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Performance of Some Faba Bean Varieties in Relation to Phosphorus Fertilization and Some Microelements Spraying

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Abstract

In order to study the effect of phosphorus fertilization rates and microelements spraying treatments on plant characteristics and yield traits as well as some seed chemical properties of faba bean varieties, an experiment was conducted in two successive growing seasons of 2018/2019 and 2019/2020 in the Farm of Agricultural Research and the Experimental Center of Faculty of Agriculture at Moshtohor, (Toukh Directorate, Kalyubia Governorate) Benha Univ. Egypt. The experimental design was split-split plot in RCBD in three replications. Phosphorus fertilizer was considered as the main plot in three rates (0, 15 and 30 kg P_2O_5/fed). Four microelements spraying treatments [Tap water (control), Zn, Mn and mixed of Zn + Mn] were arranged in the sub plot. The sub-sub plots were occupied with three faba bean varieties (Giza 716, Nubaria 3 and Sakha 4). The obtained results could be outlined as following: Increasing phosphorus fertilizer rate from 0 to 30 kg P_2O_5/fed induced significantly increased most vegetative growth, yield attributes, yield and seed chemical properties of faba bean under study except, mid physiological maturity, height to 1st pod and phosphorus use efficiency were significantly decreased with rising phosphorus rates during the both seasons. The foliar spray by Zn and Mn as a single or in combination had significant effect on most faba bean traits under study compared with no microelements added during the both seasons. Faba bean plant treated with microelements foliar spray using Zn in combination with Mn was the most effective treatment for most faba bean characteristics in the both seasons. Mean performances of the investigated faba bean varieties for most faba bean traits under study were significant different during the both seasons. Faba bean variety Sakha 4 had higher values of chlorophyll content index at 85 DAS, plant height, height to 1st pod, No. of branches/plant, plant weight, No. of pods/plant, No. of seeds/plant, seed yield/plant, biological yield/fed, seed yield/fed, straw yield/fed, phosphors use efficiency, seed N content and seed protein yield/fed in the both seasons. While, Nubaria 3 variety significantly gave the maximum mean values in mid physiological maturity, harvest index and 100-seed weight in the both seasons, respectively. The first order interactions between treatments 30 kg P_2O_5/fed × Zn + Mn, 30 kg P_2O_5/fed × Sakha 4 and Zn + Mn × Sakha 4 as well as the second order interaction between treatments 30 kg P_2O_5/fed × Zn + Mn × Sakha 4 were significantly recorded the maximum seed yield/plant, biological yield/fed, seed yield/fed and straw yield/fed in the both seasons. Therefore, this study recommends that Sakha 4 variety treated by 30 P_2O_5/fed and mixed spraying with Zn 0.3 % + Mn 0.3 % in order to improve the production of faba bean under the condition of Toukh Directorate, Kalyubia Governorate, Egypt.

Keywords: Faba bean varieties, phosphorus fertilization, Zinc, Manganese.

Introduction

Faba bean (*Vicia faba* L.) is the most important legume crop for human and livestock in Egypt. It makes an important contribution to the diet of people in many countries. It represents a very interesting class of food crops due to its high protein content (30 %). It can grow successfully in different soil types and it increases soil fertility. World average cultivated area of faba bean reached 6136193 fed in 2019; the total production was 5431503 tonnes, with an average productivity of 885 kg/fed. In Egypt, Egyptian statistics indicates decreasing of faba bean cultivated area from 333757 fed in 2001 year to about 66248 fed in 2019, with decreasing percent of about 80.15 % that lead to a decrease in faba bean production from 439480 tonnes in 2001 to about 95789 tonnes in 2019, with decreasing percent by about 78.20 % in 2019 comparing with 2001 (**http://www.fao.org/faostat**).

Phosphorus is one of the major essential elements in plant life. These unique properties of phosphate produce water-stable anhydrides and esters that are important in energy storage and transfer in plant biochemical processes. Most notable are adenosine diphosphate and triphosphate (ADP and ATP). Energy is released when a terminal phosphate is split from ADP or ATP. The transfer of phosphate molecules to ATP from energy-transforming processes and from ATP to energy-requiring processes in the plants is known as phosphorylation. A portion of the energy derived from photosynthesis is conserved by phosphorylation of ADP to yield ATP in a process called photophosphorylation. Energy released during respiration is similarly harnessed in a process called oxidative phosphorylation. Beyond their role in energy-transferring processes, phosphate bonds serve as important linkage groups. Phosphate is a structural component of phospholipids, nucleic acids,

nucleotides, coenzymes, and phosphoproteins. Phospholipids are important in membrane structure. Nucleic acids of genes and chromosomes carry genetic material from cell to cell. As a monoester, phosphorus provides an essential ligand in enzymatic catalysis. Phytic acid, the hexaphosphate ester of *myo*-inositol phosphate, is the most common phosphorus reserve in seeds **(Barker and Pilbeam, 2006 and Bakhsh *et al.* 2008)**.

Several investigations reported that increasing phosphorus rates caused significant increase in most vegetative growth, yield components, yield and seed chemical properties traits of faba bean except, No. of days from planting to 50 % physiological maturity, height to 1st pod and phosphorus use efficiency were significantly decreased (**Weldua *et al.* 2012; Desta *et al.* 2015; Nebiyu *et al.* 2016; Abd AlKader *et al.* 2017; El-Agrodi *et al.* 2017; El-Sobky and Yasin 2017; Ghazi 2017; Kandil *et al.* 2019; Negasa *et al.* 2019 and Yasmin *et al.* 2020).**

Microelements are required in small amounts and they affect directly or indirectly photosynthesis, vital processes in plants such as respiration, protein synthesis and reproduction phase **(Kabata & Pendias 1999 and Epstein & Bloom 2005).**

Zinc acts either as a metal component of enzymes or as a functional, structural, or regulatory cofactor of a large number of enzymes. More than 80 zinc containing proteins have been reported. The rate of protein synthesis and the protein content of zinc deficient plants are drastically reduced. The accumulation of amino acids and amides in these plants demonstrates the importance of zinc for protein synthesis. Zinc is an essential component of RNA polymerase and if the zinc is removed, the enzyme is inactivated. Zinc is also a constituent of ribosomes and is essential for their structural integrity **(Epstein and Bloom, 2005).**

Manganese serves as an activator for enzymes in growth processes. It assists iron in chlorophyll formation. It is part of the system where water is split and oxygen gas is liberated. The splitting of water is an oxidation, namely $2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^-$. The other protein in which manganese is an integral constituent is the manganese-containing superoxide dismutase. This enzyme is widespread in aerobic organisms. The function of this enzyme is to provide protection from free oxygen radicals formed when O_2 receives a single electron. Superoxide dismutase's convert this highly toxic free radical into hydrogen peroxide (H_2O_2) which is subsequently broken down to water **(Epstein and Bloom, 2005)**.

Several investigators reported that significantly increases on most vegetative growth, yield components, yield and seed chemical analysis of faba bean by using microelements foliar spray of Zn and Mn singly or combined (**Weldua *et al.* 2012; Mekkei 2014; Salem *et al.* 2014; Desta *et al.* 2015; Jarecki *et al.*, 2016; El-Agrodi *et al.* 2017; El-Sobky and Yasin 2017; Ghazi 2017; Al-Selawy *et al.* 2018; Mahdy and Ahmed 2018; El-Shafey *et al.* 2019; Al-Shumary 2020 and Nour El-Din *et al.* 2020).**

Varietal differences among faba bean varieties have been reported by many investigators as **Mekkei 2014; Salem *et al.* 2014; Jarecki *et al.*, 2016; Nebiyu *et al.* 2016; Abd AlKader *et al.* 2017; Al-Selawy *et al.* 2018; Mahdy and Ahmed 2018; El-Shafey *et al.* 2019; Kandil *et al.* 2019; Negasa *et al.* 2019; Al-Shumary 2020 and Nour El-Din *et al.* 2020,** they found that significant differences among the test varieties in most faba bean traits

The objectives of the present study are to investigate the effect of three rates of phosphorus fertilization and four treatments of microelements foliar spray and three faba bean varieties and their interactions on vegetative growth, yield components, yield and seed chemical properties of faba bean.

Materials and Methods:

A field experiment was carried out in the Farm of Agricultural Research and the Experimental Center of Faculty of Agriculture at Moshtohor, (Toukh Directorate, Kalyubia Governorate) Benha Univ. Egypt, during the two successive seasons of 2018/2019 and 2019/2020. The objective of this investigation was to study the effect of some phosphorus fertilization rates and microelements spraying treatments on growth vegetative, yield components, yield as well as some seed chemical properties of three faba bean varieties.

The factors under study which arranged in split-split plot in randomized complete block design with three replications.

The main plots were assigned to three phosphorous fertilizer rates (0, 15 and 30 kg P_2o_5/fed). Phosphorus rates were added after ridging and before sowing in form of calcium super phosphate (12.5 % P_2O_5) in both growing seasons.

Four microelements spraying treatments [Tap water (control), Zn 0.6 %, Mn 0.6 % and Zn 0.3 % + Mn 0.3 %] were arranged in the sub-plots. Microelements were repeated three times as foliar spray; the first at 40 days after sowing (DAS) and repeated with 15 days intervals during both seasons in form of Zinc Sulphate ($Zn\ So_4.\ 7\ H_2o$) and Manganese Sulphate ($Mn\ So_4.\ H_2o$) for microelements under study using Gelatine Powder as a wetting agent to be sure that the solution mostly covered the green parts, the spray solution volume was 400 L/fed using a hand operated compressed air. The application was carried out between 02:00 and 04:00 p.m.

The sub-sub plots were occupied with three faba bean varieties *i.e.*, Giza 716, Nubaria 3 and Sakha 4. The variety seeds were obtained from Food Legumes Research Section, Field Crops Research Institute, Agricultural Research Center, Egypt.

Soil samples were taken before faba bean sowing to depth of 0-30 cm for chemical and mechanical analysis of the experimental soil were determined according to the methods of Association of Official Analytical Chemists described in **(A.O.A.C., 2005)** and represented in **Table 1** in each of two growing seasons. Soil texture of the experimental site was clay texture with pH nearly of 8.0.

Table 1. Chemical and mechanical properties of the experimental soil during the 2018/2019 and 2019/2020 seasons.

Properties	Season	
	2018/2019	2019/2020
Chemical analysis		
E.C.	2.26	2.32
pH (1 :2.5)	7.97	7.95
$CaCo_3$ %	2.96	2.90
O.M %	2.23	2.46
N % (total)	0.210	0.223
N (mg/kg) (Exchangeable)	70.31	75.15
P % (total)	0.130	0.159
P (mg/kg) (Exchangeable)	23.49	27.16
K % (total)	0.62	0.63
K (mg/kg) (Exchangeable)	916.46	943.68
Soluble cations and anions (mg/kg)		
Mn^{++}	7.9	9.3
Fe^{++}	10.5	8.8
Zn^{++}	2.3	2.4
Ca^{++}	182.4	187.4
Mg^{++}	48.60	50.58
K^{+}	46.80	52.26
Na^{+}	201.94	204.24
Cl^{-}	231.82	261.64
Co_3^{--}	0.00	0.00
$H\ Co_3^{-}$	357.46	378.20
So_4^{--}	516.48	490.08
Particle size distribution (mechanical analysis)		
Course sand %	7.31	5.43
Find sand %	27.75	24.33
Silt %	14.41	13.52
Clay %	50.53	56.72
Texture grade	**Clay**	**Clay**

The preceding summer crop in the both seasons was maize (*Zea mays* L.). The sub-sub plot area was 10.8 m^2 and contained five ridges of 3.6 m long and 60 cm apart. Faba bean seeds were planted on 6th November in the first season 2018/2019 and 29th October in second season 2019/2020. Faba bean planting was done by the local method of dibbling 2 to 4 seeds in each hill by hand with distance between hills was 15 cm apart and after 35 days of sowing thinning was carried out in order to maintain better two seedlings/hill (93333 plants/fed). Nitrogen fertilizer was applied in form of urea (46 % N), according to the recommended rate 20 kg N/fed at one dose before the first irrigation in each season. The normal cultural practices for growing faba bean plants were done as recommended.

Characters studied:

1- Chlorophyll content index (CCI) at 85 days after sowing, three plants in three different ridges were randomly selected, and chlorophyll content index (CCI) of upper, middle and lower leaves was measured by a Minolta Chlorophyll Meter SPAD-502 (MINOLTA CO., LTD. JAPAN).

2- Number of days to 50 % physiological maturity (days).

At harvest, random sample of ten guarded plants from each sub-sub plots in the both seasons was taken to determine the following measurements:

3- Plant height (cm).

4- Height to first pod (cm).

5- Number of branches/plant on the main stem.

6- Plant weight (g).

7- Number of pods/plant.

8- Number of seed plant.

9- Seed yield/plant (g).

10- Harvest index (%), it was calculated by using the following formula:

Harvest index (%) = (Seed yield/plant / plant weight) × 100.

The whole faba bean plants of three middle ridges of each sub-sub plots have been used for estimating of

11- Weight of 100-seed (g).

12- Biological yield/fed (kg).

13- Seed yield/fed (kg), it was calculated by using the following formula:

Seed yield/fed = (biological yield/fed × harvest index)/100.

14- Straw yield/fed (kg), it was calculated by using the following formula:

Straw yield/fed = biological yield/fed - seed yield/fed.

15- Phosphorus use efficiency (kg grain/kg P_2O_5 applied) was calculated according to **Fageria and Barbosa (2007)** as follows:

$$\mathbf{PUE} = \frac{\textbf{Seed yield of treatment (kg/fed)} - \textbf{Seed yield of control (kg/fed)}}{\textbf{Phosphorus applied (kg/fed)}}$$

Seeds samples were taken after harvest at random from each seeds of ten plants to determine some seed chimerical properties in Agricultural Analyses and Consultations Center (Project No. CP4-092-BEN) of Faculty of Agriculture at Moshtohor, Benha university, Egypt to estimate:

16- Seed nitrogen content according to the modified micro Kjeldahl method was determined according to the methods of Association of Official Analytical Chemists described in **(A. O. A. C., 2005)**.

17- Seed protein yield/fed (kg), it was calculated by using the following formula

Seed protein yield/fed = (seed yield/fed × seed N content × 6.25)/100.

18- Seed P content.

19- Seed Zn content (mg/kg).

20- Seed Mn content (mg/kg).

Phosphorus was determined colorimetrically was measured by flame-photometer. However, Zn and Mn determined by Atomic Absorption Spectrophotometer (Perkin-Elmer 2380) according to the methods described in **(A. O. A. C., 2005)**.

Statistical analysis:

The analysis of variance was carried out according to the procedure described by **Gomez and Gomez (1984).** Data were statistically analyzed according to using the MSTAT-C Statistical Software Package **(Freed, 1991).** Where the F-test showed significant differences among means L. S. D. test at 0.05 level was used to compare between means.

Results and Discussion:

1- Effect of phosphorus fertilization rates:

Results in **Tables 2, 3, 4 and 5** indicated that increasing phosphorus fertilization rates from 0 up to 30 kg P_2O_5/fed caused significant increments in most vegetative growth, yield attributes, yield and seed chemical properties of faba bean under study except, No. of days from planting to 50 % physiological maturity, height to 1st pod and phosphorus use efficiency were significantly decreased with rising phosphorus fertilization rates during 2018/2019 and 2019/2020 seasons. Meanwhile, seed N content, seed Zn content and seed Mn content were not significantly affected in the both seasons. But, the differences between phosphorus fertilization rates at 15 and 30 kg P_2O_5/fed on mid physiological maturity, plant height, No. of branches/plant, No. of pods/plant and 100-seed weight in the both seasons as well as biological yield/fed, seed yield/fed and straw yield/fed in the first season in addition to seed P content in second season were not significant.

Faba bean plants treated with 30 kg P_2O_5/fed recorded significantly the maximum chlorophyll content index at 85 DAS (35.84 and 40.56), plant height (91.15 and 105.68 cm), No. of branches/plant (3.170 and 4.149), plant weight (48.61 and 94.62 g), No. of pods/plant (7.885 and 13.183), No. of seeds/plant (26.08 and 47.04), seed yield/plant (20.43 and 41.77 g), harvest index (41.58 and 43.89 %), 100-seed weight (77.90 and 88.54 g), biological yield/fed (2100.3 and 3532.1 kg), seed yield/fed (881.8 and 1565.3 kg), straw yield/fed (1218.6 and 1966.8 kg), seed protein yield/fed (198.63 and 367.27 kg) and seed P content (0.607 and 0.624 %) as well as recorded significantly the shortest period from planting to 50 % physiological maturity (132.14 and 134.33 days) as well as gave lower position of the 1st pod (17.09 and 21.05 cm) in the both seasons, respectively.

The superiority rations in the first season between 30 kg P_2O_5/fed and each of 0 and 15 kg P_2O_5/fed were 4.00 and 16.63 % for chlorophyll content index; 12.05 and 108.28 % for No. of branches/plant; 16.01 and 78.58 % for plant weight; 11.28 and 70.56 % for No. of pods/plant; 15.14 and 78.14 % for No. of seeds/plant; 6.99 and 40.85 % for biological yield/fed; 9.12 and 52.85 % for seed yield/fed; 5.52 and 33.27 % for straw yield/fed; 11.47 and 70.05 % for seed protein yield/fed in addition to 6.68 and 58.90 % for seed P content, respectively. The increases rations in the second season when faba bean treated with 30 kg P_2O_5/fed over each of 0 and 15 kg P_2O_5/fed were 6.07 and 20.32 % for chlorophyll content index; 13.06 and 90.63 % for No. of branches/plant; 11.66 and 61.80 % for plant weight; 9.68 and 56.09 % for No. of pods/plant; 11.92 and 62.99 % for No. of seeds/plant; 8.23 and 40.47 % for biological yield/fed; 10.49 and 54.95 % for seed yield/fed; 6.50 and 30.75 % for straw yield/fed; 14.11 and 71.78 % for seed protein yield/fed in addition to 1.46 and 34.19 % for seed P content, respectively. The maximum phosphorus use efficiency was recorded from faba bean treated with 15 kg P_2O_5/fed being 15.42 and 27.10 kg seed/kg P_2O_5 applied in the both seasons respectively.

Such results stated the vital role of phosphorus fertilization in improving the productivity of faba bean. The superiority of phosphorus application as 30 kg P_2O_5/fed on seed yield/fed may be due to its good effect on chlorophyll content index, plant height, No. of branches/plant, plant weight, No. of pods/plant, No. of seeds/plant, seed yield/plant, harvest index, 100-seed weight and biological yield/fed as well as recorded lower position of the 1st pod during the both seasons. These results are in harmony with those obtained by **Weldua *et al.* 2012; Desta *et al.* 2015; Nebiyu *et al.* 2016; Abd AlKader *et al.* 2017; El-Agrodi *et al.* 2017; El-Sobky and Yasin 2017; Ghazi 2017; Kandil *et al.* 2019; Negasa *et al.* 2019 and Yasmin *et al.* 2020.**

2- Effect of foliar spray by microelements treatments:

Results presented in **Tables 2, 3, 4 and 5** indicated that most vegetative growth, yield components, yield and seed chemical analysis of faba bean in the both seasons were significant increased by microelements foliar spray using Zn and Mn singly or combined over the control treatment (Tap water) except, height to 1st pod was significantly decreased in 2018/2019 and 2019/2020 seasons. Meanwhile, No. of branches/plant, seed N content and seed P content were not significant. But, the differences between foliar spray by singly Zn and Zn in combination with Mn on most traits were not significant in the both seasons.

Faba bean plants treated with microelements foliar spray using Zn + Mn was the most effective treatment and significantly produced the maximum plant height (92.42 and 108.54 cm), plant weight (46.21 and 89.49 g), No. of pods/plant (7.518 and 12.619), No. of seeds/plant (24.70 and 44.78), seed yield/plant (19.52 and 39.71 g), harvest index (41.64

and 43.85 %), 100-seed weight (77.95 and 87.96 g), biological yield/fed (2134.2 and 3521.3 kg), seed yield/fed (897.9 and 1561.1 kg), straw yield/fed (1236.3 and 1960.2 kg), phosphors use efficiency (14.75 and 27.13 kg seed/kg P_2O_5 applied) and seed protein yield/fed (196.98 and 355.38 kg) as well as gave significantly lower position of the 1st pod (17.90 and 21.46 cm) in the both seasons, respectively. Meanwhile, faba bean plants treated with foliar spray by singly Zn recorded the longest period from planting to mid physiological maturity (135.11 and 138.33 days) in addition to recorded the highest seed Zn content (113.02 and 122.31 mg/kg) in the both seasons, respectively.

The maximum chlorophyll content index at 85 DAS (35.74 and 39.73) and seed Mn content (35.10 and 41.06 mg/kg) in the both seasons, respectively were obtained from faba bean plants treated with foliar spray by singly Mn.

In the first season the superiority rations when using microelements foliar spray of Mn, Zn or Zn + Mn over the control treatment (tap water) were 13.64, 5.25 and 9.44 % for chlorophyll content index; 35.52, 49.10 and 60.45 % for plant weight; 35.33, 45.73 and 53.96 % for No. of pods/plant; 36.34, 48.97 and 59.15 % for No. of seeds/plant; 34.10, 46.87 and 54.23 % for biological yield/fed; 41.20, 57.22 and 68.40 % for seed yield/fed; 29.63, 40.37 and 45.33 % for straw yield/fed; 14.90, 32.95 and 40.88 % for phosphorus use efficiency; 47.34, 70.11 and 78.29 % for seed protein yield/fed; 4.72, 21.71 and 12.04 % for seed Zn content in addition to 73.68, 14.65 and 40.28 % for seed Mn content, respectively. The increases rations in the second season when faba bean treated with Mn, Zn or Zn + Mn over the control were 13.35, 5.65 and 8.96 % for chlorophyll content index; 17.44, 27.55 and 35.63 % for plant weight; 21.21, 31.09 and 37.87 % for No. of pods/plant; 22.05, 33.24 and 41.48 % for No. of seeds/plant; 27.89, 38.45 and 45.07 % for biological yield/fed; 38.46, 52.94 and 62.43 % for seed yield/fed; 20.96, 28.95 and 33.69 % for straw yield/fed; 60.08, 79.42 and 86.08 % for phosphorus use efficiency; 42.35, 63.35 and 69.92 % for seed protein yield/fed; 4.11, 19.88 and 12.11 % for seed Zn content in addition to 59.46, 13.59 and 33.09 % for seed Mn content, respectively.

The increase in vegetative, yield components, yield and seed chemical properties of faba bean with the application of microelements especially Zn + Mn treatment may be due to the synergetic role of microelements in improving directly or indirectly photosynthesis, vital processes in plant such as respiration, protein synthesis, reproduction phase, biochemical and physiological activities.

The superiority of microelements application as mixed Zn + Mn on seed yield/fed may be due to its good effect on plant height, plant weight, No. of pods/plant, No. of seeds/plant, seed yield/plant, harvest index, 100-seed weight and biological yield/fed in addition to lower position of the 1st pod.

Many investigators came out with similar results as **Mekkei 2014; Jarecki *et al.*, 2016; El-Sobky and Yasin 2017; Al-Selawy *et al.* 2018; Mahdy and Ahmed 2018; El-Shafey *et al.* 2019; Al-Shumary 2020 and Nour El-Din *et al.* 2020** who found that foliar spray with mixed between Zn and Mn gave the best traits of faba bean.

3- Faba bean varieties performance:

Mean performances of the investigated faba bean varieties (Giza 716, Nubaria 3 and Sakha 4) for most vegetative growth, yield components, yield and seed chemical analysis of faba bean under study were significant affected except, seed P content, seed Zn content and seed Mn content during 2018/2019 and 2019/2020 seasons as shown in **Tables 2, 3, 4 and 5**. The differences in mid physiological maturity between Sakha 4 and Giza 716 as well as among Nubaria 3 and Giza 716 on phosphorus use efficiency did not reach the level of significance only in the first season.

Results may reveal the superiority of Sakha 4 variety in chlorophyll content index at 85 DAS (37.23 and 41.20), plant height (100.38 and 111.53 cm), height to 1st pod (23.42 and 27.40 cm), No. of branches/plant (2.993 and 3.839), plant weight (51.84 and 97.93 g), No. of pods/plant (8.168 and 13.338), No. of seeds/plant (28.33 and 49.63), seed yield/plant (21.26 and 41.93 g), biological yield/fed (2396.7 and 3901.5 kg), seed yield/fed (979.1 and 1671.3 kg), straw yield/fed (1417.6 and 2230.2 kg), phosphors use efficiency (14.40 and 30.42 kg seed/kg P_2O_5 applied), seed N content (3.612 and 3.798 %) and seed protein yield/fed (223.32 and 401.30 kg) in the both seasons, respectively.

In the first season the superiority ratios between faba bean variety of Sakha 4 over each of Giza 716 and Nubaria 3 were 25.14 and 9.31 % for chlorophyll content index; 28.82 and 15.55 % for plant height; 37.36 and 10.84 % for height to 1st pod; 53.09 and 16.32 % for No. of branches/plant; 38.20 and 82.66 % for plant weight; 23.89 and 69.00 % for No. of pods/plant; 45.73 and 81.49 % for No. of seeds/plant; 34.41 and 74.32 % for biological yield/fed; 28.47 and 86.32 % for seed yield/fed; 38.86 and 66.89 % for straw yield/fed in addition to 45.06 and 91.92 % for seed protein yield/fed, respectively. The excess ratios in the second season when faba bean planting variety of Nubaria 3 over each of Giza 716 and Sakha 4 were 20.68 and 10.87 % for chlorophyll content index; 16.61 and 10.64 % for plant height; 38.95 and 7.75 % for height to 1st pod; 40.21 and 13.92 % for No. of branches/plant; 27.65 and 54.98 % for plant weight; 16.94 and 49.78 % for No. of pods/plant; 33.95 and 58.82 % for No. of seeds/plant; 27.10 and 66.82 % for biological yield/fed; 20.72 and 78.50 % for seed yield/fed; 32.34 and 59.02 % for straw yield/fed in addition to 40.64 and 85.55 % for seed protein yield/fed, respectively.

Table 2. Mean values of chlorophyll content index at 85 DAS, days to 50 % physiological maturity, plant height, height to 1st pod and No. of branches/plant as affected by phosphorus fertilization rates, foliar spray by some microelements and varieties of faba bean during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Chlorophyll content index at 85 DAS		Days to 50 % physiological maturity (days)		Plant height (cm)		Height to 1st pod (cm)		No. of branches/plant	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Phosphorus fertilization rates (P)											
0		30.73	33.71	135.45	139.78	84.60	98.36	25.46	27.85	1.522	2.166
15 kg P_2O_5/fed		34.46	38.24	133.53	136.31	89.41	103.93	19.07	23.65	2.829	3.652
30 kg P_2O_5/fed		35.84	40.56	132.14	134.33	91.15	105.68	17.09	21.05	3.170	4.129
L.S.D at 5%		**1.05**	**1.32**	**1.81**	**2.25**	**2.87**	**3.52**	**1.45**	**1.53**	**0.536**	**0.623**
Microelements (M)											
Control (Tap water)		31.45	35.05	131.89	134.41	83.03	96.59	23.52	27.33	2.403	3.180
Zn		33.10	37.03	135.11	138.33	90.20	104.91	19.54	23.30	2.541	3.364
Mn		35.74	39.73	133.52	136.92	87.90	100.60	21.18	24.63	2.496	3.279
Zn + Mn		34.42	38.19	134.30	137.56	92.42	108.54	17.90	21.46	2.588	3.439
L.S.D at 5%		**0.87**	**0.96**	**1.61**	**1.75**	**2.11**	**2.35**	**1.25**	**1.29**	**N.S.**	**N.S.**
Faba bean varieties (V)											
Giza 716		34.06	37.16	132.31	134.56	86.87	100.80	21.13	25.43	2.573	3.370
Nubaria 3		29.75	34.14	135.31	139.14	77.92	95.64	17.05	19.72	1.955	2.738
Sakha 4		37.23	41.20	133.50	136.72	100.38	111.53	23.42	27.40	2.993	3.839
L.S.D at 5%		**0.65**	**0.89**	**1.21**	**1.36**	**1.98**	**2.15**	**1.02**	**1.11**	**0.315**	**0.383**
F test Prob.	**P × M**	**	**	**	**	**	**	**	**	**N.S.**	**N.S.**
	P × V	**	**	**N.S.**	**N.S.**	**	**	**	**	**	**
	M × V	**	**	**N.S.**	**N.S.**	**	**	**N.S.**	**N.S.**	**N.S.**	**N.S.**
	P × M × V	**	**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**

**** Significant and N.S. No significant**

Table 3. Mean values of plant weight, No. of pods/plant, No. of seeds/plant, seed yield/plant and harvest index as affected by phosphorus fertilization rates, foliar spray by some microelements and varieties of faba bean during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Plant weight (g)		No. of pods/plant		No. of seeds/plant		Seed yield/plant (g)		Harvest index (%)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Phosphorus fertilization rates (P)											
0		27.22	58.48	4.623	8.446	14.64	28.86	10.53	23.52	38.21	39.77
15 kg P_2O_5/fed		41.90	84.74	7.086	12.020	22.65	42.03	17.27	36.67	40.78	42.92
30 kg P_2O_5/fed		48.61	94.62	7.885	13.183	26.08	47.04	20.43	41.77	41.58	43.89
L.S.D at 5%		**5.32**	**7.65**	**1.575**	**1.636**	**2.98**	**3.25**	**2.57**	**2.98**	**0.69**	**0.73**
Microelements (M)											
Control (Tap water)		28.80	65.98	4.883	9.153	15.52	31.65	11.12	26.20	38.14	39.22
Zn		42.94	84.16	7.116	11.999	23.12	42.17	17.78	36.82	40.85	43.26
Mn		39.03	77.49	6.608	11.094	21.16	38.63	15.89	33.21	40.13	42.45
Zn + Mn		46.21	89.49	7.518	12.619	24.70	44.78	19.52	39.71	41.64	43.85
L.S.D at 5%		**4.62**	**5.88**	**1.354**	**1.621**	**2.53**	**3.16**	**2.38**	**2.72**	**0.63**	**0.72**
Faba bean varieties (V)											
Giza 716		28.38	63.19	4.833	8.905	15.61	31.25	10.88	25.41	37.78	39.65
Nubaria 3		37.51	76.72	6.593	11.406	19.44	37.05	16.10	34.62	42.29	44.50
Sakha 4		51.84	97.93	8.168	13.338	28.33	49.63	21.26	41.93	40.51	42.43
L.S.D at 5%		**4.21**	**4.98**	**1.258**	**1.435**	**2.44**	**2.84**	**2.19**	**2.48**	**0.61**	**0.69**
F test Prob.	**P × M**	**	**	**N.S.**	**N.S.**	**	**	**	**	**	**
	P × V	**	**	**	**	**	**	**	**	**	**
	M × V	**	**	**N.S.**	**N.S.**	**	**	**	**	**N.S.**	**N.S.**
	P × M × V	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**	**	**	**	**N.S.**	**N.S.**

**** Significant and N.S. No significant**

Table 4. Mean values of 100-seed weight, biological yield/fed, seed yield/fed, straw yield/fed and phosphorus use efficiency as affected by phosphorus fertilization rates, foliar spray by some microelements and varieties of faba bean during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	100-seed weight (g)		Biological yield (kg/fed)		Seed yield (kg/fed)		Straw yield (kg/fed)		Phosphorus use efficiency	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Phosphorus fertilization rates (P)											
0		70.83	81.20	1491.2	2514.4	576.9	1010.2	914.4	1504.2	--	--
15 kg P_2O_5/fed		75.46	86.84	1963.0	3263.5	808.1	1416.7	1154.9	1846.8	15.42	27.10
30 kg P_2O_5/fed		77.90	88.54	2100.3	3532.1	881.8	1565.3	1218.6	1966.8	10.16	18.50
L.S.D at 5%		**3.11**	**3.56**	**156.8**	**176.5**	**84.6**	**95.7**	**91.5**	**103.4**	**2.23**	**2.57**
Microelements (M)											
Control (Tap water)		70.51	82.14	1383.8	2427.3	533.2	961.1	850.7	1466.2	10.47	14.58
Zn		76.07	86.60	2032.4	3360.5	838.3	1469.9	1194.1	1890.6	13.92	26.16
Mn		74.38	85.39	1855.7	3104.2	752.9	1330.7	1102.8	1773.5	12.03	23.34
Zn + Mn		77.95	87.96	2134.2	3521.3	897.9	1561.1	1236.3	1960.2	14.75	27.13
L.S.D at 5%		**2.63**	**2.83**	**136.7**	**158.7**	**76.8**	**87.9**	**79.6**	**87.8**	**2.11**	**2.99**
Faba bean varieties (V)											
Giza 716		68.49	80.35	1374.9	2338.8	525.5	936.3	849.4	1402.5	12.24	11.98
Nubaria 3		81.50	92.61	1783.1	3069.7	762.1	1384.5	1020.9	1685.2	11.73	26.01
Sakha 4		74.19	83.61	2396.7	3901.5	979.1	1671.3	1417.6	2230.2	14.40	30.42
L.S.D at 5%		**2.54**	**2.69**	**125.4**	**145.9**	**71.6**	**75.4**	**69.8**	**81.7**	**1.98**	**2.54**
F test Prob.	**P × M**	**N.S.**	**N.S.**	**	**	**	**	**	**	**	**
	P × V	**	**	**	**	**	**	**	**	**N.S.**	**N.S.**
	M × V	**	**	**	**	**	**	**	**	**N.S.**	**N.S.**
	P × M × V	**N.S.**	**N.S.**	**	**	**	**	**	**	**N.S.**	**N.S.**

**** Significant and N.S. No significant**

Table 5. Mean values of seed N content, seed protein yield/fed, seed P content , seed Zn content and seed Mn content as affected by phosphorus fertilization rates, foliar spray by some microelements and varieties of faba bean during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Seed N content (%)		Seed protein yield (kg/fed)		Seed P content (%)		Seed Zn content (mg/kg)		Seed Mn content (mg/kg)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Phosphorus fertilization rates (P)											
0		3.214	3.366	116.81	213.80	0.382	0.465	100.60	110.38	26.26	32.02
15 kg P_2O_5/fed		3.500	3.616	178.19	321.85	0.569	0.615	101.53	111.11	26.68	32.60
30 kg P_2O_5/fed		3.574	3.732	198.63	367.27	0.607	0.624	103.24	112.22	27.17	33.12
L.S.D at 5%		**N.S.**	**N.S.**	**9.25**	**11.67**	**0.028**	**0.031**	**N.S.**	**N.S.**	**N.S.**	**N.S.**
Microelements (M)											
Control (Tap water)		3.269	3.442	110.48	209.15	0.507	0.552	92.86	102.03	20.21	25.75
Zn		3.551	3.691	187.94	341.65	0.524	0.577	113.02	122.31	23.17	29.25
Mn		3.423	3.538	162.78	297.72	0.515	0.571	97.24	106.22	35.10	41.06
Zn + Mn		3.475	3.614	196.98	355.38	0.531	0.572	104.04	114.39	28.35	34.27
L.S.D at 5%		**N.S.**	**N.S.**	**7.84**	**10.91**	**N.S.**	**N.S.**	**4.88**	**5.11**	**3.76**	**4.22**
Faba bean varieties (V)											
Giza 716		3.490	3.653	116.36	216.28	0.519	0.567	99.61	108.47	25.64	31.01
Nubaria 3		3.185	3.263	153.95	285.34	0.557	0.599	100.89	111.07	26.67	32.95
Sakha 4		3.612	3.798	223.32	401.30	0.482	0.538	104.87	114.17	27.80	33.79
L.S.D at 5%		**0.115**	**0.136**	**6.35**	**7.83**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**
F test Prob.	**P × M**	**N.S.**	**N.S.**	**	**	**	**	**	**	**	**
	P × V	**N.S.**	**N.S.**	**	**	**	**	**N.S.**	**N.S.**	**N.S.**	**N.S.**
	M × V	**N.S.**	**N.S.**	**	**	**N.S.**	**N.S.**	**	**	**	**
	P × M × V	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**

**** Significant and N.S. No significant**

Nubaria 3 variety significantly produced the maximum days to 50 % physiological maturity (135.31 and 139.14 days), harvest index (42.29 and 44.50 %) and 100-seed weight (81.50 and 92.61 g) in the both seasons, respectively.

The superiority ratios in the first season between faba bean variety of Nubaria 3 over each of Sakha 4 and Giza 716 were 4.39 and 11.94 % for harvest in addition to 9.85 and 19.00 % for 100-seed weight, respectively. In the second season, the excess ratios when planting faba bean variety of Nubaria 3 over each of Sakha 4 and Giza 716 varieties were 4.88 and 12.23 % for harvest index in addition to 10.76 and 15.26 % for 100-seed weight, respectively.

The shortest period from planting to 50 % physiological maturity (132.31 and 134.56 days) was achieved by plant of Giza 716 variety during the both seasons, respectively.

These differences may be due to the genetic differences between faba bean varieties. Also, It could be concluded that faba bean variety of Sakha 4 surpassed the other faba bean varieties to increase seed yield/fed may be due to more likely attributed to the increases in chlorophyll content index, No. of pods/plant, No. of seeds/plant and seed yield/plant. These results are in agreement with those obtained by **Abd AlKader *et al*. 2017; Al-Selawy *et al*. 2018; Mahdy and Ahmed 2018; El-Shafey *et al*. 2019; Kandil *et al.* 2019; Negasa *et al.* 2019; Al-Shumary 2020 and Nour El-Din *et al.* 2020,** who reported marked differences in most vegetative growth, yield components, yield and seed chemical analysis among faba bean varieties**.**

4- Effect of the interaction between phosphorus fertilization rates and foliar spray by microelements treatments:

Results in **Tables 6, 7 and 8** showed that the interaction effect between phosphorus fertilization rates (0, 15 and 30 kg P_2O_5/fed) and microelements foliar spray treatments (tap water, Zn, Mn and Zn + MN) induced significant differences on most vegetative growth, yield components, yield and seed chemical analysis of faba bean in the both seasons. While, No. of branches/plant, No. of pods/plant, 100-seed weight and seed N content were insignificantly affected by the interaction during the two seasons, as shown in **Tables 2, 3, 4 and 5**.

Faba bean plants treated with 30 P_2O_5/fed and foliar application with Zn + Mn recorded the maximum plant height (95.22 and 111.16 cm), plant weight (58.27 and 107.57 g), No. of seeds/plant (30.99 and 53.87), seed yield/plant (25.21 and 49.06 g), harvest index (43.04 and 45.51 %), biological yield/fed (2430.7 and 3954.4 kg), seed yield/fed (1051.0 and 1807.9 kg), straw yield/fed (1379.8 and 2146.5 kg), seed protein yield/fed (238.97 and 426.51 kg) and seed P content (0.616 and 0.632 %) as well as gave significantly lower position of the 1st pod (14.30 and 19.07 cm) in the both seasons, respectively. On the other hand, the minimum chlorophyll content index at 85 DAS (27.77 and 30.39), plant height (79.39 and 91.44 cm), plant weight (19.09 and 46.15 g), No. of seeds/plant (1060 and 22.23), seed yield/plant (7.04 and 17.29 g), harvest index (36.56 and 37.38 %), biological yield/fed (1049.9 and 2006.9 kg), seed yield/fed (387.01 and 751.2 kg), straw yield/fed (662.8 and 1255.8 kg), seed protein yield/fed (74.96 and 152.95 kg), seed P content (0.374 and 0.454 %), seed Zn content (92.00 and 101.21 mg/kg) and seed Mn content (20.00 and 25.29 mg/kg) in addition to higher position of the 1st pod (28.89 and 31.94 cm) were obtained from faba bean plants under without adding phosphorus fertilization or microelements (tap water) in the both seasons, respectively.

The shortest period from sowing to 50 % physiological maturity (130.78 and 132.78 days) were recorded from faba bean treated with 30 kg P_2O_5/fed and without microelements application (tap water) in the both seasons respectively. On the other hand, the longest period from sowing to 50 % physiological maturity (137.22 and 141.55 days) was recorded from faba bean plants under without phosphorus added and foliar application with zinc in the both seasons respectively.

The maximum phosphorus use efficiency (17.47 and 33.54 kg seed/kg P_2O_5 applied) was recorded from faba bean treated with 15 kg P_2O_5/fed and foliar application with Zn + Mn in the both seasons respectively. On the other hand, the minimum mean values of phosphorus use efficiency (8.29 and 12.83 kg seed/kg P_2O_5 applied) were obtained from faba bean treated with 30 kg P_2O_5/fed and without microelements application (tap water) in the both seasons respectively.

Faba bean plants treated with 30 kg P_2O_5/fed and foliar spray by singly Zn recorded the highest seed Zn content (116.38 and 123.92 mg/kg), while with the same rate of phosphorus fertilization with foliar spray by singly Mn recorded the maximum chlorophyll content index at 85 DAS (37.66 and 42.40) and seed Mn content (35.85 and 41.90 mg/kg) in the both seasons, respectively. The results reported here are in harmony with those obtained **Weldua *et al*. 2012; Desta *et al*. 2015; El-Agrodi *et al*. 2017; El-Sobky and Yasin 2017 and Ghazi 2017**, who reported marked differences in mean values of most faba bean traits as affected by the interaction between phosphorus and microelements.

Table 6. Mean values of chlorophyll content index at 85 DAS, days to 50 % physiological maturity, plant height, height to 1st pod and plant weight of faba bean as affected by the interaction between phosphorus fertilization rates and foliar spray by some microelements during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Chlorophyll content index at 85 DAS		Days to 50 % physiological maturity (days)		Plant height (cm)		Height to 1st pod (cm)		Plant weight (g)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Control	27.77	30.39	133.22	136.78	79.39	91.44	28.89	31.94	19.09	46.15
	Zn	29.88	32.92	137.22	141.55	86.42	101.14	24.14	26.40	30.08	62.25
	Mn	33.45	36.92	135.00	139.89	84.22	96.96	26.47	28.67	27.71	58.91
	Zn + Mn	31.80	34.61	136.33	140.89	88.38	103.91	22.32	24.37	32.01	66.59
15	Control	32.14	36.00	131.67	133.67	83.50	97.85	21.60	26.61	31.64	70.63
	Zn	34.25	38.08	134.67	137.78	91.52	106.86	18.24	23.03	46.76	90.05
	Mn	36.12	39.87	133.67	136.78	88.96	100.47	19.35	24.01	40.86	83.98
	Zn + Mn	35.34	38.99	134.11	137.00	93.64	110.55	17.07	20.94	48.33	94.30
30	Control	34.43	38.77	130.78	132.78	86.21	100.48	20.07	23.44	35.69	81.14
	Zn	35.17	40.10	133.44	135.67	92.65	106.74	16.24	20.46	51.96	100.17
	Mn	37.66	42.40	131.89	134.11	90.52	104.36	17.74	21.22	48.51	89.58
	Zn + Mn	36.12	40.98	132.45	134.78	95.22	111.16	14.30	19.07	58.27	107.57
L.S.D at 5%		**1.51**	**1.66**	**2.79**	**3.03**	**3.66**	**4.07**	**2.17**	**2.23**	**8.00**	**10.18**

Table 7. Mean values in No. of seeds/plant, seed yield/plant, harvest index, biological yield/fed and seed yield/fed of faba bean as affected by the interaction between phosphorus fertilization rates and foliar spray by some microelements during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	No. of seeds/plant		Seed yield/plant (g)		Harvest index (%)		Biological yield (kg/fed)		Seed yield (kg/fed)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Control	10.60	22.23	7.04	17.29	36.56	37.38	1049.9	2006.9	387.1	751.2
	Zn	16.05	30.97	11.76	25.48	38.84	40.64	1654.3	2692.6	647.0	1101.2
	Mn	14.78	29.30	10.60	23.67	38.00	39.86	1523.9	2495.1	583.0	1002.1
	Zn + Mn	17.14	32.92	12.73	27.63	39.44	41.20	1736.8	2862.7	690.3	1186.2
15	Control	17.25	33.66	12.20	27.92	38.45	39.34	1495.6	2516.0	576.7	996.2
	Zn	25.16	45.15	19.50	39.96	41.47	44.26	2182.4	3520.2	908.3	1564.5
	Mn	22.23	41.75	16.77	36.34	40.77	43.26	1939.0	3271.0	795.0	1416.8
	Zn + Mn	25.98	47.55	20.62	42.45	42.44	44.84	2235.1	3746.7	952.3	1689.2
30	Control	18.71	39.06	14.13	33.39	39.41	40.94	1606.0	2758.9	635.7	1135.9
	Zn	28.15	50.39	22.06	45.02	42.25	44.87	2260.5	3868.7	959.5	1744.1
	Mn	26.46	44.84	20.31	39.63	41.61	44.22	2104.2	3546.4	880.8	1573.2
	Zn + Mn	30.99	53.87	25.21	49.06	43.04	45.51	2430.7	3954.4	1051.0	1807.9
L.S.D at 5%		**4.38**	**5.47**	**4.12**	**4.71**	**1.09**	**1.25**	**236.8**	**274.9**	**133.0**	**152.2**

Table 8. Mean values of straw yield/fed, phosphorus use efficiency, seed protein yield/fed, seed P content , seed Zn content and seed Mn content of faba bean as affected by the interaction between phosphorus fertilization rates and foliar spray by some microelements during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Straw yield (kg/fed)		Phosphorus use efficiency		Seed protein yield (kg/fed)		Seed P content (%)		Seed Zn content (mg/kg)		Seed Mn content (mg/kg)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Control	662.8	1255.8	--	--	74.96	152.95	0.374	0.454	92.00	101.21	20.00	25.29
	Zn	1007.3	1591.4	--	--	135.06	240.57	0.385	0.468	110.61	121.08	22.86	28.77
	Mn	940.9	1493.1	--	--	116.74	209.19	0.372	0.464	96.43	105.52	34.36	40.19
	Zn + Mn	1046.5	1676.6	--	--	140.47	252.50	0.395	0.475	103.36	113.71	27.84	33.85
15	Control	919.0	1519.9	12.64	16.33	121.07	217.72	0.552	0.587	92.87	101.93	20.22	25.77
	Zn	1274.0	1955.7	17.42	30.88	206.00	365.67	0.576	0.635	112.05	121.93	23.10	29.26
	Mn	1144.0	1854.1	14.13	27.65	174.20	316.89	0.569	0.628	97.23	106.21	35.08	41.10
	Zn + Mn	1282.8	2057.5	17.47	33.54	211.49	387.13	0.581	0.609	103.95	114.38	28.33	34.29
30	Control	970.2	1623.0	8.29	12.83	135.41	256.78	0.595	0.615	93.70	102.94	20.40	26.20
	Zn	1300.9	2124.6	10.42	21.43	222.76	418.70	0.612	0.626	116.38	123.92	23.54	29.73
	Mn	1223.4	1973.2	9.93	19.04	197.39	367.07	0.605	0.621	98.07	106.93	35.85	41.90
	Zn + Mn	1379.8	2146.5	12.02	20.72	238.97	426.51	0.616	0.632	104.80	115.07	28.88	34.66
L.S.D at 5%		**4.40**	**4.66**	**2.98**	**4.23**	**13.58**	**18.90**	**0.043**	**0.047**	**8.45**	**8.85**	**6.51**	**7.31**

5- Effect of the interaction between phosphorus fertilization rates and faba bean varieties:

Interaction effect between phosphorus fertilization rates (0, 15 and 30 kg P_2O_5/fed) and faba bean varieties (Giza 716, Nubaria 3 and Sakha 4) was significant on most vegetative growth, yield components, yield and seed chemical analysis in 2018/2019 and 2019/2020 seasons, as shown in **Tables 9, 10 and 11.** Meanwhile, days to 50 % physiological maturity, phosphorus use efficiency, seed N content, seed Zn content and seed Mn content were insignificantly affected by the interaction in the two growing seasons, as shown in as shown in **Tables 2, 4 and 5.**

Sakha 4 variety treated with 30 kg P_2O_5/fed gave the greatest chlorophyll content index at 85 DAS (39.74 and 44.42), plant height (103.24 and 114.05 cm), No. of branches/plant (3.763 and 4.633), plant weight (64.06 and 115.64 g), No. of pods/plant (9.978 and 15.043), No. of seeds/plant (35.11 and 58.31), seed yield/plant (27.01 and 50.85 g), biological yield/fed (2707.0 and 4532.9 kg), seed yield/fed (1140.4 and 1994.3 kg), straw yield/fed (1566.6 and 2538.6 kg) and seed protein yield/fed (267.77 and 497.14 kg) in the two seasons respectively. On the other hand, the lowest chlorophyll content index at 85 DAS (27.83 and 31.42), plant height (73.87 and 91.49 cm) and No. of branches/plant (1.230 and 1.778) were obtained from Nubaria 3 variety under without phosphorus application in the both seasons, respectively. While, Giza 716 variety without phosphorus applied recorded the minimum plant weight (17.99 and 45.53 g), No. of pods/plant (3.165 and 6.533), No. of seeds/plant (9.99 and 22.38), seed yield/plant (6.51 and 17.05 g), harvest index (35.95 and 37.27 %), 100-seed weight (64.59 and 75.95 g), biological yield/fed (989.8 and 2037.8 kg), seed yield/fed (358.1 and 762.9 kg), straw yield/fed (631.7 and 1274.9 kg) and seed protein yield/fed (73.98 and 164.80 kg) in the two seasons respectively.

Nubaria 3 variety treated with 30 kg P_2O_5/fed produced the maximum harvest index (43.72 and 46.64 %), 100-seed weight (85.22 and 95.07 g) and seed P content (0.643 and 0.656 %) in addition to the lowest height to 1st pod (14.52 and 17.06 cm) in the both seasons, respectively. Sakha 4 variety without phosphorus application gave the higher position of the 1st pod (28.88 and 31.10 cm) as well as the lowest seed P content (0.351 and 0.431 %) respective in the both seasons.

These results are in agreement with that obtained by **Nebiyu *et al.* 2016; Abd AlKader *et al.* 2017; Kandil *et al.* 2019 and Negasa *et al.* 2019,** found that most faba bean traits were significantly affected by interaction between phosphorus and faba bean varieties.

Table 9. Mean values of chlorophyll content index at 85 DAS, plant height, height to 1st pod, No. of branches/plant and plant weight as affected by the interaction between phosphorus fertilization rates and faba bean varieties during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Chlorophyll content index at 85 DAS		Plant height (cm)		Height to 1st pod (cm)		No. of branches/plant		Plant weight (g)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Giza 716	30.91	33.08	83.53	95.39	26.39	29.51	1.498	2.035	17.99	45.53
	Nubaria 3	27.83	31.42	73.87	91.49	21.09	22.93	1.230	1.778	26.96	58.38
	Sakha 4	33.45	36.63	96.41	108.21	28.88	31.10	1.838	2.685	36.72	71.52
15	Giza 716	34.80	37.97	87.90	102.29	19.92	25.08	2.968	3.715	30.87	65.66
	Nubaria 3	30.08	34.18	78.85	97.16	15.54	19.17	2.143	3.040	40.08	81.93
	Sakha 4	38.51	42.56	101.47	112.35	21.74	26.70	3.378	4.200	54.75	106.64
30	Giza 716	36.46	40.43	89.18	104.72	17.08	21.69	3.255	4.360	36.28	78.37
	Nubaria 3	31.34	36.83	81.04	98.28	14.52	17.06	2.493	3.395	45.49	89.85
	Sakha 4	39.74	44.42	103.24	114.05	19.66	24.39	3.763	4.633	64.06	115.64
L.S.D at 5%		**1.13**	**1.54**	**3.43**	**3.72**	**1.77**	**1.92**	**0.546**	**0.663**	**7.29**	**8.63**

Table 10. Mean values in No. of pods/plant, No. of seeds/plant, seed yield/plant, harvest index and 100-seed weight as affected by the interaction between phosphorus fertilization rates and faba bean varieties during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	No. of pods/plant		No. of seeds/plant		Seed yield/plant (g)		Harvest index (%)		100-seed weight (g)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Giza 716	3.165	6.533	9.99	22.38	6.51	17.05	35.95	37.27	64.59	75.95
	Nubaria 3	4.843	8.535	14.03	27.06	10.88	24.11	40.16	41.14	76.96	88.75
	Sakha 4	5.860	10.270	19.90	37.13	14.21	29.39	38.52	40.90	70.94	78.90
15	Giza 716	5.353	9.373	17.08	32.67	11.89	26.73	38.33	40.48	69.15	81.52
	Nubaria 3	7.238	12.345	20.89	39.96	17.37	37.71	42.99	45.74	82.33	94.02
	Sakha 4	8.668	14.343	29.99	53.46	22.56	45.56	41.03	42.56	74.91	84.98
30	Giza 716	5.980	10.810	19.74	38.69	14.24	32.43	39.04	41.20	71.74	83.59
	Nubaria 3	7.698	13.338	23.40	44.12	20.04	42.05	43.72	46.64	85.22	95.07
	Sakha 4	9.978	15.403	35.11	58.31	27.01	50.85	41.97	43.82	76.73	86.95
L.S.D at 5%		**2.179**	**2.485**	**4.23**	**4.92**	**3.79**	**4.30**	**1.06**	**1.20**	**4.40**	**4.66**

Table 11. Mean values of biological yield/fed, seed yield/fed, straw yield/fed, seed protein yield/fed and seed P content as affected by the interaction between phosphorus fertilization rates and faba bean varieties during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Biological yield (kg/fed)		Seed yield (kg/fed)		Straw yield (kg/fed)		Seed protein yield (kg/fed)		Seed P content (%)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0	Giza 716	989.8	2037.8	358.1	762.9	631.7	1274.9	73.98	164.80	0.375	0.455
	Nubaria 3	1482.6	2485.1	598.4	1026.0	884.2	1459.2	110.87	198.22	0.420	0.511
	Sakha 4	2001.3	3020.2	774.1	1241.6	1227.2	1778.6	165.58	278.39	0.351	0.431
15	Giza 716	1533.3	2359.7	590.4	961.6	942.9	1398.1	131.90	223.16	0.570	0.613
	Nubaria 3	1874.1	3279.5	811.1	1510.5	1063.0	1769.0	166.05	314.02	0.607	0.630
	Sakha 4	2481.7	4151.3	1022.8	1777.9	1459.0	2373.4	236.62	428.37	0.531	0.602
30	Giza 716	1601.6	2619.0	628.1	1084.4	973.5	1534.6	143.19	260.88	0.613	0.633
	Nubaria 3	1992.5	3444.5	876.8	1617.2	1115.7	1827.3	184.94	343.77	0.643	0.656
	Sakha 4	2707.0	4532.9	1140.4	1994.3	1566.6	2538.6	267.77	497.14	0.565	0.582
L.S.D at 5%		**217.2**	**252.7**	**124.0**	**130.6**	**120.9**	**141.5**	**11.00**	**13.56**	**0.042**	**0.043**

6- Effect of the interaction between foliar spray by microelements treatments and faba bean varieties:

Results in **Tables 12 and 13** indicated that chlorophyll content index at 85 DAS, plant height (cm), plant weight (g), No. of seeds/plant, seed yield/plant (g), 100-seed weight (g), biological yield/fed (kg), seed yield/fed (kg), straw yield/fed (kg), seed protein yield/fed (kg), seed Zn content (mg/kg) and seed Mn content (mg/kg) were significantly affected by the interaction between foliar spray by microelements treatments (tap water, Zn, Mn and Zn + Mn) and faba bean varieties (Giza 716, Nubaria 3 and Sakha 4) during the both seasons. While, physiological maturity, height to 1st pod, No. of branches/plant, No. of pods/plant, harvest index, phosphorus use efficiency, seed N content and seed P content were insignificantly affected by the interaction in the both seasons, as shown in **Tables 2, 3, 4 and 5.**

Sakha 4 plants treated with mixed foliar application of Zn + Mn produced the greatest plant height (103.87 and 118.88 cm), plant weight (59.02 and 109.18 g), No. of seeds/plant (31.95 and 56.01), seed yield/plant (24.89 and 48.68 g), biological yield/fed (2704.8 and 4316.3 kg), seed yield/fed (1137.7 and 1921.9 kg), straw yield/fed (1567.1 and 2394.4 kg) and seed protein yield/fed (261.60 and 464.00 kg) in the respective both seasons. Meanwhile, with the same faba bean variety and foliar spray by singly Zn recorded the highest seed Zn content (115.63 and 125.64 mg/kg) and with foliar spray by singly Mn recorded the highest chlorophyll content index at 85 DAS (39.82 and 43.69) and seed Mn content (36.27 and 42.49 mg/kg) in the both seasons, respectively. On the other hand, the minimum chlorophyll content index at 85 DAS (27.80 and 32.08), plant height (72.02 and 89.26 cm) were recorded from faba bean variety of Nubaria 3 without microelements application (tap water) in the both seasons respectively. While, the lowest plant weight (20.62 and 50.37 g), No. of seeds/plant (11.49 and 24.07), seed yield/plant (7.51 and 18.79 g), 100-seed weight (64.37 and 77.39 g), biological yield/fed (1005.4 and 1847.5 kg), seed yield/fed (365.6 and 686.0 kg), straw yield/fed (639.9 and 1161.6 kg), seed protein yield/fed (76.85 and 149.69 kg), seed Zn content (91.22 and 99.77 mg/kg) and seed Mn content (19.77 and 24.73 mg/kg) in the two seasons, respectively.

Nubaria 3 variety treated with mixed foliar application of Zn + Mn gave the heaviest 100-seed weight (84.92 and 95.36 g) in the both seasons, respectively. The results reported here are in harmony with those obtained **Mekkei 2014; Jarecki *et al.*, 2016; El-Shafey *et al.* 2019; Al-Shumary 2020 and Nour El-Din *et al.* 2020**, found that most faba bean traits were significantly affected by interaction between microelements application and faba bean varieties.

Table 12. Mean values of chlorophyll content index at 85 DAS, plant height, plant weight, No. of seeds/plant, seed yield/plant, 100-seed weight as affected by the interaction between foliar spray by some microelements and faba bean varieties during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Chlorophyll content index at 85 DAS		Plant height (cm)		Plant weight (g)		No. of seeds/plant		Seed yield/plant (g)		100-seed weight (g)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	Giza 716	32.00	34.32	81.27	95.39	20.62	50.37	11.49	24.07	7.51	18.79	64.37	77.39
	Nubaria 3	27.80	32.08	72.02	89.26	25.96	63.43	13.49	29.31	10.43	26.31	76.45	89.15
	Sakha 4	34.55	38.76	95.81	105.12	39.84	84.13	21.59	41.57	15.42	33.50	70.73	79.87
Zn	Giza 716	33.72	36.67	88.88	102.09	31.20	68.20	17.17	34.05	12.08	27.94	69.66	81.38
	Nubaria 3	29.31	34.00	79.84	97.91	41.39	81.62	21.44	40.09	17.96	37.68	83.22	93.45
	Sakha 4	36.28	40.43	101.88	114.73	56.22	102.66	30.74	52.37	23.29	44.83	75.34	84.99
Mn	Giza 716	35.76	39.68	86.28	99.68	27.49	62.51	15.17	31.04	10.47	25.17	68.38	80.36
	Nubaria 3	31.64	35.82	77.48	94.71	37.30	74.21	19.25	36.27	15.79	33.75	81.42	92.50
	Sakha 4	39.82	43.69	99.94	107.40	52.29	95.75	29.05	48.57	21.42	40.72	73.34	83.31
Zn + MN	Giza 716	34.75	37.97	91.04	106.05	34.21	71.67	18.59	35.83	13.45	29.72	71.56	82.27
	Nubaria 3	30.23	34.68	82.34	100.69	45.38	87.62	23.57	42.51	20.21	40.74	84.92	95.36
	Sakha 4	38.27	41.93	103.87	118.88	59.02	109.18	31.95	56.01	24.89	48.68	77.35	86.26
L.S.D at 5%		1.30	1.78	3.96	4.30	8.42	9.96	4.88	5.68	4.38	4.96	5.08	5.38

Table 13. Mean values of biological yield/fed, seed yield/fed, straw yield/fed, seed protein yield/fed, seed Zn content and seed Mn content as affected by the interaction between foliar spray by some microelements and faba bean varieties during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Treatment	Trait	Biological yield (kg/fed)		Seed yield (kg/fed)		Straw yield (kg/fed)		Seed protein yield (kg/fed)		Seed Zn content (mg/kg)		Seed Mn content (mg/kg)	
	Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	Giza 716	1005.4	1847.5	365.6	686.0	639.9	1161.6	76.85	149.69	91.22	99.77	19.77	24.73
	Nubaria 3	1273.5	2384.2	510.6	986.2	762.9	1398.0	97.26	197.65	92.61	101.59	19.93	25.82
	Sakha 4	1872.5	3050.2	723.3	1211.1	1149.2	1839.1	157.34	280.10	94.74	104.72	20.92	26.71
Zn	Giza 716	1528.9	2538.1	590.4	1035.0	938.5	1503.0	134.27	247.52	111.54	118.85	22.13	27.70
	Nubaria 3	1964.7	3368.5	850.2	1552.5	1114.5	1816.0	177.25	328.43	111.87	122.44	23.00	29.62
	Sakha 4	2603.5	4175.0	1074.2	1822.3	1529.3	2352.6	252.31	448.99	115.63	125.64	24.37	30.43
Mn	Giza 716	1346.1	2247.0	511.6	900.1	834.6	1346.9	112.41	204.61	94.53	103.50	33.53	39.20
	Nubaria 3	1815.1	3001.2	766.3	1362.4	1048.9	1638.8	153.87	276.44	96.27	105.64	35.49	41.49
	Sakha 4	2405.8	4064.3	981.0	1729.7	1424.9	2334.6	222.05	412.11	100.93	109.53	36.27	42.49
Zn + MN	Giza 716	1619.0	2722.6	634.5	1124.1	984.5	1598.5	141.91	263.30	101.13	111.75	27.15	32.40
	Nubaria 3	2078.8	3524.9	921.4	1637.1	1157.4	1887.8	187.42	338.84	102.80	114.62	28.25	34.86
	Sakha 4	2704.8	4316.3	1137.7	1921.9	1567.1	2394.4	261.60	464.00	108.17	116.80	29.65	35.54
L.S.D at 5%		**250.8**	**291.8**	**143.2**	**150.8**	**139.6**	**163.4**	**12.70**	**15.66**	**8.36**	**9.30**	**6.78**	**8.02**

7- Effect of the interaction among phosphorus fertilization rates, microelements treatments and faba bean varieties:

Results in **Table 14** revealed that the interaction among phosphorus fertilization rates × foliar spray by microelements treatments × faba bean varieties had significant effect on chlorophyll content index at 85 DAS, No. of seeds/plant, seed yield/plant, biological yield/fed, seed yield/fed and straw yield/fed in the both seasons.

Faba bean variety of Sakha 4 treated with 30 P_2O_5/fed and mixed foliar application of Zn + Mn gave the greatest No. of seeds/plant (39.12 and 67.57), seed yield/plant (31.28 and 60.52 g), biological yield/fed (3037.4 and 4904.9 kg), seed yield/fed (1307.6 and 2223.4 kg) and straw yield/fed (1729.8 and 2681.5 kg) in the both seasons, respectively. While, with the same faba bean variety and phosphorus fertilizer rate with foliar spray by singly Mn gave the highest chlorophyll content index at 85 DAS (42.24 and 46.54) in the both seasons, respectively. On the other hand, the minimum values in No. of seeds/plant (6.71 and 16.51), seed yield/plant (4.01 and 12.16 g), biological yield/fed (643.3 and 16143.2 kg), seed yield/fed (220.6 and 568.8 kg) and straw yield/fed (422.7 and 1044.4 kg) were recorded by faba bean variety of Giza 716 under without adding phosphorus or microelements in the both seasons, respectively. While, faba bean variety of Nubaria 3 under without applied phosphorus fertilization or microelements (tap water) produced the lowest chlorophyll content index at 85 DAS (25.41 and 28.21) in the both seasons, respectively.

Conclusion

This study recommends that Sakha 4 variety treated by 30 P_2O_5/fed and mixed spraying with Zn + Mn in order to improve the production of faba bean under the condition of Toukh Directorate, Kalyubia Governorate, Egypt.

Table 14. Mean values of chlorophyll content index at 85 DAS, No. of seeds/plant, seed yield/plant, biological yield/fed, seed yield/fed and straw yield/fed as affected by the interaction between phosphorus fertilization rates, foliar spray by some microelements and faba bean varieties during 2018/2019 (1st) and 2019/2020 (2nd) seasons.

Trait			Chlorophyll content index at 85 DAS		No. of seeds/plant		Seed yield/plant (g)		Biological yield (kg/fed)		Seed yield (kg/fed)		Straw yield (kg/fed)	
P	**M**	**V**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
0	control	**Giza 716**	27.25	29.58	6.71	16.51	4.01	12.16	643.3	1613.2	220.6	568.8	422.7	1044.4
		Nubaria 3	25.41	28.21	9.78	19.81	7.01	16.99	1001.0	1847.8	385.6	734.5	615.4	1113.3
		Sakha 4	30.66	33.37	15.31	30.36	10.09	22.73	1505.3	2559.8	555.0	950.2	950.3	1609.6
	Zn	**Giza 716**	30.81	32.28	11.19	24.28	7.40	18.68	1113.5	2178.5	407.0	827.4	706.5	1351.1
		Nubaria 3	26.89	31.41	15.71	29.35	12.40	26.26	1664.2	2731.7	682.0	1144.3	982.2	1587.4
		Sakha 4	31.95	35.07	21.24	39.28	15.49	31.49	2185.2	3167.7	852.0	1332.0	1333.2	1835.7
	Mn	**Giza 716**	33.21	36.43	9.80	22.47	6.37	16.98	972.8	1970.2	350.4	733.9	622.4	1236.3
		Nubaria 3	30.71	33.87	14.43	27.35	11.09	24.07	1530.0	2511.4	610.0	1023.9	920.0	1487.5
		Sakha 4	36.42	40.47	20.12	38.09	14.34	29.97	2069.0	3003.8	788.7	1248.4	1280.3	1755.4
	Zn + MN	**Giza 716**	32.35	34.04	12.27	26.27	8.26	20.39	1229.5	2389.2	454.3	921.5	775.2	1467.7
		Nubaria 3	28.29	32.17	16.20	31.72	13.02	29.11	1735.2	2849.6	716.1	1201.1	1019.1	1648.5
		Sakha 4	34.75	37.62	22.94	40.77	16.90	33.38	2245.6	3349.4	900.5	1435.9	1345.1	1913.5
15	control	**Giza 716**	33.11	35.51	13.14	25.46	8.45	19.83	1155.3	1867.9	422.5	691.5	732.8	1176.4
		Nubaria 3	27.59	32.35	14.36	30.34	10.80	27.35	1344.3	2587.9	540.0	1067.5	804.3	1520.4
		Sakha 4	35.73	40.15	24.25	45.19	17.35	36.59	1987.3	3092.3	767.5	1229.5	1219.8	1862.8
	Zn	**Giza 716**	34.36	37.46	18.94	35.39	13.37	29.37	1721.2	2558.7	668.5	1068.5	1052.7	1490.2
		Nubaria 3	30.31	34.14	23.88	43.62	20.32	41.50	2082.3	3542.7	916.0	1675.0	1166.3	1867.7
		Sakha 4	38.09	42.64	32.65	56.44	24.81	49.00	2743.6	4459.2	1140.5	1950.0	1603.1	2509.2
	Mn	**Giza 716**	36.25	40.08	16.64	32.49	11.50	26.57	1502.5	2271.3	575.0	928.5	927.5	1342.8
		Nubaria 3	31.29	35.46	20.78	40.25	17.24	37.93	1949.8	3182.7	832.0	1496.5	1117.8	1686.2
		Sakha 4	40.81	44.07	29.26	52.50	21.56	44.51	2364.6	4358.9	978.0	1825.5	1386.6	2533.4
	Zn + MN	**Giza 716**	35.49	38.82	19.61	37.35	14.23	31.16	1754.1	2740.8	695.5	1158.0	1058.6	1582.8
		Nubaria 3	31.11	34.78	24.55	45.62	21.13	44.06	2119.9	3804.6	956.5	1803.0	1163.4	2001.6
		Sakha 4	39.42	43.37	33.79	59.69	26.50	52.13	2831.3	4694.7	1205.0	2106.5	1626.3	2588.2
30	control	**Giza 716**	35.63	37.88	14.61	30.25	10.08	24.39	1217.7	2061.5	453.6	797.6	764.1	1263.9
		Nubaria 3	30.41	35.68	16.33	37.78	13.47	34.59	1475.3	2716.9	606.2	1156.6	869.1	1560.3
		Sakha 4	37.26	42.75	25.20	49.16	18.83	41.19	2124.9	3498.4	847.4	1453.6	1277.5	2044.8
	Zn	**Giza 716**	35.98	40.26	21.39	42.47	15.46	35.76	1752.0	2877.0	695.7	1209.2	1056.3	1667.8
		Nubaria 3	30.73	36.45	24.74	47.31	21.17	45.29	2147.7	3831.0	952.7	1838.1	1195.0	1992.9
		Sakha 4	38.79	43.59	38.33	61.38	29.56	54.00	2881.7	4898.0	1230.2	2185.0	1651.5	2713.0
	Mn	**Giza 716**	37.81	42.53	19.08	38.16	13.54	31.95	1563.1	2499.5	609.3	1037.8	953.8	1461.7
		Nubaria 3	32.93	38.12	22.54	41.22	19.04	39.26	1965.6	3309.5	856.8	1566.7	1108.8	1742.8
		Sakha 4	42.24	46.54	37.77	55.13	28.36	47.67	2783.9	4830.3	1176.2	2115.2	1607.7	2715.1
	Zn + MN	**Giza 716**	36.41	41.05	23.89	43.86	17.86	37.62	1873.5	3037.8	753.7	1292.9	1119.8	1744.9
		Nubaria 3	31.29	37.08	29.97	50.18	26.48	49.05	2381.3	3920.5	1091.6	1907.3	1289.7	2013.2
		Sakha 4	40.65	44.81	39.12	67.57	31.28	60.52	3037.4	4904.9	1307.6	2223.4	1729.8	2681.5
L.S.D at 5%			**2.25**	**3.08**	**8.45**	**9.84**	**7.59**	**8.59**	**434.4**	**505.4**	**248.0**	**261.2**	**241.8**	**283.0**

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أداء بعض أصناف الفول البلدي وعلاقتهم بالتسميد الفوسفاتي والرش ببعض العناصر الصغرى

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أجريت تجربة حقلية في مركز البحوث والتجارب الزراعية بكلية الزراعة بمشتهر جامعة بنها (مركز طوخ . محافظة القليوبية . مصر) خلال الموسمين 2019/2018 و 2020/2019 لدراسة تأثير ثلاثة معدلات من السماد الفوسفاتي (0، 15 و 30 كجم فو$_2$أ$_5$/فدان) والرش بأربعة معاملات من العناصر الصغري (بدون إضافة، الزنك، المنجنيز والزنك + المنجنيز) على صفات النمو الخضري والمحصول ومكوناته وبعض الصفات الكيميائية لبذور ثلاثة أصناف من الفول البلدي (جيزة 716، نوبارية 3 و سخا 4). وكان التصميم التجريبي المستخدم هو القطع المنشقة مرتين في ثلاثة مكررات حيث تم توزيع معدلات السماد الفوسفاتي في القطع الرئيسية بينما تم توزيع معاملات العناصر الصغري في القطع الشقية الأولى وتم توزيع الأصناف في القطع الشقية الثانية.

ويمكن تلخيص أهم النتائج فيما يلي:.

- أشارت النتائج أن زيادة معدلات السماد الفوسفاتي من 0 و 15 إلى 30 كجم فو$_2$أ$_5$/فدان حققت زيادة معنوية في معظم قيم صفات النمو الخضري، المحصول، مكوناته والصفات الكيميائية لبذور الفول البلدي تحت الدراسة في كلا الموسمين على العكس قيم عدد الإيام من الزراعة حتى 50 % من النضج الفسيولوجي، إرتفاع أول قرن و كفاءة إستخدام الفوسفور إنخفضت مع زيادة مستوى السماد الفوسفاتي في كلا الموسمين.
- أوضحت النتائج أن الرش الخضري بالعناصر الصغرى بالمعاملة الفردية أو المعاملة المختلطة أدت إلى زيادة معنوية في قيم معظم صفات الفول البلدي تحت الدراسة مقارنة بعدم إستخدام العناصر الصغرى خلال موسمي التجربة. كما أشارت النتائج أن رش نباتات الفول بالمعاملة المختلطة (الزنك + المنجنيز) كانت أفضل المعاملات حيث أعطت أعلى القيم في معظم قيم صفات النمو الخضري، المحصول، مكوناته والصفات الكيميائية لبذور الفول البلدي في كلا الموسمين.
- أظهرت النتائج أن إداء أصناف الفول البلدي تحت الدراسة كانت مختلفة معنوية في معظم قيم الصفات المدروسة لمحصول الفول البلدي خلال موسمي الدراسة. زراعة صنف الفول البلدي سخا 4 حقق معنوياً أعلى القيم لصفات دليل الكلوروفيل عند 85 يوم من زراعة الفول البلدي، إرتفاع النبات، أرتفاع أول قرن، عدد الأفرع/نبات، وزن النبات، عدد القرون/نبات، عدد البذور/نبات، محصول البذور/نبات، المحصول البيولوجي/فدان، محصول البذور/فدان، محصول القش/فدان، كفاءة إستخدام الفوسفور، محتوي البذور من النتيروجين و محصول البروتين/فدان خلال موسمي الدراسة. بينما زراعة صنف الفول نوبارية 3 أعطت معنوياً أعلى القيم لصفات عدد الإيام من الزراعة حتى 50 % من النضج الفسيولوجي، دليل الحصاد ووزن 100 بذرة خلال موسمي الزراعة.
- التفاعلات من الدرجة الأولى بين المعاملات 30 كجم فو$_2$أ$_5$/فدان × زنك + منجنيز، 30 كجم فو$_2$أ$_5$/فدان × سخا 4 و زنك + منجنيز × سخا 4 والتفاعل من الدرجة الثانية بين المعاملات 30 كجم فو$_2$أ$_5$/فدان × زنك + منجنيز × سخا 4 أنتجت معنوياً أعلى متوسط قيم لصفات محصول البذور/نبات، المحصول البيولوجي/فدان، محصول البذور/فدان، محصول القش/فدان مقارنةً بالتفاعلات بين المعاملات الأخري في كلا الموسمين.

الخلاصة:

- توصي النتائج بزراعة الفول البلدي صنف سخا 4 مع التسميد الفوسفاتي بمعدل 30 كجم فو$_2$أ$_5$/فدان مع الرش الخضري بخليط من العناصر الصغرى (زنك 0.3 % + منجنيز 0.3 %) حيث عظمت إنتاجية محصول الفول البلدي بوحدة المساحة في مركز طوخ . محافظة القليوبة . مصر.