Response of some Faba Bean Cultivars (*Vicia Faba* L.) to Phosphorus Fertilization Under El-Tur and New Valley Conditions

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ABSTRACT

One of the most important winter-sown legume crops worldwide is the faba bean. It is important to optimize the productivity of stable cultivars under favourable environmental conditions, agricultural practices, and phosphorus fertilizer to increase faba bean production especially, under climate change. The study was conducted in the two different locations, El-Kharga-New Valley and El-Tur location, South Sinai, during two successive seasons, 2020-2021 and 2021-2022, to study the response of some faba bean cultivars to phosphorus fertilization under El-Tur and New Valley conditions. The experiments included four faba bean cultivars i.e., Sakha1, Espain, Mariout 2 and Giza 843 and three phosphorus levels i.e., 0, 25and 50 kgP_2O_5\fed (12.5%P_2O_5). The results indicated that Sakha1cultivar produced the highest seed yield and its components. Fertilizing faba bean plants with 50 kg P_2O_5 produced the highest value of growth characters, seed yield and its components during two seasons. The results revealed that Sakha1 variety produced the highest values of seeds, straw, and biological yields in both seasons, Espain cultivar recorded the highest value of 100-seed weight and number of seeds /pod during the two growing seasons, while the highest value of the plant height and number of pods per branche were obtained by Mariout 2 broad bean variety in both seasons. The results indicated that increasing phosphorus fertilizer addition up to 50 P_2O_5 kg\fed, recorded significant increments in all traits of faba bean under this study except phosphorus use efficiency which was significantly decreased with increasing phosphorus rates. Fertilizing faba bean cultivar Sakha-1 with 50 kg P_2O_5/fed gave the highest values of yield and its component under environmental conditions of El-Kharga location. The highest positive correlation and coefficient were observed between seed yields and most of the studied traits as an average of four cultivars and three levels of phosphorus in both seasons. As a result, the PC1, PC2and PC3 were retained for the final analysis, in which the three PCs expressed more variability and support the choice of the trait with a positive loading factor. Principle component analysis showed that out of all PCs, the three first main PCs (PC1, PC2 and PC3) extracted had eigenvalues larger than one, while the rest of the other PCs had eigenvalues less than one (Eigenvalue <1).

Key Words: Cultivars, Faba bean, different location, Pearson correlation, PCA, Phosphorus Fertilizer

INTRODUCTION

The faba bean (*Vicia faba* L.) is a widely grown crop in Egypt because it offers the majority of Egyptians a dependable source of sustenance. The faba bean is one of the most significant leguminous crops grown in Egypt. They are a consistent ingredient in the bulk of animal meals are occasionally used as nourishment for humans (Dawood et al., 2019; Khalifa, 2019). The production of faba bean in Egypt declined from 439380 tonnes in 2001 to roughly 96789 tonnes in 2019, a decline of about 78.20% from 2001 to 2019. Egyptian data show that from 333757 fed in 2001 to roughly 66248 fed in 2019 less faba bean was grown there (FAO, 2019). Faba bean is used for the nutrition of humans and animal because it is good source of protein (almost 285g\kg in dry seed) starch, callous, minerals and vitamins (Ismail &Fayed, 2020). The fertility of the soil is increased by include faba beans in cropping system. Due to its high effectiveness in establishing symbiosis with specific Rhizobium bacteria and resulting biological nitrogen fixation, it is associated with decreased need for fertilizer input in agricultural fields and an increase in soil biological activity, (BNF).The two primary agricultural practices that benefit from BNF are crop rotation cycles that include legumes and the intercropping of legumes with crop content fix N.Like cereals or horticultural crops (Jensent et al., 2010). The absorption of legume residues into the soil enhances soil qualities such as organic matter bulk density, porosity, and field capacity .Faba bean can fix up to 200 $KgNha^{-1}$ (Adekiya et al., 2017; Salahin et al., 2013). High –quality protein, vitamins, and other important nutrients can be in abundance in faba bean seeds 290g\Kg^{-1} % of dry matter (Khazaei &Vandeneberg, 2020; Marchell et al., 2021).

The productivity of the faba bean is influenced by variety of factors, including cultivars, cultural methods, phosphorus fertilizer and environmental conditions (Ibrahim, 2016). Panayiota et al. (2021) showed that the biomass, seed yield and yield components varied significantly among the six conditions. The majority of parameters were primarily controlled by the environment, while only one thousand seed weight was equally influenced by genotype and environment. Sustainability, Bakry et al. (2011); Khattab et al. (2015) and Osman et al. (2010) reported that breeding high yielding cultivars can increase faba bean production per unit area. There are notable variations among faba bean varieties. Pluduma-Paumina et al. (2018) concluded

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that faba bean yield has been significantly affected by varieties (Panayiota et al., 2021) showed that there were significant differences in the biomass, seed yield, and yield components among the six conditions. Only thousand seed weight was equally influenced by genotype and environment, whereas the most of attributes were primarily influenced by the environment. Sustainability, Bakry et al. (2011); Khattab et al. (2015) and Osman et al. (2010) reported that breeding high yielding cultivars can increase faba bean production per unit area. There are notable variations among faba bean varieties. Pluduma-Paumina et al. (2018) concluded that faba bean yield has been significantly affected by varieties.

Utilizing appropriate crops and kinds that have been adapted to the new climatic conditions would help mitigate the impact of climate change on agriculture. In this sense, modern breeding must achieve several of goals, including balancing agricultural production and the environment, ensuring the abundance, security, and quality of food and seeds, as well as ensuring climate robustness (Lammerts et al., 2018). Thus, to boost resistance to a wide range of stresses and maintain productivity, food security, and agricultural sustainability, adaptive characteristics must be bred. In parallel, the need for food security and environmentally acceptable crops has grown, leading to the construction of cropping systems that contain annual grain legumes (Duc et al., 2015). Despite the fact that grain legumes are sometimes referred to as climate-smart crops, they are primarily grown in marginal areas where the range and intensity of abiotic and biotic challenges are anticipated to rise (Bahl, 2015). To ensure food and nutritional security, it is crucial to increase their capacity to adapt to climate change. Their lack of genetic variety has always been a significant hindrance to their increased adaptation. To do this, plant breeders must step up efforts to find or create a variety of germplasm lines that can withstand or even benefit from climatic aberrations (Bahl, 2015). Faba bean is considered a crop species adapted to a wide range of climatic conditions and soil type (Singh et al., 2013) as it is highly affected by environmental fluctuation. Thus, it is essential to use stable genotypes that are well suited to a variety of settings. This will aid in boosting productivity and acreage when used in conjunction with proper management practices. Due to this, it is necessary to assess the genotype's adaptability and stability to a variety of conditions (Maalouf et al., 2019).

The results of numerous investigation showed that broad bean cultivars differ substantially in their growth and seed output. Gasim et al. (2015) reported that in bred lines, the yield and its constituent parts are highly variable. The plant height, number of pods per plant, 100-seed weight, seed yield per plant, and seed yield (ardab-fed) varied significantly between broad bean cultivars (Abdel-Baky et al., 2019). Field bean seed yield and thousand seed weight has been significantly.

Abou El-Seba et al. (2016) stated that the plant height, weight, and number of pods per plant and seed output of faba bean cultivars varied significantly. Numerous studies found that the vegetative and yield characteristics of evaluated cultivars varied significantly (Nour El-Din et al., 2020). Al-Summary (2020) found that most faba bean features showed substantial change between the test types, and most vegetative development ,yield components,yield,and seed chemical analysis among faba bean varieties also showed notable differences.

Phosphorous (P), one of the fundamental and essential minerals for plant growth, has a positive impact. It can be ascribed to the nutrients' accessibility and role in promoting vegetative development. Enhancing the partitioning of carbohydrates into pod yield and photosynthesis. It also has a direct impact on the majority of crucial biological processes. As a result, it serves as a key catalyst for cell division, promoting plant development, and energy storage and transmission for processes like photosynthesis, respiration, protein and nucleic acid synthesis, as well as ion transport across cell membrane (Fageria, 2009). Increase the rate to 70 kg/ha from 0 kg/ha the involvement of phosphorus in delivering sugars from the sites where they are formed into photosynthetic product to the seeds, and hence an increase in the seed production, may account for the much higher seed output. Similar results were reported by Abido and Seadh (2014); Anhar et al. (2021); Bakry et al. (2011); Negasa et al. (2019) and Yohannes et al. (2014).

Phosphorus is one of the most crucial elements for plant nutrition. Plants need phosphorus for cell division, growth, the utilization of sugar and starch, photosynthesis, and the formation of their nuclei .Phosphorus is essential for the broad bean seedling's recovery from transplant shock. Because energy from photosynthesis and the metabolism of carbohydrates is stored in phosphate compounds like ATP and ADP for use in growth and reproduction later on, inclouding those mentioned and demonstrated previously, those results concur with those reported by many works (Adak and Kibritic, 2016; El-Agrodi et al., 2017 and Sarkar et al., 2017).

In comparison to the control treatment, broad bean seed and biological yields considerably increased when broad bean plants were fertilized with 46 Kg P_2O_5\ha (Kubure et al., 2015).The number of pods per plant , biological and seed yield per plant, and unit area of the broad bean were all improved by spraying 40 Kg of phosphorus per ha. The 30 Kg of phosphorus per acre that resulted in the maximum 100-seed weight (Adak and Kibritei, 2016). The effects of phosphorus fertilization (0, 37, and 74 kg P_2O_5/ha) on the number of plants, pods, pod length, 100-seed weight, and number of seeds in pods and plants were all significant (Abd Alkader et al., 2017). The straw yield significantly increased when 26.16 kg P was applied compared to the control treatment. Additionally, raising P fertilization to 39.34 kg P fed^{-1} significantly increased straw output compared to levels of 26.16 kg P fed-^{1} (El-Agrodi et al., 2017). Anhar et al. (2021) reported that the number of pods/plant, 100-seed weight, and seed output significantly increased than control treatments after added 70 kg p/ha of phosphorus fertilizer level. The relationship between faba bean production, yield components, and mineral phosphorus application rate (Yasmin et al., 2020). Fertilization with 40 kg ha^{-1} significant influence on plant height, number of branches / plant, number of pods / plant , 100- seed weight, seed yield Stover and protein content as compared with control treatment. El-Safy et al. (2021) indicated that with the exception of mid physiological maturity and phosphorus usage efficiency, most vegetative growth, yield characteristics, yield, and seed chemical parameters of the faba bean dramatically increased with increasing phosphorus fertilization rates from 0 to 30 kg P_2O_5/fed. Considering the crucial part phosphorus fertilizer plays in raising faba bean traits. The superiority of applying 30 kg of phosphorus may be attributed to its positive effects on the index of chlorophyll content, plant height, branches number, plant weight, pods number and seeds per plant, plant seed yield, H.I, 100-seed weight, and biological yield/fed, during both seasons. Ali et al. (2019) revealed that increasing the phosphorus content of 15.5 kg P_2O_5 feed, 31 kg P_2O_5, and 46.5 kg P_2O_5. Increase the researched characters noticeably. The highest results were generally obtained by adding 46.5 kg of P_2O_5 fed, followed by 31 and 15.5 kg of P_2O_5 fed. In contrast, (without application treatment) was worse in this reg (Bakry et al., 2011; Khattab et al., 2015 and Osama et al., 2010).

Thus, this work aims to study the response of some faba bean cultivars to phosphorus fertilization under El-Tur and New Valley conditions.

MATERIALS AND METHODS

Field Experiments were conducted for two consecutive growing seasons 2020-2021 and 2021-2022 at two different locations.i.e.El-Kharga region-New valley Government (25^0 33^- 50.8 N, 30^0 $37'52''$E)(L1) and El- Tur location. South Sinai Government (28^0 $21'$ $12''$N, 33^0 $38'$ $40''$ E) (L2) for each location, soil and water properties are presented in table (1, 2).

These trails were performed to study the influence of some faba bean cultivars, (V1) Espain, (V2) Sakha1, (V3) Mariout 2, and (V4) Giza 834were sown in 15and 20 October in the first and second seasons, respectively. The seed of faba bean cultivars were obtained from Food Legumes Research Section, Field Crops Research Institute, Agricultural Research Center. Three levels of phosphorus (Zero (F0), 25(F1) and (F2)50 kg P_2O_5/fed) were applied as calcium superphosphate fertilizer (12.5 %P_2O_5). Phosphorus rates were added after ridging and before sowing in both seasons. Nitrogen, in the form of ammonium nitrate (33.5% N), was applied at the rate of 30 kg N fed, as start dose before first irrigation. Potassium sulphate (48% K_2O) was added at the rate 50 kg\fed 30 days after sowing. Each experimental basic unit included 5 ridges, 60 cm apart and 3.5 m long, comprising an area of 10.5 m^2.

A split-split plot design with three replicates was used in both seasons. The main plots were devoted to locations and the sub plot were occupied by four faba bean cultivars whereas, the sub-sub plots were assigned to the three phosphorus fertilizer. Data were subjected to the proper analysis according to Gomez and Gomez(1984). Means were compared using the least significant difference (LSD) value at 5 % level of probability.

Soil samples were taken before faba bean sowing to a depth of 0-30 cm for chemical analysis of the according to the methods of Association of Official Analytical Chemists described (A.O.A.C., 2005) and presented in **Table1, 2and Meteorological data in Table 3,4.**

Table1. Some physical and chemical properties of a representative soil sample in the experimental site before sowing as mean for two seasons (0-30 cm depth) and water analysis.

Table 1. Soil Chemical Analysis at New Valley

Depth (cm)	pH	EC (dS m^{-1})	Soluble cations (meq L^{-1})				Soluble anions (meq L^{-1})				ESP	Texture class
			Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}		
0-30	8.7	2.19	2.9	1.7	38.0	6.4	0.0	22.0	22.0	4.5	26.3	Sandy
irrigation Water analysis												
-	7	2.1	24	26.73	230	37	NIL	3 50.14	186.8	171.6	-	-

Table 2. Some physical and chemical properties of a representative soil samples in the experimental site before sowing and after experiments as mean for two seasons on 0-30 cm depth (El-Tour location)

Soil Analysis	
Properties	**Values**
Patrice size distribution	
Texture Class	Sandy
PH	7.41
EC (ds m^{-1})	3.39
Total $CaCO_3$ (%)	33.5
Total Organic Carbon (%)	0.264
Total Organic Matter (%)	0.459
Available Elements (ppm)	
N	17.5
P	1.60
K	47.1
Irrigation Water Analysis	
PH	6.80
EC (ds m^{-1})	3.73
Available Elements (ppm)	
Aminouim Nitrogen	5.60
Nitrare Nitrogen	22.9
P	0.11
K	0.71

Table3.Meteorological data El-Tor location(2020-2021and 2021-2022)

Month	Solar radiation	TMP_MAX	TMP_MIN	Relative humidity (%)	Precipitation (mm/day)	Wind speed (m/s)
October	18.797	32.448	19.819	46.830	0.015	6.74
November	15.487	27.795	15.808	49.086	o.o23	4.72
December	13.701	22.160	11.230	52.550	0.062	4.67
June	15.519	22.920	9.977	49.149	0.002	4.64
Feb	19.390	23.113	10.565	50.295	0.0427	5.65
March	23.880	27.71	12.712	41.391	0.137	6.25
April	27.712	32.967	16.548	28.985	0.001	6.84
Season 2021-2022						
October	18.605	29.309	18.930	55.337	0.001	6.54
November	-18.788	-76.804	-86.406	-49.290	0.003	5.48
December	-12.019	20.546	9.143	52.969	0.023	4.98
June	15.508	18.998	6.916	52.550	0,132	5.16
Feb	19.117	22.291	9.357	50.660	0.003	5.48
March	23.662	24.494	-10.677	41,839	0.000	6.58
April	25.506	33.934	17.586	30.737	0.001	6.56

Tale 4. Meteorological data- El-Kharga location (2020-2021 and 2021-2022)

Month	Solar radiation	TMP_MAX	TMP_MIN	Relative humidity (%)	Precipitation (mm/day)	Wind speed (m/s)
October	13.57	34.01	18.974	33.96	0.00	4.05
November	10.94	29.59	14.921	30.48	0.00	2.84
December	9.49	20.61	7.792	20.47	0.00	3.12
June	9.93	22.38	7.983	44.19	0.00	2.61
Feb	12.96	23.66	8.146	37.07	0.005	3.37
March	15.31	27.69	12.057	27.39	0.002	3.63
April	18.1	34.32	15.218	19.18	0.000	3.49
Season 2021-2022						
October	13.23	21.04	7.55	34.34	0.00	3.74
November	10.25	21.47	6.92	42.08	0.00	-987
December	9.13	28.39	11.62	47.12	0.12	3.06
June	9.87	21.77	18.23	46.98	0.00	3.582
Feb	12.71	23.87	21.52	41.38	0.013	3.25
March	15.3	24.69	24.12	29.10	0.002	3.89
April	17.98	36.32	15.69	19.18	0.000	3.45

Source of Meteorological data: Nasa\Power Ceres Native (https:\\power.iarc.nasa.gov\index.php)

Characters studied:

At harvest, a random sample of ten guarded plants from each sub plot, in both growing seasons was taken to determine the following characters:

1. Plant height (P.H) 2- Number of branches/ plant (B\P) 3-Number of seeds / pod (S\P), 4-Number of pods\m^2 (P\m^2) 5-Number of seeds / plant (S\P) 6- 100- seed weight (S.W (g)). The whole faba bean plants of the two inner ridges of each sub plot were harvested to determine the following

1-Seed yield kg/fed (S.Y) 2- Biological yield kg/fed (B.Y) 2- Straw yield kg/fed (St.Y) 4-Crop index (C.I %)

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

$$PUE = \frac{\text{seed yield of treatment kg/fed -seed yield of control (kg/fed)}}{\text{Phosphorus applied (kg/fed)}}$$

Statistical analysis

The data of seed yield and its components were analyzed according to Gomez and Gomez (1984). Significance of correlation coefficients was tested at the probability levels of 0.05 and 0.01. Plot Pearson's correlation coefficient and principal component analysis (PCA) were applied for a better understanding of the relationship among studied traits across experimental factors. The ANOVA, Plot Pearson's correlation coefficient and PCA were done using a computer software program SPSS version 25 and Origin Pro 2021 version b 9.5.0.193.

RESULTS AND DISCUSSION

Data in Table (5) revealed that the plant height(cm), 100- seed weight(g),seed, straw, biological yield kg\fed, crop index% and phosphorus use efficiency(PUE) during two growing seasons , were affected by different locations, location-1 resulted in significantly increment in yield and attributes, higher values of seed yield and most of its component of faba bean cultivars higher than location-2 and PUE . The increase in seed yield, PUE and other studied traits could be due to different environmental conditions and may be due to water salinity at the location 1 lower than location2, (Panayiota et al., 2021). Although grain legumes are often characterized as climate-smart crops, they are mainly cultivated in marginal environments where the range and intensity of abiotic and biotic stresses area expected to increase (Bahl, 2015), also, the studied traits in the first season's surprise second seasons, the mean of seed yield in the first season was (1839.5 kg\fed) while in the second season was (1718.5 kg\fed).

Table 5. Different location effects on yield and its components of faba bean at two growing seasons.2020-2021and 2021-2022

Location	P.H(cm)	No. of B/P	No. of P/B	No. of P/ m^2	No. of S/P	100 S.W. (g)	S.Y Kg/fed	St. Y. Kg/fed	B.Y. Kg/fed	C.I. %	PUE
Season 2020-2021											
L1	133.86	8.00	7.80	185.1	4.83	111.43	1964	3330	5294	59.38	23.33
L2	102.69	6.36	7.28	166.8	4.19	105.78	1715	3123	4838	56.48	20.92
LSD at 5%	3.105	0.63	N.S	N.S	N.S	3.752	96.7	144.5	72	0.08	0.030
Season 2021-2022											
L1	126.83	7.75	7.36	173.1	4.86	106.4	1825	3108	4933	59.46	21.66
L2	95.22	5.61	6.75	147.o	3.56	102.0	1612	2987	4599	55.25	21.41
LSD at 5%	2.99	1.14	N.S	22.14	0.52	1.47	129	119.4	99.8	0.08	0.012

(P.H) plant height, (B\P) No of Branches \ plant, (P\B) No of pods\ branche, (P\$m^2$) No of (Pods\$m^2$),(S\P) No of Seeds\pod,100 S.W(100-Seedweight(gm),(S.Y)seed yield kg\Fed,(St.y) Straw yield kg\Fed,(B.Y)Biological yield kg\Fed, C.I(Crop Index %.),L1(El-Kharga-New Valley),L 2(El-Tur location)

Data presented in table (6) revealed that the four faba bean cultivars V1 Espain, v2 Sakha-1, V3 Mariout-2 and V4 Giza 843) were significantly different in all studied characters. V1 (Espain) faba bean cultivar was superior to other cultivars in No. of seed/ pod and 100-seed weight during the two seasons, while V2 (Sakha-1) cultivar was superior to other cultivars in No.of branches /plant, seed, straw, biological yields kg/fed and crop index in the first and second seasons, respectively. The highest value of plant height, No. of pods/ plant, No. of pods/$m^2$and water use efficiency were obtained by (V3) Mariout 2 cultivar. Similar results were obtained by several authors (Osman et al., 2010; Bakry et al., 2011; Khattab et al., 2015; Gasim et al, 2015; Abou –El-Seba et al., 2016; Ali et al., 2019; Nour El-Din et al., 2020; Al-Sumary, 2020). Showed that Sakha-1 cv. recorded the highest values of plants height; number of seeds/pods and straw yield "ton/fed". While Sakha-1 have higher values of plant height 101.50(cm), number of seeds/pods 3.32 and straw yield (1.392ton/fed.) as mean average on the two seasons, respectively. These results agree with Abbas et al. (2012); Abd El-Hakim (2003); Awaad (2002); El-Galfy (2005); El-Sayed (2010); Maha & El-Wakil (2002); Metwally et al. (2000); Saad & El-Kholy (2000) and Talaat & Abdallah (2008).

Table 6. Seed yield and its attributes as affected by faba bean cultivars in the two growing seasons. 2020-2021and 2021-2022

	P.H(Cm)	No. of B/P	No. of P/B	No. of P/ m^2	No. of S/P	100 S.W. (g)	S.Y Kg/fed	St.Y Kg/fed	B.Y. Kg/fed	C.I. %	PUE
Season 2020-2021											
V1	108.89	6.722	4.528	102.1	5.278	127.35	1777	2913	4690	61.00	26.05
V2	108.44	9.222	8.694	187.1	4.444	106.84	2136	3501	5637	61.01	19.63
V3	135.56	6.833	10.033	239.9	4.278	98.07	1965	3131	5096	62.76	30.56
V4	120.22	5.944	6.906	174.9	4.056	101.98	1480	3358	4838	44.07	17.24
LSD5 %	**3.685**	**0.5415**	**0.7061**	**7.08**	**0.395**	**3.88**	**102.7**	**194.1**	**180.3**	**0.08**	**0.064**
Season 2021-2022											
V1	102.39	6.389	4.111	86.7	5.056	123.83	1643	2829	4472	58.08	23.74
V2	99.78	7.833	8.056	168.2	4.056	100.92	1963	3208	5171	61.19	17.19
V3	127.17	7.111	9.611	224.4	4.056	94.77	1827	2995	4822	62.50.	31.92
V4	114.78	5.389	6.444	160.9	3.667	97.31	1440	3159	4599	45.58	17.05
LSD5 %	**3.207**	**0.416**	**o.529**	**9.98**	**0.436**	**2.12**	**101.3**	**184**	**175.4**	**0.06**	**0.005**

v1 (Espain), v2 (Sakha1), v3 (Mariout-2), v4 (Giza 843).

Data presented in table (7) revealed that P- levels (0, 25, 50 kg P_2O_5/fed) significantly affected all growth traits, seed yield and its attributes both seasons. All studied traits significantly increased with increasing fertilizer- levels from 0 to 50 kg P_2O_5/fed and the difference between them were obvious through two growing seasons. Faba bean responded to increasing P-level up to 50 kg P_2O_5/ fed, faba bean with 25 kg P_2O_5 kg\fed came in the second rank after 50 P_2O_5 kg/fed application, followed by without P-level, in both seasons. Increasing P-rates rates from 0 to 50kg/fed caused significant increments in yield and its components except P- use efficiency was significantly decreased with increasing fertilization rates in both seasons, the highest P- efficiency (23.8 and 22.68 kg seed yield/kg P_2O_5) were obtained by 25 kgP_2O_5 at both seasons,. Phosphorus is as one of the major elements for plant nutrition. Plants need P- for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division. P- stimulates root development in the young plant, thus increasing its ability to absorb other soil nutrients. Energy from photosynthesis and metabolism of carbohydrates is stored in P- compounds as ATP and ADP for later use in growth and reproduction, consequently, enhancing most growth and yield traits. The obtained results agree with Adak & Kibritic (2016); El-Agrodi et al. (2017) and Sarkar et al. (2017). Ali et al. (2019) and El-Safy et al. (2021) found that P- levels from zero to 46.5kg P_2O_5/fed, had a significant positive effects on all studied yield. Increasing P-levels released straw and biological yields by 27.92 and 22.92% with P-level increased from 0.0 to 46.5 kg P_2O_5/fad. As mean two seasons. These results are in agreement with those reported by Maha and ElWakil (2002); Abdalla (2002); Nawar and Mousa (2002); Khalil et al. (2004); Abd-Elaziz, El-Set (2005); Attia (2009); Ibrahim (2009); El-Saady et al. (2011); Abbas et al. (2012) and Abou-Amer et al. (2014), who found that faba bean seed yield and it's attributes significantly increased with increasing the rate of P-fertilization. In this connection, Chemeda et al. (2021) found that the maximum and minimum plant height and number of pods per plant (119.6cm and 13.98) and (102.7cm and 11.66) were recorded from plots receiving 92 and 0 kg P_2O_5 ha^{-1} respectively. Similarly, the highest and lowest grain yield and above ground biomass yield (4099.6 and 8127.4 kg/ha^{-1}) and (3073.3 and 5713.8 kg/ ha^{-1}) were recorded from plots receiving 115 and 0 kg P_2O_5 ha^{-1} respectively. Generally, their results indicate that P-applied (69 kg P_2O_5/ ha^{-1}) with grain yield (3996.8 kg/ ha^{-1}), is economically feasible treatment for improving productivity of faba bean crop.

The three – factor interaction was significant for all studied traits at two locations in both seasons, hence, it is statistically valid to discuss the results of that interaction regardless of the significance of two-factor interactions.

Data in table (8) indicated that Sakha-1 (v2) superior to all other varieties and produced the highest values number of branche per plant(11.0 and 10.67),number of pods / branche (12.8 and 12.0) and number of pods / m^2 (316 and 296) ,resulting in the highest seed yield(3037 and 2860 kg/fed),straw yield (4988 and 4166 kg/fed) and biological yield (6982and 6314) kg/fed)in both seasons , respectively, at the highest level of application (50 kg P_2O_5/fed).

Table 7. Response the yield and yield components of faba bean to phosphorus fertilizer at two growing seasons. 2020-2021and 2021-2022

	P.H (Cm)	No. of B/P	No. of P/B	No. of P/ m^2	No. of S/P	100 S.W. (g)	S.Y Kg/fed	St. y. Kg/fed	B.Y. Kg/fed	C.I. %	PUF
					Season 2020-2021						
F0	102.67	6.042	6.312	123.9	3.708	100.49	1248	2772	4020	46.22	----
F1	120.12	7.208	7.633	177.7	4.583	108.25	1843	3349	5192	57.11	23.80
F2	132.17	8.292	8.675	226.3	5.250	117.07	2427	3558	5985	70.47	23.58
LSD5%	**2.339**	**0.264**	**0.342**	**6.62**	**0.298**	**1.79**	**53.4**	**162.5**	**149.3**	**0.042**	**0.013**
					Season 2021-2022						
F0	95.79	5.667	5.875	110.1	3.458	96.79	1171	2515	3686	47.65	-------
F1	112.62	6.667	7.167	162.4	4.208	103.33	1738	3151	4889	57.18	22.68
F2	124.67	7.708	8.125	207.7	4.958	112.50	2246	3477	5723	67.25	21.50
LSD5%	**2.99**	**0.281**	**0.245**	**6.28**	**0.298**	**2.23**	**62.7**	**169.3**	**139.5**	**0.042**	**0.o12**

Table 8. The interaction effect between four faba bean cultivars and three levels of phosphorus at two locations in at both seasons. 2020-2021and 2021-2022

	P.H(Cm)		**No. of B/P**		**No. of P/B**		**No. of P/m^2**		**No. of S/P**		**100 S.W.(g)**		**S.Y. Kg/fed**		**St. Y. Kg/fed**		**B.Y. Kg/fed**		**C.I. %**		**PUE**	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
L1V1F0	111.30	105.00	7.33	7.00	3.87	3.67	63.30	58.00	4.33	4.00	124.98	120.01	1077.00	1029.00	2397.00	2303.00	3434.00	3332.00	46.84	45.54	-- --	--
L1V1F1	129.33	122.33	8.33	8.00	4.37	4.00	103.00	90.00	4..67	4.33	131.22	127.21	1670.00	1579.00	3321.00	3027.00	4991.00	4676.00	50.34	52.18	23.72	22.0
L1V1F2	137.67	135.33	9.00	9.00	4.93	4.67	142.00	124.70	5.00	5.00	139.76	136.82	2016.00	1781.00	4035.00	3879.00	6051.00	5660.00	50.17	46.19	18.78	15.04
L1V2F0	122.33	115.00	8.33	8.00	8.50	8.00	175.70	164.30	4.00	3.67	106.87	101.84	2078.00	1935.00	3065.00	2857.00	5142.00	4792.00	67.97	67.90	----	---
L1V2f1	136.67	126.67	9.00	9.00	9.87	9.33	204.70	204.30	4.33	4.00	118.08	105.95	2594.00	2411.00	3225.00	2934.00	6159.00	5244.00	80.43	82.17	20.64	19.04
L1V2F2	146.00	138.67	11.00	10.67	12.80	12.00	253.00	239.00	5.00	4.67	125.48	116.23	3037.00	2860.00	3707.00	3004.00	6744.00	5865.00	81.88	95.32	19.18	18.5
L1V3F0	141.33	130.67	7.33	7.00	7.50	7.00	170.00	162.30	3.67	3.33	84.20	83.88	1259.00	1176.00	3143.00	2940.00	4402.00	4116.00	41.48	41.45	------	--
L1V3F1	155.33	141.67	8.00	7.67	9.50	9.00	248.00	235.70	4.00	3.67	91.42	89.32	2113.00	1998.00	3272.00	3037.00	5384.00	5034.00	64.76	65.98	34.16	32.88
L1V3F2	164.00	151.00	8.33	8.33	10.53	10.00	313.70	195.30	4.33	4.00	99.86	94.28	2892.00	2698.00	3422.00	3613.00	6311.00	6314.00	84.55	74.67	32.66	30.44
L1V4F0	101.33	95.00	5.00	4.67	6.30	6.00	123.30	112.70	3.00	2.67	95.39	91.28	1126.00	1043.00	2643.00	2240.00	3769.00	3283.00	45.35	49.36	---- -	---
L1V4F1	122.67	122.33	6.33	6.00	7.33	7.00	189.70	175.00	3.67	3.00	105.57	99.68	1590.00	1508.00	3995.00	3738.00	5589.00	5246.00	39.82	40.39	18.55	18.6
L1V4F2	138.33	136.33	8.00	7.67	8.13	7.67	235.30	215.30	4.33	4.00	114.36	110.33	2034.00	1880.00	4948.00	3822.00	6982.00	5702.00	41.10	49.48	18.16	16.74
L2V1F0	77.67	70.67	4.00	3.33	3.67	3.33	76.70	50.70	4.67	4.67	117.05	112.15	1224.00	1116.00	2588.00	2333.00	3812.00	3648.00	47.29	47.83	---	----
L2V1F1	92.00	84.67	5.67	5.00	5.00	4.33	103.30	83.00	6.00	5.67	122.50	118.83	2050.00	1890.00	2617.00	2421.00	4667.00	4311.00	78.33	79.20	33.04	30.96
L2V1F2	105.33	96.33	6.00	6.00	5.33	4.67	124.00	113.30	7.00	6.67	129.73	127.94	2624.00	2465.00	2812.00	2705.00	5436.00	5170.00	93.3	91.12	28.0	26.98
L2V2F0	66.67	61.67	7.00	4.33	6.00	5.33	113.00	86.70	3.33	3.00	86.50	85.29	1098.00	1049.00	3518.00	3003.00	4616.00	4052.00	31.26	35.03	-	----
L2V2F1	80.67	72.33	9.00	5.00	7.33	6.67	164.30	135.30	4.67	4.00	94.63	93.15	1593.00	1487.00	3725.00	3385.00	5319.00	4872.00	42.82	44.29	19.8	17.52
L2V2F2	98.33	84.33	11.00	5.67	7.67	7.00	211.70	179.30	5.33	5.00	109.47	103.04	2041.00	1895.00	3968.00	4166.00	6009.00	6061.00	51.44	45.48	18.86	16.92
L2V3F0	105.33	101.00	4.67	4.45	9.00	8.67	158.00	144.00	3.33	3.33	98.53	94.43	1170.00	1028.00	2726.00	2150.00	3851.00	3178.00	43.15	48.53	-	-----
L2V3F1	118.00	115.33	8.00	6.00	11.33	11.00	232.70	212.70	4.67	4.67	104.13	98.70	1763.00	1604.00	3268.00	3280.00	5030.00	4885.00	54.31	49.3	23.72	23.04
L2V3F2	129.33	123.33	9.00	6.89	12.33	12.00	317.00	296.70	5.67	5.33	110.27	108.04	2305.00	2175.00	2958.00	2948.00	5263.00	5123.00	7792	73.78	22.7	22.94
L2V4F0	95.33	87.33	4.67	4.00	5.67	5.00	111.30	102.00	3.33	3.00	90.50	85.46	997.00	952.00	2179.00	2090.00	3151.00	3081.00	45.75	45.55	000	000
L2V4F1	125.33	115.67	5.33	4.67	6.33	6.00	176.00	162.70	4.67	4.33	98.43	93.80	1428.00	1371.00	3667.00	3488.00	5037.00	4920.00	39.3	40.99	16.76	17.24
L2V4F2	138.33	130.00	6.33	5.33	7.67	7.00	214.00	198.00	5.33	5.00	107.63	103.33	1786.00	1725.00	3718.00	3573.00	5443.00	5359.00	48.03	48.28	15.64	15.78
LSD5%	**6.94**	**7.87**	**0.92**	**1.01**	**1.35**	**1.03**	**22.44**	**21.57**	**1.01**	**0.88**	**6.30**	**5.68**	**175.20**	**193.70**	**436.50**	**442.80**	**399.00**	**378.20**	**0.12**	**0.14**	**0.012**	**0.021**

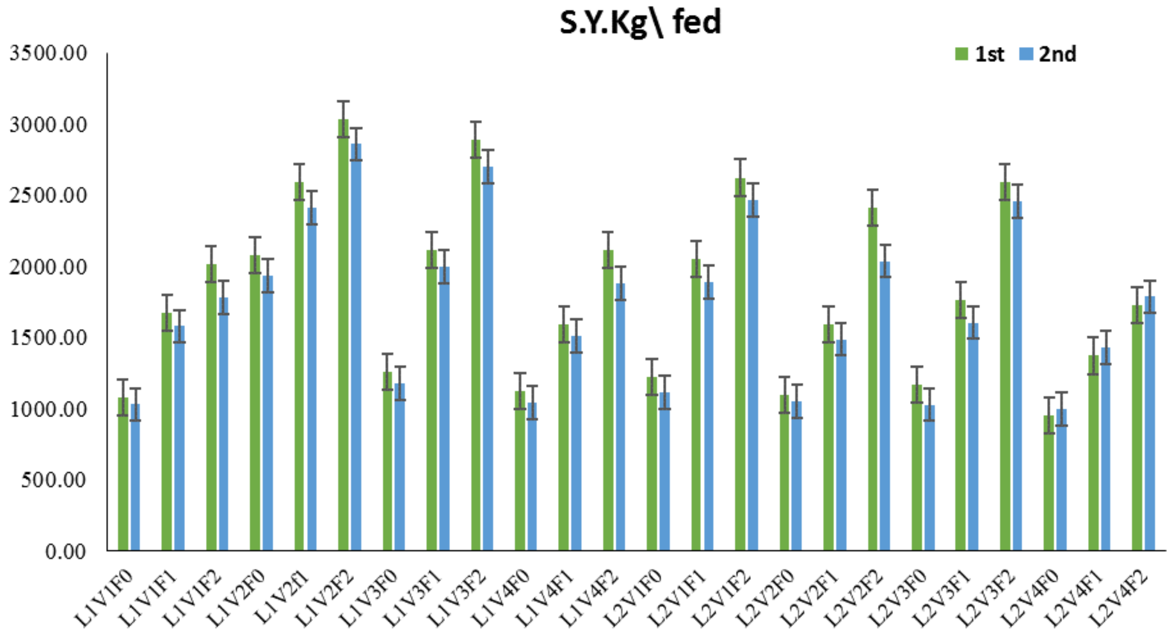


Fig 1. Seed yield of faba bean as affected by the interaction effect between four cultivars and three levels of phosphorus at two locations in at both seasons

However Espain had highest values for number of seeds/pod (7.0 and 6.76) and 100-seed weight (139.76 and 136.82 g) in both respective seasons, resulting in a high crop index (93.30 and 91.12%) respectively. The lowest values for all studied traits in four cultivars resulted from zero addition of phosphorus fertilizer. However, the phosphorus use efficiency (PUE) significantly decreased with increasing rate of P-rates from 25 to 50 kg P_2O_5/fed, in the two locations and all fab bean cultivars.

The correlation matrix plot (correlogram)

The correlation matrix plot illustrating Pearson's correlation coefficient was used to clearly show the correlations between the attributes of four different broad bean cultivars and three amounts of phosphorus at two locations over both seasons (table 9). A positive correlation ($p<0.01$) was observed among all possible pairs for S.Y Kg/fed; No. of B/P; No. of P/B; No. of P/m^2; No. of S/P; 100-S.W. (g); S.Y Kg/fed; St. Y. Kg/fed; B.Y. Kg/fed; and C.I. %. Similarly, S.Y Kg/fed traits depicted a significant positive correlation among all of them ($p<0.01$) in the first season. However, in the second season S.Y Kg/fed showed a significant positive correlation with all the studied traits ($p<0.01$). Except 100-S.W. (g) and St.Y. Kg/fed, which had a negligible effect on seed yield, ($p>0.05$). Generally, the highest positive correlation was observed between seed yields (Kg/fed) with most of the studied traits of four cultivars of faba bean cultivars under three levels of P- effects in both seasons (table 9). These results agree, Alghamd (2007) found significant positive correlations between seed yield and each of number of pods per plant, number of seeds per plant, seed weight per plant and biological yield. Tadesse et al. (2011) found number of pods / plants, number of seeds per pod, thousand seed weight and plant height had significant association with seed yield / plot. The seed yield / plant exhibited significant positive correlation with, pod length, plant height, branches /plant, pods /plant and hundred seed weight (Badol et al., 2009). Ulukan et al. (2003) also significant positive relationships found between biological yield and plant height and grain number/pod. Keneni and Jarso (2002) indicated positive and significant correlation between seed yield and no. of pods \ plant.

Tale 9. The correlation matrix plot between the studied traits of faba bean under the interaction effect of four cultivars and three levels of phosphorus at two locations in at both seasons

			Season 2									
			P.H(Cm)	No. of B/P	No. of P/B	No. of P/m2	No. of S/P	100 S.W.(g)	S.Y Kg/fed	St. Y. Kg/fed	B.Y. Kg/fed	C.I. %
Season 1	P.H(Cm)	r	1	.763**	.533**	.656**	.026	.146	.531**	.376	.545**	.326
		p		.000	.007	.001	.902	.496	.008	.070	.006	.120
	No. of B/P	r	.393	1	.656**	.616**	.159	.353	.650**	.223	.523**	.546**
		p	.058		.000	.001	.457	.091	.001	.296	.009	.006
	No. of P/B	r	.513*	.358	1	.904**	-.027	-.279	.585**	.211	.473*	.476*
		p	.010	.086		.000	.901	.186	.003	.321	.020	.019
	No. of P/m^2	r	.666**	.402	.889**	1	.092	-.193	.639**	.440*	.644**	.422*
		p	.000	.052	.000		.671	.365	.001	.032	.001	.040
	No. of S/P	r	-.032	.054	.139	.221	1	.694**	.562**	.213	.464*	.515**
		p	.880	.803	.518	.299		.000	.004	.319	.023	.010
	100 S.W.(g)	r	.142	.269	-.213	-.182	.232	1	.354	.104	.278	.346
		p	.509	.203	.318	.396	.276		.090	.628	.189	.097
	S.Y Kg/fed	r	.537**	.620**	.595**	.678**	.468*	.426*	1	.386	.828**	.847**
		p	.007	.001	.002	.000	.021	.038		.062	.000	.000
	St Y Kg/fed	r	.352	.600**	.275	.471*	.027	.042	.325	1	.837**	-.153
		p	.092	.002	.193	.020	.901	.846	.121		.000	.475
	B.Y. Kg/fed	r	.327	.670**	.397	.465*	.311	.366	.626**	.744**	1	.409*
		p	.119	.000	.055	.022	.139	.079	.001	.000		.047
	C.I. %	r	.343	.296	.432*	.432*	.518**	.434*	.865**	-.175	.286	1
		p	.101	.161	.035	.035	.010	.034	.000	.414	.175	

Principal component analysis (PC)

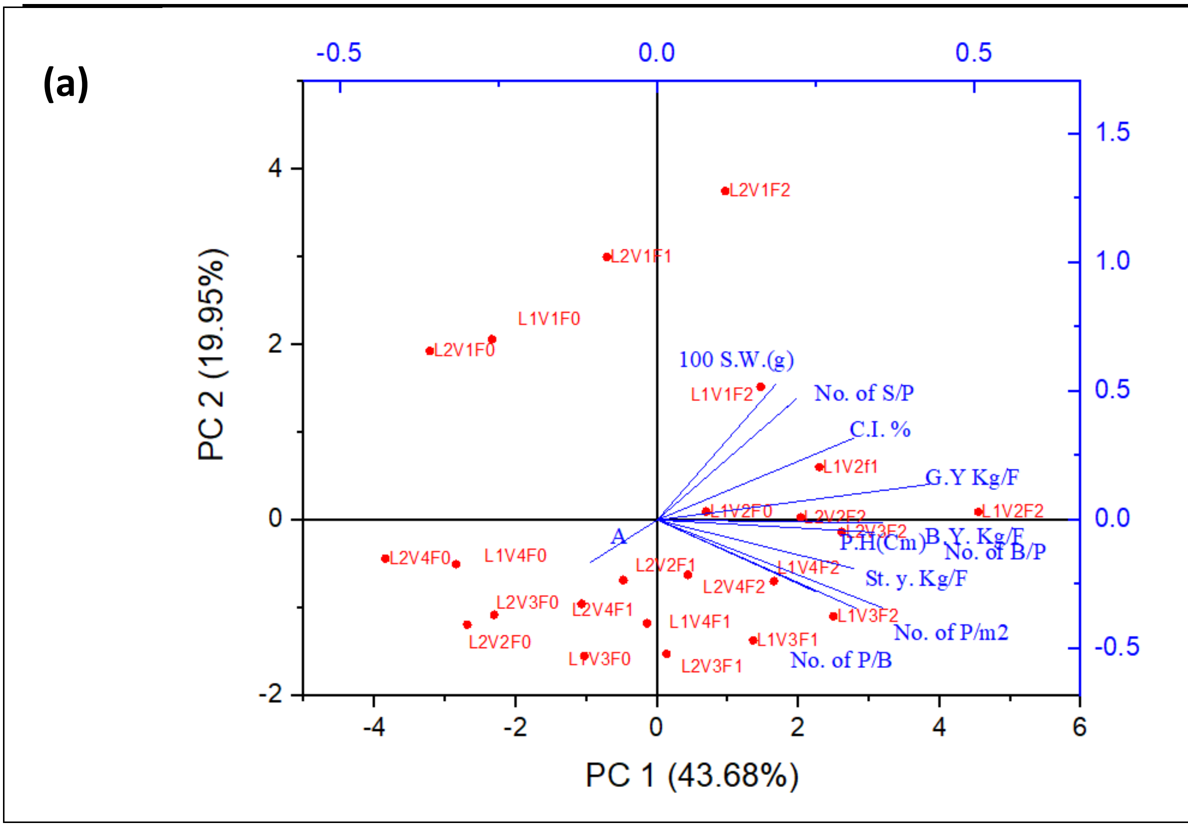
The five PCs for all faba bean traits under three experimental factors (i.e., faba bean cultivars, levels of phosphorus) at two locations at both seasons, are shown in Table10, Out of all PCs, the three first main PCs (PC1 PC2, and PC3) extracted had eigenvalues as **4**.76131, 2.16461 and 1.45412 in the first season and 5.02666, 2.08019 and 1.40553 in the **se**cond season which accounted for (47.61%, 21.65 and 14.54%) and (50.27%, 20.80%,14.06%) of the variation, respectively, with a cumulative total (47.61%, 69.26%, 83.80%) and (50.27%, 71.07%, 85.12%) from total variation in first and second seasons respectively. Therefore, the PC1, PC2 and PC3 were kept for the final analysis, in which, the three PCs explain variance more than an individual attribute (Sharma, 1996) and it expresses more variability and support to select the trait with a positive loading factor.

The contributions of PC1 to the total variance were higher than PC2 (21.65%, 20.80%) and PC3 (14.54%, 14.06%), with PC1 describing only about 47.61%, 50.27% of the measured data from total variability in both seasons respectively.. The PC1 had a positive correlation for all studied traits of faba bean verities, at both locations in both seasons. The PC2 has identified all studied traits of faba bean verities possessing positive loading factors and contribution to the variables except P.H (Cm), No. of B/P, No. Of P/B, No. of P/m^2., and St.Y. Kg/fed in both seasons. (Figure 2).

Also, Tiwari and Singh (2019) found that first three PC exhibited eigen values more than one and explained about 75.53% of the total variations, so first three PCs were given due importance for further explanation. First PC considered as the most important component which explained 44.00% of the total variance. The third principal component accounted for 15.13% of the total variance, and was positively influenced by PH and PL. Rebaa et al. (2017) found that, the first three PCs accounted for 40.56% of the total variation, of which PC1, PC2 and PC3 explained 20.64, 11.22 and 8.70% of the variation, respectively. Zayed et al. (2022) found that the first PCs had 54.40% and 37.90% of the total variation (PC1) and PC2explained 14.30% and 24.90% of the total variation for morphological and biochemical traits, respectively. The cumulative ratio of the first six primary PCs explained all variations of total variation.

Table10. Results of principal component analysis (PCA) in the first seven principal components (PCs) for the studied faba bean traits as affected by the three experimental factors (i.e., fab bean cultivars, levels of phosphorus) at two locations at both seasons

		PC1	PC2	PC3	PC4	PC5	PC6	PC7
1st Season	P.H(Cm)	0.309	-0.188	0.085	-0.348	0.690	-0.207	-0.144
	No. of B/P	0.342	-0.048	-0.374	-0.123	-0.498	-0.290	0.310
	No. Of P/B	0.313	-0.343	0.317	-0.046	-0.218	0.500	0.067
	No. of P/m2	0.355	-0.342	0.257	0.045	0.110	-0.058	0.220
	No. of S/P	0.219	0.469	0.091	0.381	0.135	-0.394	-0.060
	100 S.W.(g)	0.187	0.529	-0.165	-0.019	0.299	0.565	0.465
	S.Y Kg/fed	0.428	0.138	0.158	-0.007	-0.137	-0.115	0.087
	St.Y. Kg/fed	0.250	-0.280	-0.489	0.287	0.195	-0.121	0.210
	B.Y. Kg/fed	0.355	-0.011	-0.328	0.312	-0.044	0.329	-0.695
	C.I. %	0.311	0.319	0.414	-0.109	-0.213	-0.094	-0.181
	Eigenvalue	4.76131	2.16461	1.45412	0.57327	0.47854	0.29832	0.13619
	% Of Variance	47.61%	21.65%	14.54%	5.73%	4.79%	2.98%	1.36%
	Cumulative	47.61%	69.26%	83.80%	89.53%	94.32%	97.30%	98.66%
2nd Season	P.H(Cm)	0.330	-0.182	0.018	0.555	-0.225	0.661	-0.110
	No. of B/P	0.362	-0.057	-0.197	0.492	0.190	-0.452	-0.112
	No. Of P/B	0.327	-0.375	-0.215	-0.195	0.398	-0.210	0.583
	No. of P/m2	0.365	-0.330	-0.009	-0.173	0.352	0.244	-0.427
	No. of S/P	0.199	0.541	0.049	-0.284	0.477	0.408	0.541
	100 S.W.(g)	0.133	0.589	0.024	0.413	0.219	-0.186	-0.025
	S.Y Kg/fed	0.412	0.148	-0.086	-0.223	-0.389	-0.095	-0.020
	St.Y. Kg/fed	0.229	-0.051	0.717	-0.042	-0.028	-0.151	-0.112
	B.Y. Kg/fed	0.384	0.059	0.385	-0.152	-0.250	-0.151	-0.030
	C.I. %	0.306	0.215	-0.492	-0.237	-0. 37495	0. 00273	0.121
	Eigenvalue	5.02666	2.08019	1.40553	0.84933	0.2971	0.24066	0.06657
	%of Variance	50.27%	20.80%	14.06%	8.49%	2.97%	2.41%	0.67%
	Cumulative	50.27%	71.07%	85.12%	93.62%	96.59%	98.99%	99.66%



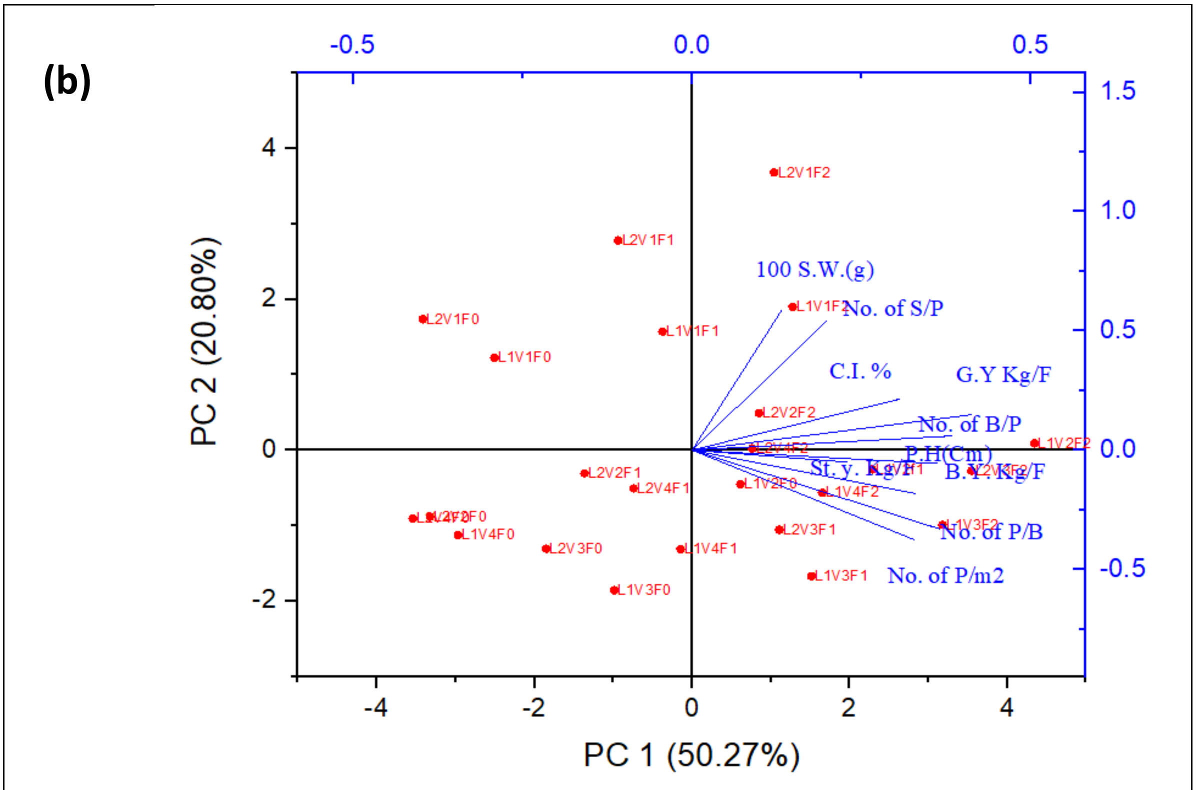


Fig 2. A biplot diagram based on PC1 and PC2 shows similarities and dissimilarities relationships among the measured traits across four faba bean cultivars and different three levels of phosphorus at two studied locations in both seasons, a) 1st season, b) 2nd season

CONCLUSION

Inconclusion, the fertilizing broad bean Sakha-1 varieties with 50 kg P_2O_5/fed gave the highest values of yield and its component under environmental conditions El-Kharga-New Valley (New Valley governorate) and El-Tur location (South Sinai government). The highest positive correlation was observed between seed yield (Kg/fed) with most of the studied traits of four cultivars of faba bean cultivars under three levels of phosphorus effects in both seasons. Out of all PCs, the three (PC1 PC2, and PC3) extracted had (Eigenvalue >1). While the rest of other PCs had eigenvalues. The PC1, PC2 and PC3 were therefore retained for the final analysis, in which the three PCs express more variability and support the choice of the trait with a positive loading factor because they explain variance more thoroughly than a single characteristic.

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الملخص العربي

إستجابة بعض أصناف الفول البلدي للتسميد الفوسفاتى تحت ظروف منطقة الطور والوادي الجديد

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يعد الفول البلدى من أهم المحاصيل البقولية الشتوية على مستوى العالم ، ولزيادة إنتاجية الفول البلدى ويعد إختيار الأصناف المناسبة والتى تتناسب مع الظروف البيئية ، وإستخدام الممارسات الزراعية المناسبة ومنها مستويات التسميد الفوسفاتى،من الأمور التى تساهم بشكل كبير فى زيادة إنتاجية الفول البلدى خاصة فى ظل التغيرات المناخية.

أجريت الدراسة خلال موسمى ٢٠٢٠-٢٠٢١ و٢٠٢١-٢٠٢٢ بالمواقع الأتية فى موقعين : الموقع الأول (الخارجة- محافظة الوادى الجديد) والموقع الثانى (موقع الطور – محافظة جنوب سيناء) يهدف لدراسة مدى إستجابة بعض أصناف الفول البلدى(نوبارية١ ، سخا١ ، مريوط٢ ، وجيزة ٨٤٣) لثلاث مستويات من التسميد الفوسفاتى (بدون إضافة ، ٢٥ ، ٥٠ كجم بو٢أ٥ (١٢,٥ %) بمواقع مختلفة (الخارجة- الوادى الجديد ، والطور – جنوب سيناء) على محصول الفول البلدى ومؤشراتة وكفاءة إستخدام الفوسفور ويمكن تلخيص أهم النتائج على النحو التالى :

أدى زراعة أصناف الفول البلدى فى الموقع الأول (الخارجة- الوادى الجديد) أدى إلى زيادة معنوية فى كل من محصول البذور ومؤشرات المحصول وذلك فى كلا موسمين الزراعة،أن صنف الفول سخا ١ متفوق على بقية الأصناف (الأسبانى ومريوط ٢ ، وجيزة ٨٤٣) وأعطى أعلى القيم فى كلا من محصول البذور ،والقش والمحصول البيولوجى كجم/فدان فى كلا الموسمين. بإستثناء عدد البذور/قرن، ووزن ال١٠٠ بذرة.

سجل الصنف الفول الأسبانى أعلى القيم فى كلا من وزن ال١٠٠ بذرة ، وعدد البذور/قرن خلال موسمى الدراسة ، بينما سجل الصنف الفول البلدى مريوط٢ أعلى القيم فى كلا من إرتفاع النبات ، وعدد القرون/ فرع وكفاءة إستخدام الفوسفور فى كلا الموسمين

كما دلت النتائج أنه بزيادة التسميد الفوسفورى حتى معدلات إضافة من(بدون إلى ٥٠ كجم/فدان) تسبب فى زيادة معنوية فى كل من صفات النمو ،و ممحصول البذور ومكوناتة فيما عدا كفاءة إستخدام الفسفور كان هناك نقص معنوى بزيادة مستويات التسميد الفوسفاتى

اعطى صنف الفول البلدى سخا١ مع مستوى التسميد الفوسفوري (٥٠ كحم فو٢أ٥) تحت ظروف الخارجة الوادى أعلى القيم فى كل من المحصول ومكوناته خلال موسمي الدراسة.لوحظ وجود تفاعل معنوى بين عوامل الدراسة ، حيث أدت زراعة الفول صنف سخا ١ مع مستوى التسميد الأعلى (٥٠ كحم/فدان) تحت ظروف الوادى الجديد إلى تحقيق أعلى القيم فى كل من المحصول ومكوناتة خلال موسمى الدراسة.

فيما يتعلق بمعامل الإرتباط: لوحظ وجود علاقة إرتباط طردية بين محصول الحبوب (كجم / ف) مع معظم الصفات المدروسة لأربعة أصناف من أصناف الفول تحت ثلاثة مستويات لتأثير الفسفور في كلا الموسمين.

كما أثبت إختبار تحليل مكونات المحصول أن كانت أول ثلاثة مكونات الرئيسية PC1 PC2) و (PC3المستخرجة تحتوي على قيم ذاتية أكبر من الواحد الصحيح .(Eigenvalue> 1) بينما كان لبقية المكونات الأخرى قيم ذاتية أقل من الواحد .(Eigenvalue <1)مما يشير الى الاحتفاظ بـ PC1 و PC2 و PC3للتحليل النهائي ، حيث تشرح تلك المكونات الثلاثة التباين أكثر من سمة فردية وتعبر عن مزيد من التباين والدعم لاختيار السمة مع عامل تحميل إيجابي فيما يخص المحصول ومكوناته.

الكلمات الدالة: أصناف – الفول البلدى – المواقع المختلفة- الإرتباط – تحليل مكونات المحصول – التسميد الفوسفاتى