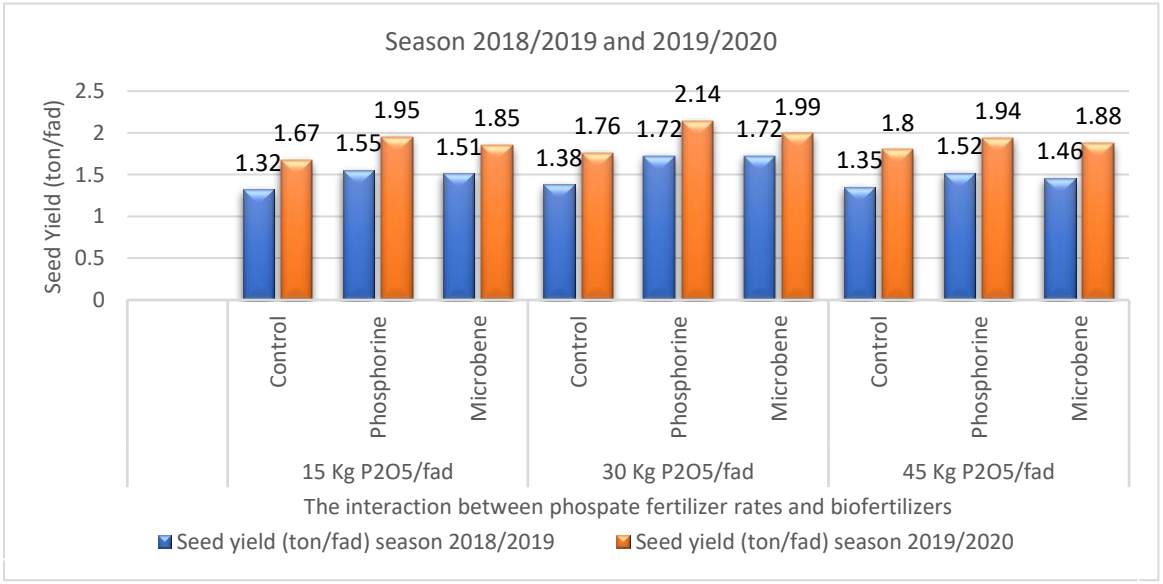

Fig.6: The interaction effect between phosphate fertilizer rates and biofertilizers on seed yield (ton/fad) in the 2018/2019 and 2019/2020 seasons.

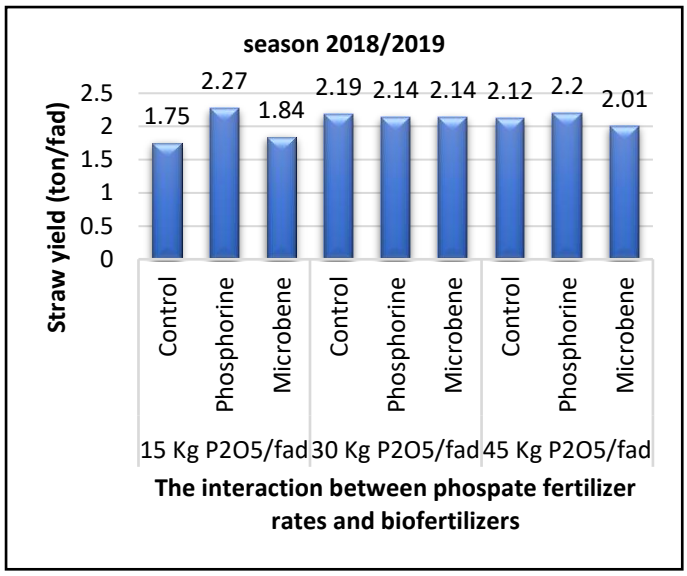

Fig.7: The interaction effect of bio and mineral phosphate fertilizers on straw yield (ton/fad) of two faba bean cultivars in the 2018/2019 season.

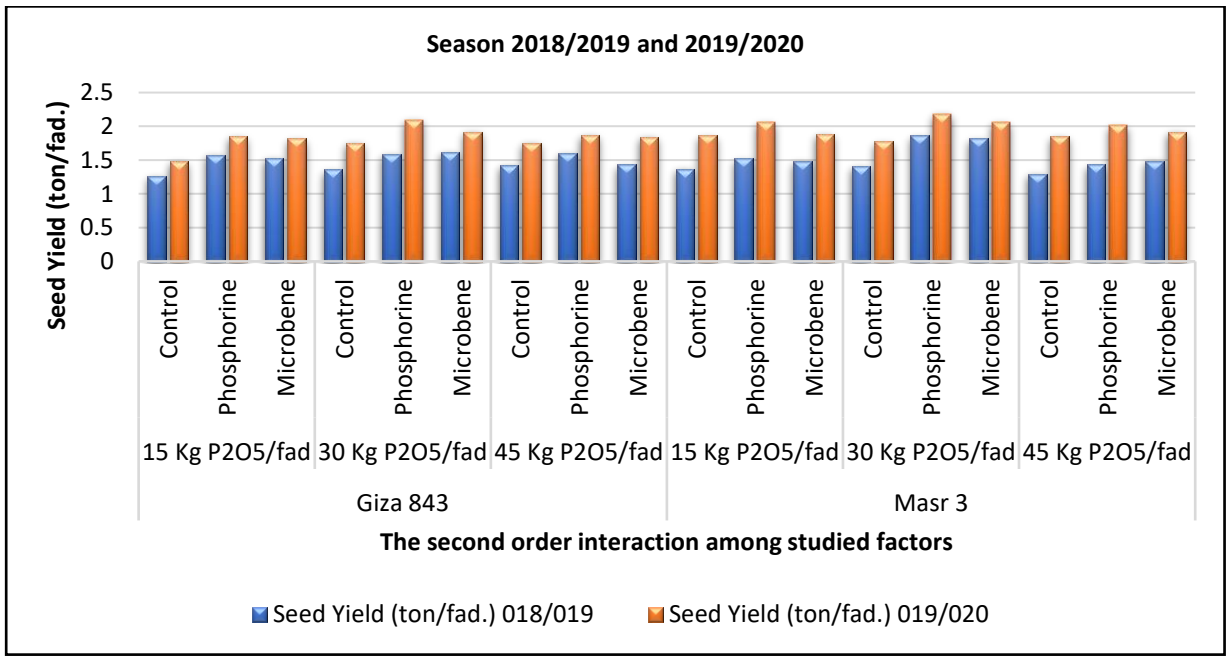

Fig.8: The second-order interactions effect of bio and mineral phosphate fertilizers on seed yield (ton/fad) of Giza 843 and Masr 3 faba bean cultivars in the 2018/2019 and 2019/2020 seasons.

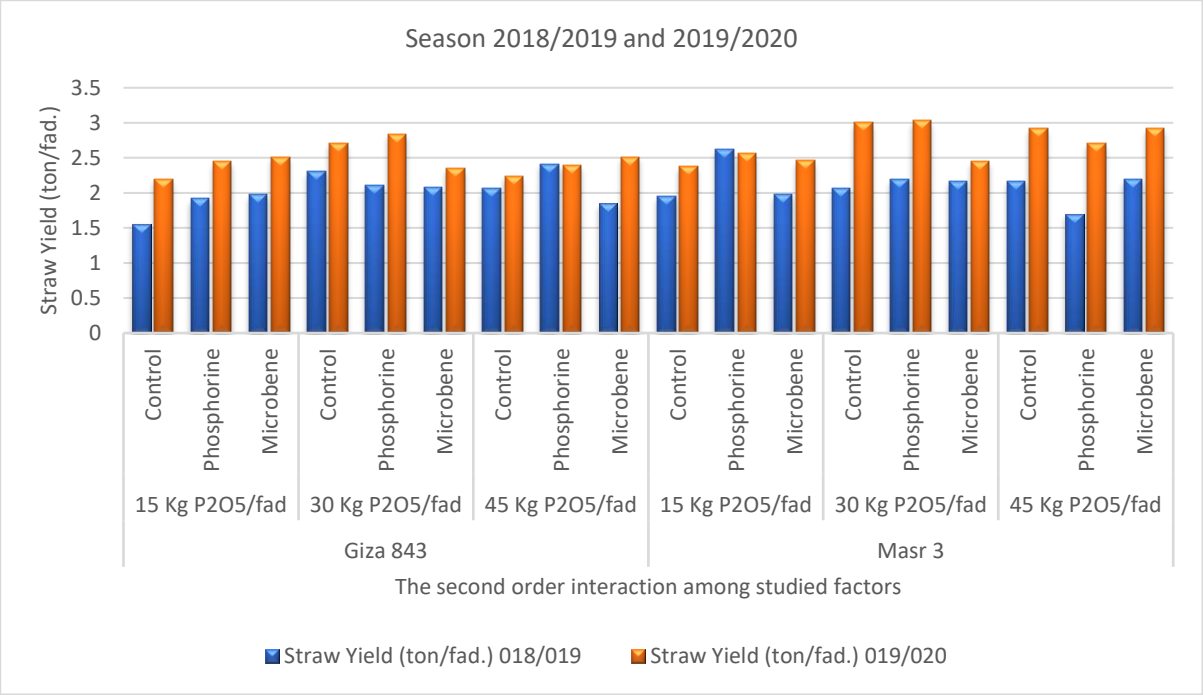

Fig.9: The second-order interactions effect of bio and mineral phosphate fertilizers on straw yield (ton/fad), of Giza 843 and Masr 3 faba bean cultivars in the 2018/2019 and 2019/2020 seasons.

3- Husk%, crude protein%, and total carbohydrates %

Results in Table 4 exposed that there were significant differences between the two faba bean cultivars in husk through the second season only, where Giza 843 had a higher value of husk percentage than the Masr 3 cultivar. While the cultivars did not possess significant differences in percentages of protein and carbohydrates in both seasons.

Phosphate fertilizer rates had a significant effect on husk, protein and carbohydrates percentages in both seasons. The lowest values of husk 13.33 and 12.22% were observed when phosphorus fertilizer was applied at a rate of 15 kg P_2O_5/fad in the two consecutive seasons, respectively. This result is logical if we look at the weight of 100-seeds, as it was somewhat high in the lower levels of phosphate fertilizer. The highest values of protein percentage 24.22 and 24.67 % and carbohydrate content 54.13 and 53.62% were obtained when phosphate fertilizer was added at a rate of 30 kg P2O5/fad in the first and second seasons, respectively. These results may be due to the role of facilitated phosphorus in enhancing the fullness of seeds and increasing their components, especially protein and carbohydrates. The previous results are in accordance with those reported by Shahram and Peyman (2016), El-Sobky and Yasin (2017), and Akl and El-Fattah (2019).

The use of biofertilizers led to a significant decrease in the husk% of faba bean seeds (Table 4), where the lowest values of seed husk 13.23 and 12.55% were obtained when Phosphorine was applied in in two consecutive seasons, respectively. On the contrary, the use of bio-fertilizers led to a significant increase in the protein and carbohydrate contents of the seeds compared to the control treatment (without inoculation) in the two seasons. The inoculation with Microbene gave the highest the percentages of protein 24.23 and 24.10%, while Phosphorine gave the highest values of carbohydrate content 54.03 and 54.52% in two seasons, respectively.

Concerning the interaction effect, the exhibited results in **(Fig.10,11&12)** focus that the interaction between cultivars and phosphate fertilizer rates had a significant effect on husk and protein percentages in the two seasons and carbohydrate contents in the 2019/2020 season, only.

Table 4: Means of faba bean seed husk%, crude protein %, and total carbohydrates content% for Giza 843 and Masr 3 cultivars affect by bio and mineral phosphate fertilization in 2018/2019 and 2019/2020 season.

Traits	Husk percentage		Protein percentage		Total carbohydrates content	
Season	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Cultivars						
Giza 843	13.89	13.72	23.86	23.84	53.38	53.32
Masr 3	14.16	12.86	23.22	23.51	53.36	53.00
F test	N.S.	*	N.S.	N.S.	N.S.	N.S.
Phosphate fertilizer rates						
15 Kg P_2O_5/fad	13.33	12.22	22.99	23.05	52.96	52.45
30 Kg P_2O_5/fad	14.52	14.00	24.22	24.67	54.13	53.62
45 Kg P_2O_5/fad	14.23	13.65	23.40	23.30	53.02	53.43
F test	*	**	**	**	**	*
$RLSD_{at\ 0.05}$	0.78	0.30	0.47	0.73	0.72	0.73
Biofertilizers						
Control	15.14	14.05	22.55	22.84	52.29	52.01
Phosphorine	13.23	12.55	23.84	24.09	54.03	54.52
Microbene	13.71	13.28	24.23	24.10	53.78	52.96
F test	**	**	**	**	**	**
$RLSD_{at\ 0.05}$	0.65	0.76	0.39	0.74	0.64	0.68

Where: N.S., * and ** mean non-significant and significant at 5 and 1 % level of probability, respectively.

The lowest husk percentages were 12.22 and 12.12 % in the 2018/2019 and 2019/2020 seasons, respectively, recorded to Giza 843 cv. when fertilized by 15 kg P_2O_5/fad. On the contrary, the cultivar Giza 843 gave the highest protein and total carbohydrate contents 24.55 and 54.34%, respectively, when receiving 30 kg P_2O_5/fad in the first season. While, the highest protein percentage 25.17% was recorded in Masr 3 cultivar when fertilized by phosphorus at a rate of 30 kg P_2O_5/fad in the second season. On the other hand, the interaction between faba bean cultivars and biofertilizers **(Fig.13&14)** exhibited a significant effect on crude protein % and total carbohydrate contents in the second season, where the highest protein 24.85% was obtained from inoculation Giza 843 cultivar with Microbene bio-fertilizer. While, the highest total carbohydrate content 54.72% was obtained from inoculation Giza 843 cultivar with Phosphorine bio-fertilizer.

The second-order interaction among the studied factors did not reveal any significant effect on husk, protein, and carbohydrate percentages in both seasons.

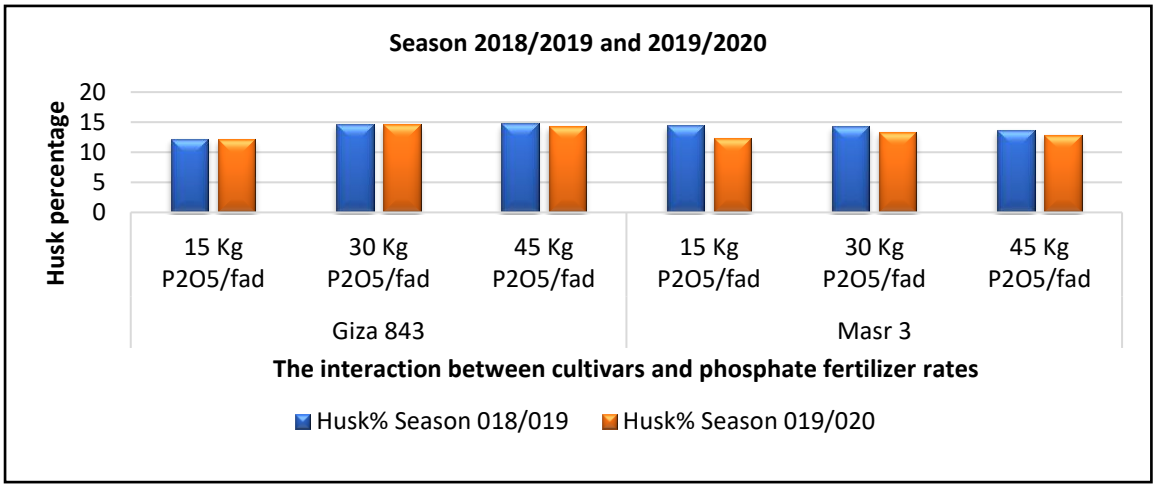

Fig.10: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on husk (%) in the 2018/2019 and 2019/2020 seasons.

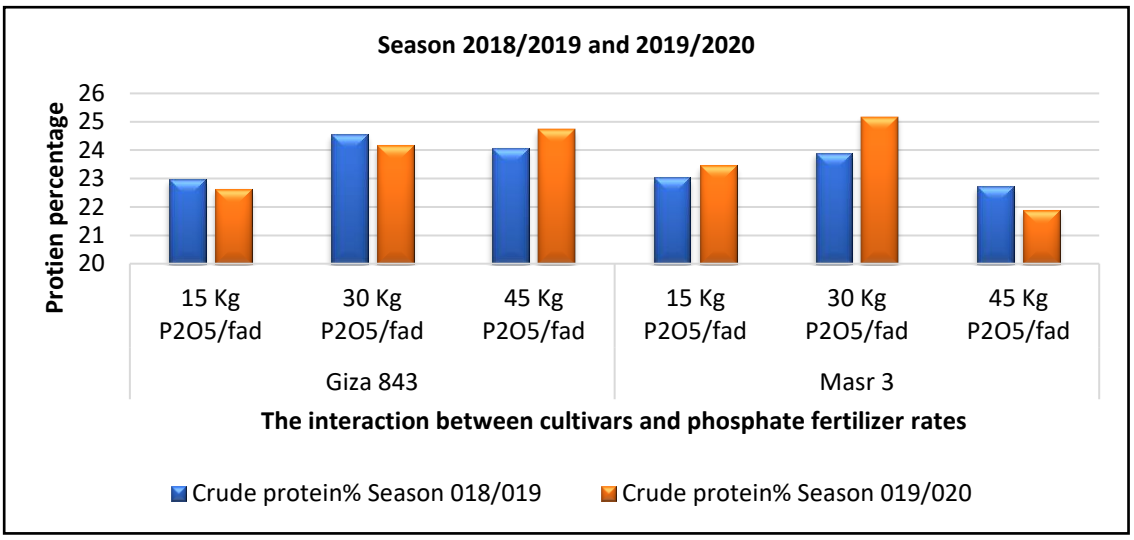

Fig.11: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on husk (%) in the 2018/2019 and 2019/2020 seasons.

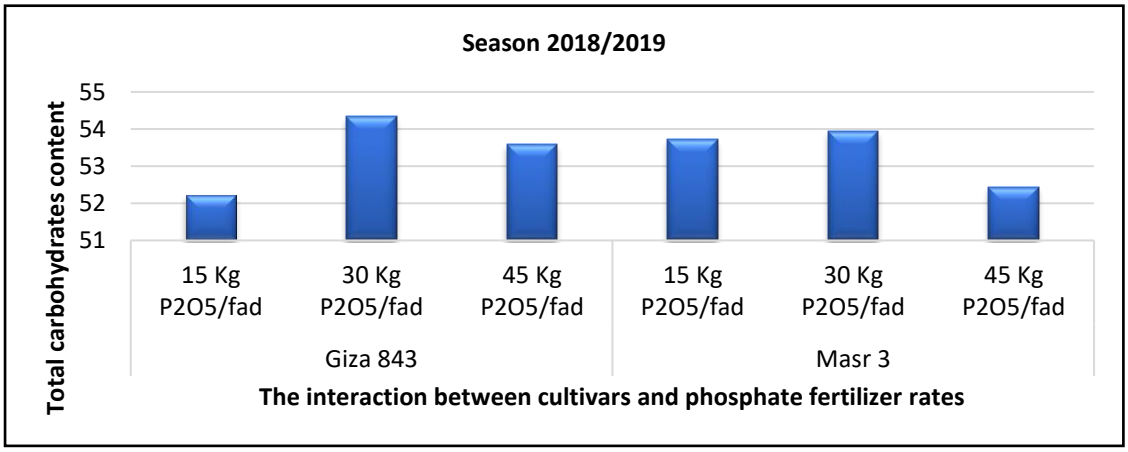

Fig.12: The interaction effect between faba bean cultivars and mineral phosphate fertilizer rates on total carbohydrates content in the 2018/2019 season.

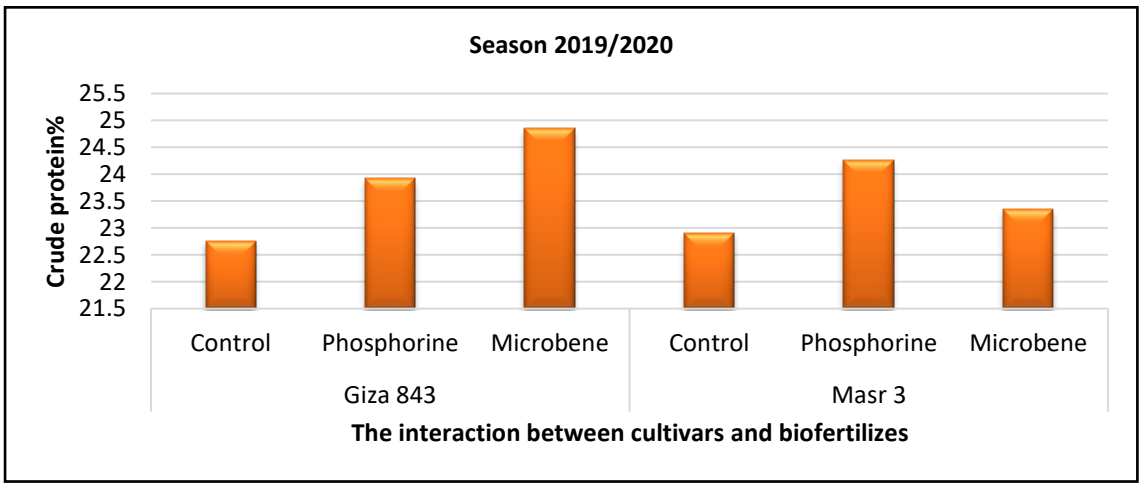

Fig.13: The interaction effect between faba bean cultivars and bio fertilizers on crude protein % in the 2019/2020 season.

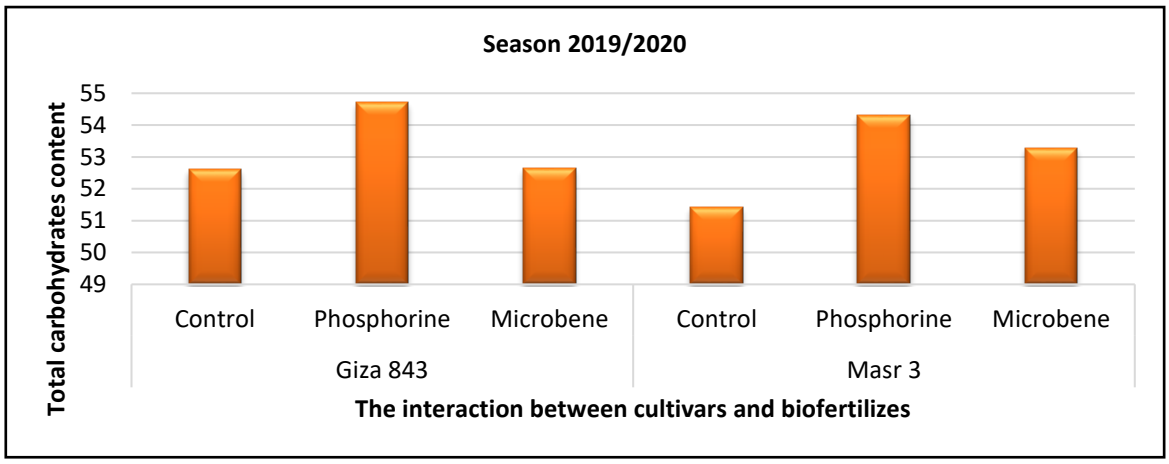

Fig. 14: The interactions effect of bio and mineral phosphate fertilizers on total carbohydrates content of two faba bean cultivars in the 2019/2020 season.

4- Linear response for phosphate fertilization upon studied traits.

The used levels of phosphate fertilization were 15, 30 and 45 kg P_2O_5/fad. Consequently, the linear response could be estimated for all studied traits to assess the clear conclusion for the effect of phosphate fertilization needed for faba bean under New Valley conditions.

The analysis of variance revealed that the significant linear responses of phosphate fertilization were exerted for plant height and seed index in both seasons, branches number/plant, shelling, seed yield/fad, straw yield/fad, husk%, protein% and carbohydrate content in season 2. The obtained fluctuation of linear response for phosphate fertilization resembled both seasons for the studied traits may be revealed to the effects of edaphic factors from one season to another under the New Valley conditions. Consequently, more studies need to do to assess the remarkable conclusion for phosphate fertilizer upon faba bean under these areas.

5- Correlation coefficients between each pairs of studied traits in the two seasons.

The significant positive and high values of correlation coefficients in Table 5 possessed that seed yield/fad were estimated with each of plant height, branches number/plant, shelling, protein% and carbohydrate content in both seasons. The same results could be found for the number of branched/plant, and carbohydrate content with the same previous traits in both seasons. Moreover, protein percentage was correlated in significant and positive values with each of the number of branches/plant, seed yield/fad and carbohydrate content in both seasons. Furthermore, the positive significant correlations were recorded among plant height and each of the branches number/plant, seed index, and carbohydrate content in both seasons. It is remarkable results that the traits *i.e.* branches number/plant, seed yield/fad were significantly correlated with each of protein and carbohydrate in both seasons. In addition to, the protein and carbohydrate were correlated in positive and significant values that resembled to the two seasons. Seed index as a main component of seed yield was correlated significantly and positively values with plant height in both seasons. The obtained results interpreted the genetic make-up and real associations among all studied traits of the faba bean under New Valley conditions. The current results are in line with those advertised by Chaudhary et al., (2018), Al-Falahy and Kanoosh (2019) and Zeinab EL-Boseily (2022). Moreover, Tofiq et al., (2016) found highly positive significant correlations between seed numbers/plant and each of seed yield and seeds number/pod. Pods number/plant correlated in positive and significant values with the seed yield.

Table 5: Correlation coefficients between each pairs of studied traits in the two seasons.

		NBP	SI	SHEL	SYF	STYF	HUP	PP	CARB
PH	**S1**	0.728**	0.755**	0.420	0.597**	0.366	-0.219	0.229	0.481*
	S2	0.644**	0.539*	0.368	0.814**	0.440	-0.175	0.341	0.746**
NBP	**S1**		0.813**	0.423	0.624**	0.471*	-0.026	0.672**	0.735**
	S2		0.496*	0.359	0.769**	0.285	-0.130	0.578*	0.760**
SI	**S1**			0.517*	0.452	0.511*	-0.192	0.319	0.427
	S2			0.336	0.705**	0.449	-0.545*	0.178	0.308
SHEL	**S1**				0.689**	0.075	-0.526*	0.536*	0.454
	S2				0.391	0.320	-0.446	0.309	0.389
SYF	**S1**					0.347	-0.262	0.656**	0.701**
	S2					0.558*	-0.294	0.482*	0.592**
STYF	**S1**						0.364	0.229	0.379
	S2						-0.183	0.297	0.166
HUP	**S1**							-0.111	-0.031
	S2							0.196	-0.045
PP	**S1**								0.845**
	S2								0.508*

Where: * and ** mean significant at 5 and 1 % level of probability, respectively.
Plant height (PH), Number of branches/plant (NBP), Seed index (SI), Shelling % (SHEL), Seed yield/fad. (SYF), Straw yield/fad. (STYF), Husk % (HUP), Protein % (PP) and Carbohydrate content (CARB). Season 1 (S1) and Season 2 (S2).

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