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Chemical Composition of Some Faba Bean (*Vicia faba* L.) Cultivars as Affected by Phosphorus Fertilizer at Different Location Under New Valley Conditions

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Abstract: One of the most prime winter-sown legume crops worldwide is the faba bean. It is benefit to enhance the yield of stable cultivars under proper 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- and Al-Dakhla-New Valley during two successive seasons, 2019-2020 and 2020-2021, to study the effect of phosphorus fertilizer on the chemical composition of some faba bean cultivars at different location. The experiments included four broad bean cultivars i.e., Nubaria1, Sakha1, Mariout 2 and Wady1 and three phosphorus levels i.e., 0, 25and 50 kgP_2O_5\fed (12.5%P_2O_5). The results indicated that cultivar Sakha 1 produced the highest seed, straw and biological yield (kg\fed) and CHL.A, B. Fertilizing faba bean plants with 50 kg P_2O_5 produced the highest value of all studied traits during two seasons. The obtained results showed that the phosphorus fertilizers had an appositive effect on biochemical components in all cultivars at two locations. The treatment of (L2V2F2) has the highest chlorophyll a, b, and seed, straw and biological yield (kg\fed) while V4(Wady1) cultivar with F2, and L2 recorded the high values in carotenoids, proline, K, Ca, Mg, N, and total protein content in faba bean seeds about other cultivars. Seed yield (Kg/fed) was significantly positive correlation with chlorophyll Aand B, carotenes, nitrogen, protein ($p<0.05$). However, it was significantly strong positive correlation with proline, potassium, magnesium, and calcium with $p<0.001$.

Key words: Faba bean, cultivars, phosphorus fertilizer, pigments, minerals, proline, protein.

INTRODUCTION

Faba bean (*Vicia faba* L.) considered the main winter sown legumes crops cultivated in the world and has considerable importance as low-coast food wealthy in proteins and carbohydrates **Sepetoglu (2002)**. Faba bean has four functions in agro- ecosystems: providing food for human and feed for animal that is rich by protein; increasing soil fertility by providing to agro ecosystems N2 fixation by Rhizobium; variating the crop system to reduce treatments on growth and yield by another crops in the cyclic; and decrease fossiliferous energy consumption for crop yielding. Faba bean is used pantry of protein in human diets as fodder of human and forage crops for animal, and for perfect ability to fix atmospheric nitrogen. In many countries, mature faba bean seeds are cooked into stew or paste for human consumption, or fed directly to lives tock. In the Worldwide, 2.65 million ha of faba bean are now under cultivation, producing 5.6 Mt of dry grains **(FAOSTAT, 2022)**. Faba bean is lustrous future as a protein crop that provide adding crop cycle benefits for many area of the world. The expanded use of faba bean as a nutritious plant based protein food ingredient demands chemical and genetic investigation into seed mineral elements **Crepon *et al.* (2010)**. Faba bean is rich by protein, its content ranges from 24 %to 35 % of the seed dry matter (DM) and it is wealthy infinitive of many micronutrients often- found locking diets **(Crepon *et al.*, 2010, Robinson *et al.*, 2019)**. Seeds of faba bean of pules crop generally have higher concentration of mineral (e.g. Fe, Zn, Ca, and Mg) than cereal grains **(White and Broadly, 2009)**. **Ahamed (2022)** found that the seed chemical composition analysis revealed that the genotypes various in their composition, such as protein (26.65 to 30.72%) carbohydrate (58.00 to 62.25%), tannin (70.76 to 157.45%), phenols (32.23-51.02%) and moisture (9.15 to 10.45%). **Abou-El-Seba *et al.* (2016)** cleared that the gaining yield of crops cultivated after harvesting of legumes are equipollent to these predicable from addition of 30 to 80 kg N fertilization\ ha. **Robinson *et al.* (2019)** found that the expanded of the use of faba bean as a nutritious plant based protein food ingredient demands chemical and genetic investigation into seed mineral elements. **Kazaei, and Vandenberg, 2020)** and **Marshall *et al.* (2021)** showed that faba bean seeds are a high provenance of generous quality protein (290 g kg^{-1} % of dry matter), vitamins, and other precious nutrients.

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 bread bean cultivars. **Alghamdi and Popvic (2009)** showed that the chemical composition of legume seeds depends on many factors, including weather, cultivars and agriculture practices. **Ton *et al.* (2021)** cleared that faba bean seeds content many nutrients, depending on the differed variety**. Pluduma Paunina *et al.* (2018)** revealed that the yield of faba bean depends on temperature and moisture conditions. **Pual *et al.* (2021)** reported that faba bean yields variable from 1.5 to 2.0-ton ha^{-1} and protein content in the seed variable from 31.5 to 34.2 %DM. **(Abdel-Baky *et al.*, 2019)**. Field bean seed yield and thousand seed weight has been significantly. **Sharan *et al.*, 2021; Sabah *et al.*, 2001 and Karamanos *et al.*, 1994** showed that chemical composition of 11 field grown faba bean cultivars into cultivation spells was estimated differed between genotypes was always highly significant and most cultivars shown a invariant rank in protein concentration.

Abou El-Seba *et al.* (2016) found that the plant height, weight, and number of pods plant and seed output of faba bean cultivars varied significantly. Additionally, cultivars may be crucial in boosting seed production due to how they react to applied cultural methods and environmental factors. Numerous studies found that the vegetative and yield characteristics of evaluated cultivars varied significantly. (**Nour El-Din *et al.*, 2020). Al-Shuumary (2020)** stated that most faba bean features showed substantial changes between the test types, and most vegetative development, yield components, yield, and seed chemical analyses among faba bean cultivars also showed notable differences**. (Panayiota *et al.*, 2021)** showed that there were significant differences in the biomass, seed yield, and yield attributes among the six conditions. Only thousand seed weight was equally influenced by genotype and environment, whereas most of attributes were primarily affected by the environment. Sustainability i.e. practices increasing the growth yield by 88% over the yield of traditional forms practices. Besides different cultivars have different response to inputs.

P fertilizer, fertilization with 40 kg ha^{-1} had 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 **(Yasmin *et al.*, 2020). El-Safy *et al.* (2021a)** revealed that with the exception of mid physiological maturity and phosphorus use efficiency, most vegetative growth, yield traits, 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 output. The superiority of applying 30 kg of phosphorus per fed may be attributed to its positive effects on the index of chlorophyll content, plant height, number of branches, plant weight, number of pods and seeds per plant, plant seed yield, harvest index, 100-seed weight, and biological yield/fed, as well as the lower position of the first pod observed during both seasons. **Richards et al. (2011)** indicated that the increment in solubility of phosphorus in soil solution reasons an increment in iron executant by the plant which contributes in increment nitrogen fixation by legumes than increment protein content and seed quality. **Kadil *et al.*, 2019**, **Negasa *et al.*, 2019**, and **Yasmin *et al.* (2020**), many actualizations revealed that increment phosphorus levels given significant increment in most vegetative growth, yield attributes, yield and seed chemical properties characters of faba bean except, No. of days from height to 1st pod and phosphorus use efficiency. **El-Mahdy *et al.* (2021)** indicated that increment phosphorus fertilizer reason increase proline produce in faba bean seeds. **Abou Hussien *et al.* (2002)** reported that plant height, No. of pods and seed\plant as well as weight of pods and seeds\ plant straw, biological yield and seed protein content were increasing due to phosphorus fertilizer adding. **Mam Rasul (2017)** indicated that adding of the proper quantity of nitrogen and phosphorus can reason to increment of chlorophyll content index (CCI) in the leave and harvest index (HI%) percent of broad bean plants**. Esmail and Miran (2012)**, produced the highest values for plant height, dry matter weight, yield, the number of active nodules, phosphorus content, and protein content. Therefore, the present work aims to study the effect of phosphorus fertilizer on growth, yield, and chemical components in faba bean plants under two different locations.

MATERIALS AND METHODS

Field Experiments were conducted for two consecutive growing seasons -2019-2020 and 2020-2021 at two different locations. i.e., El-Kharga region (25^0 33' 55.5''N, 30^0 37'50.9''E) and Al-Dakhla (New valley Government) (29^0 08' 18.7''E, $25^0$32' 32.4 N) for each location, soil properties and water analysis.

These trails were performed to study the effect of phosphorus fertilizer on the chemical composition (chlorophyll a, b, carotenoids, proline, K, Ca, Mg, N, and total protein) and seed yields, of some faba bean cultivars, Nubaria1, Sakha 1, Mariout 2, and Wady1 were sown in 15and 20 October in the first and second season, 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, 25 and 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 at 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.

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 in (A.O.A.C., 2005) and presented in **Table 1.**

Table (1). 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 (El-Kharga location)

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	4.9	2.9	1.7	38.0	6.4	0.0	22.0	22.0	5	26.3	Sandy
Irrigation Water analysis												
-	7	2.1	24	26.73	230	37	NIL	350.14	186.8	171.6	-	-

El-Dakhala location

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	7.9	4.5	19.5	13.5	26.1	1.05	0.0	3..00	32.5	6.65	7.6	Sandy
Irrigation Water analysis												
-	7.5	3.1	8.712	20.56	230	23	NIL	320.18	166.5	125.8	-	-

Metrological data at different location

Table (2). Meteorological data of the two growing seasons in El-Dakhala location

Month	(T) Mean temperature (°C)	(TM) Maximum temperature (°C)	(Tm) Minimum temperature (°C)	(H) Mean humidity (%)	(PP) Precipitation amount (mm)	(V) Mean wind speed (m/s)
Oct	25.8	33.8	19	28.2	0.0	2.2
Nov	25.8	33.8	19	28.2	0.0	2.2
Dec	13.4	31.1	7.4	49.1	0.8	2.3
Janu	10.9	18.5	4.6	37.3	0.0	2.2
Feb,	13.2	21	6.7	36.6	0.5	2.6
Mar	16.8	24.8	9.6	29.1	0.5	3.1
Apr	22.2	30.6	14.4	24.2	0.0	2.9
Jun	29.3	37.8	21	19.1	0.0	2.2
			Season 2020-2021			
Oct	25.6	33.5	18.8	31.5	00.00	1.92
Nov	25.6	33.5	18.8	31.5	00.00	1.92
Dec	15.5	23.3	9.4	45.5	00.07	2.17
Janu	10.3	17.7	4.3	52.9	01.46	2.39
Feb	13.0	20.5	6.6	46.3	26.46	2.36
Mar	18.0	26.4	10.6	34.3	00.13	2.94
Apr	22.0	30.1	14.2	26.3	00.00	2.53
Jun	27.4	35.4	19.60	21.30	00.00	25.0

Table (3). Meteorological data of the two growing seasons in El-Kharga location

Month	(T) Mean temperature (°C)	(TM) Maximum temperature (°C)	(Tm) Minimum temperature (°C)	(H) Mean humidity (%)	(PP) Precipitation amount (mm)	(V) Mean wind speed (m/s)
Oct	29.6	36.2	23.0	24.6	0.0	2.0
Nov	24.0	31.7	15	34.7	0.0	7.2
Dec	16.8	23.9	9.1	46.6	0.0	7.4
Janu	13.6	21.2	5.8	41.8	0.0	7.9
Feb	16.8	23.8	8.7	37.6	0.0	9.6
Mar	19.0	26.8	10.9	33.6	0.5	3.1
Apr	32.5	42.0	26.0	18.0	0.0	16.7
Jun	36.4	46.2	28.4	17.0	0.0	10.7
			Season 2020-2021			
Oct	29.56	37.09	21.14	31.00	0.0	9.34
Nov	20.45	27.07	13.09	49.07	0.0	6.63
Dec	18.12	25.47	9.92	43.94	0.0	6.51
Janu	13.83	21.36	5.83	46.31	0.0	5.24
Feb	15.69	23.81	6.29	45.33	0.0	5.87
Mar	20.72	28.79	11.63	34.25	0.0	10.57
Apr	23.59	30.67	15.58	28.27	0.0	7.57
Jun	30.16	37.50	20.65	22.25	0.0	8.83

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. At flowering stage, representative samples from the plants of each treatment were collected to determine chlorophyll, and proline content in fresh faba bean leaves. At harvesting stages, pods of each plant were harvested at full maturity stage (120 days after sowing), counted, and weighted to determine the yield and its components (seed yield, straw, and biological yield,). Samples of faba bean seeds were taken from each treatment to determine the minerals K, Ca, Mg, N, and total protein.

Determination of photosynthetic pigments

Chlorophyll a, chlorophyll b and carotenoids were determined according to **A.O.A.C (1990)**.

Procedure: About 0.5 g of fresh leaves samples was extracted by grinding in a mortar and pestle with acetone 85 % then centrifuged. The supernatant containing the pigments was kept and the residue was extracted several times. The extracts were combined, and the volume made up to a constant volume. The optical density was measured spectrophotometrically using (Spectro Genesys 5) at 662,644 and 440 nm.

Calculation: Concentrations of chlorophyll a, b and carotenoids were calculated using formula as follows:

Chlorophyll a (mg/l) = 9.784 × E 662 – 0.99 × E 644

Chlorophyll b (mg/l) = 21.426 × E 644 – 4.65 × E 662

Carotenoids (mg/l) = 4.695 × E 440 – 0.268 (Chlorophyll a + b)

Where E: Optical density at the wavelength indicated. The concentration of pigments was then expressed in mg/g fresh weight of leaves according to the following formula: mg/g = (mg/l x dilution) / (sample weight x 1000)

Determination of free proline

Free proline concentration was measured calorimetrically in the extract of fresh materials according to **Bates *et al.* (1973)**.

Reagents: (1) Sulfosalicylic acid (3%), (2) Phosphoric acid (6M), (3) Acid-ninhydrin: It was prepared by warming 1.25 g ninhydrin in 30 ml glacial acetic acid and 20 ml 6 M phosphoric acid, with agitation, until being dissolved. Stored at 4ºC in amber yellow bottle and the reagent remains stable 24 hours.

Procedure: 1) Approximately 0.5 g plant material (fresh leaves) was homogenized in 10 ml of 3% aqueous sulfosalicylic acid and the homogenate filtered through watman no.1 filter paper. 2)Two ml of filtrate was reacted with 2 ml acid ninhydrine and 2ml of glacial acetic acid in a test tube for 1 hour at 100°C, and the reaction terminated in an ice bath. 3) The reaction mixture was extracted with 4 ml toluene, mixed vigorously with a test tube stirrer for 15-20 sec. 4) The chromophore containing toluene was aspirated from the aqueous phase, warmed to room temperature and the absorbance read at 520 nm using toluene for a blank by (Spectro Genesys 5). And 5) the proline concentration was determined from a standard curve and calculated on a fresh weight basis as follows:

$$\mu\text{mole proline/g of fresh weight} = \frac{\mu\text{g proline/ ml x ml toluene x 5}}{115.5\ \mu\text{g}/\mu\text{mole x g sample}}$$

Determinations of minerals

About 0.2 g of dried grounded shoots was digested in H_2SO_4:H_2O_2 (5:1) for chemical analysis of minerals, Na, K, Ca, and Mg.

Determination of potassium and calcium and sodium concentrations were determined using flame photometer model (JENWAY PFP7) according to **Allen (1974).**

Magnesium determination: magnesium concentration was determined using atomic absorption (UNICAM 929 AA Spectrometer) using hollow cathode lamp differs according to each measured element.

Determination of total protein content

Total protein was calculated by multiplying the total nitrogen by 5.7 in (seeds) and 6.25 in (shoots and leaves). The total nitrogen was determined by using the micro Kjeldahl method according to **A.A.C.C. (1994)**. 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 2- Biological yield (kg/fed) 2- Straw yield (kg/fed).

Statistical analysis

All obtained data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) for the factorial experiment in complete randomized block design (CRBD) combined analysis over growing seasons was done when the homogeneity test was insignificant according as published by **Gomez and Gomez, (1984)** by means of Co-STATE Computer Software. Least significant difference (LSD) method was used to test the differences between treatment means at 5 % level of probability.

RESULTS AND DISCUSSIONS

Data in Table (4) shows the effect of different locations on pigments, proline, minerals, and total protein contents and yield components of faba bean plants. Data appeared that chlorophyll a, b, carotenoids, proline, calcium, and magnesium were significantly increased in location 2 compared to location 1 except for potassium, nitrogen, and total protein there were no significant differences between these values in the two location, the seed yield, straw and biological yield (kg\fed) were significantly by different location, The increase in seed yield, and other studied traits could be due to different environmental conditions and water salinity, **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 most of attributes were primarily affected by the environment. Sustainability i.e. practices increasing the growth yield by 88% over the yield of traditional forms practices. Besides different cultivars have different response to inputs. **Pluduma.Paunina *et al.* (2018)** revealed that the yield of faba bean depends on temperature and moisture condition. **Alghamdi and Popvic (2009)** showed that the chemical composition of legume seeds is depend on many factors, including weather, cultivars and agriculture practices. **Sharan *et al.* (2021); Sabah *et al.* (2001) and Karamanos *et al.* (1994)** showed that chemical composition of 11 field grown faba bean cultivars into cultivation spells was estimated differed between genotypes was always highly significant and most cultivars shown a invariant rank in protein concentration.

Table (4). Effect of different location

Location	Chl. A	Chl. B	Carotene	proline	K	Ca	Mg	N	Protein	S.Y	St.Y	B.Y
L1	1.083	0.499	0.357	8.188	3.2722	2.964	3.2794	2.454	15.5	1696	3116	4812
L2	1.210	0.591	0.468	8.731	3.2625	3.481	3.4164	2.496	15.59	1930	3282	5212
LSD5%	0.066	0.054	0.080	0.116	0.0353	0.224	0.1151	N.S	N.S	95.8	148.7	96.5

L1 is E1- Dakhla site, L2 is El-Kharga location (seed yield kg\fed), St. Y (straw yield kg\fed), and B.Y (biological yield kg\fed

Concerning the effect of some faba bean cultivars on all measurements

Data in the table (5) cleared that the highest mean value in all biochemical components were in V4 (Wady1) except CHL. A, B and potassium was accumulated in V2 (Sakha-1) compared to other cultivars. While V2 (Sakha-1) was superior to other cultivars in CHLA, B, seed, straw and biological yields kg/fed. **Sabah *et al.* (2001) and Karamanos *et al.* (1994)).** found that chemical composition of 11 field grown faba bean varieties into cultivation intervals was estimated differed between genotypes was always highly significant and most varieties shown a invariant rank in protein concentration. **Nour El-Din *et al.* (2020) and Chemicaly (2020)** found that most faba bean features showed substantial changes between the test types, and most vegetative development, yield components, yield, and seed chemical analyses among faba bean varieties also showed notable differences. Ahamed, (2022) found that the seed chemical composition analysis revealed that the genotypes various in their composition, such as protein (26.65to30.72%) carbohydrate (58.00to62.25%), tannin (70.76to157.45%), phenols (32.23-51.02%) and moisture (9.15 to 10.45%). **Ton *et al.* (2021)** cleared that faba bean seeds content many nutrients, depending on the differed variety. **Alghamdi and Popvic (2009)** showed that the chemical composition of legume seeds depends on many factors, including weather, cultivars and agriculture practices. **Ton *et al.* (2021)** cleared that faba bean seeds content many nutrients, depending on the differed variety. **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 bread bean cultivars

Table (5). Mean performance of some faba bean cultivars for various traits

Cultivars	CHLA	CHLB	Carotene	Poralein	K	Ca	Mg	N	Protein	S.Y	St.Y	B.Y
V1	1.114	0.524	0.3906	8.324	3.1406	3.028	3.3872	2.219	14.192	1744	2410	4154
V2	1.394	0..600	0.4150	8.416	3.3439	3.162	3.2350	2.468	15.423	2019	3422	5441
V3	1.266	0.561	0.4089	8.286	3.3056	3.317	3.3722	2.486	15.538	1934	3124	5058
V4	1.066	0.496	0.4300	8.810	3.2994	3.382	3.3972	2.728	17.046	1479	3258	4737
LSD5%	0.037	0.054	0.0163	0.093	0.0495	0.093	0.0461	0.098	0.276	101.6	189.8	176.4

V1 (Nubaria1), V2 (Sakha1), V3 (Mariout2), V4 (Wady1)

Regarding the effect of phosphorus fertilizer on biochemical components in faba bean varieties

Data presented in Table (6) showed that the phosphorous fertilization treatments had a significant effect on increasing the chemical components in different faba bean cultivars. In this connection, the F_2 treatment significantly increased all values in biochemical components and Seed yield components compared to other phosphorous treatments. All studied characters were significantly increased with increasing phosphorus fertilizer levels from 0 to 50 kg P_2O_5/fed and the difference between them were obvious through the growing seasons. Faba bean crops responded to increasing phosphorus fertilizer level up to 50 kg P_2O_5/ fed fertilization. **El-Safy *et al.* (2021)**, 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 output. The superiority of adding 30 kg of phosphorus per fed may be attributed to its positive effects on the index of chlorophyll content, plant height, number of branches, plant weight, number of pods and seeds per plant, plant seed yield, harvest index, 100-seed weight, and biological yield/fed, as well as the lower position of the first pod observed during both seasons, **Kadil *et al.* (2019); Negasa *et al.* (2019) and Yasmin *et al.* (2020)** ,many actualizations revealed that increment phosphorus levels given significant increment in most vegetative growth, yield attributes, yield and seed chemical properties characters of faba bean except, No. of days from height to 1st pod and phosphorus use efficiency. **Mam Rasul (2017)** indicated that adding of the proper quantity of nitrogen and phosphorus can reason to increment of chlorophyll content index (CCI) in the leave and harvest index (HI %) percent of broad bean plants. **El-Mahdy *et al.* (2021)** indicated that increment phosphorus fertilizer reason increase proline produce in faba bean seeds

Table (6). Effect of phosphorus fertilizer

Treatments	CHLA	CHLB	Carotene	Porolein	K	Ca	Mg	N	Protein	S.Y	St.Y	B.Y
F0	0.9250	0.4408	0.3142	6.612	2.2804	2.098	2.6154	2.023	12.889	1234	2696	3930
F1	1.2213	0.5779	0.4487	9.136	3.7308	3.740	3.6800	2.588	16.175	1826	3315	5141
F2	1.2938	0.6167	0.4704	9.628	3.8058	3.830	3.7483	2.814	17.586	2361	3588	5949
LSD5%	0.0374	0.0373	0.0175	0.064	0.0337	0.054	0.0428	0.074	0.226	57.8	161.2	147.3

F0 (Zero), F1 (25 kgP_2O_5\fed), F2 (50 kgP_2O_5\fed).

The three factor interaction was significant for all studied characters in the two locations and two growing seasons, hence, it is statistically valid to discuss the results of that interaction regardless of the significance of two-factor interactions. Data also in table (7) demonstrated that the interaction between different locations, faba bean cultivars and phosphorus fertilizer treatments. Data showed that the superior mean values of pigments; chlorophyll a, b, carotenoids, and minerals; K, Ca, Mg, N, and proline and total protein were recorded in cultivar 4 when plants of faba bean applied with phosphorus fertilizer at a rate of F2 in the second location (L2V4F2) compared other treatments. The V2 (Sakha-1) with F2 fertilize and second location was superior (L2V2F2) other treatment in CHL.A, B and seed, straw and biological yield. It is clear from the data that the phosphorus fertilizer had appositive effect on increasing the biochemical components in all faba bean cultivars. The results are confirmed with those reported by **Ahmed and El-Habbasha *et al.* (2007)** who illustrated clearly that supplied faba bean plants with phosphorus fertilization increased the mean values of N, P, K and protein content. In this concern, amending soils with phosphorus before sowing seeds seemed to be a most efficient treatment than amending soils with phosphorus after seedling emergence. Similar results were reported by **El-Shamma *et al*. (2000) and Abou Hussien *et al*. (2002)** indicating the positive effect of phosphorus fertilizers on the protein content in seeds. The effect of phosphorus on the chlorophyll content in plants was also reported by **Jiang *et al*. (2007); Pingoliya *et al*. (2015) and Chrysargyris *et al*. (2016). Esmail and Miran (2012)** indicated that the highest values of plant height, dry matter weight, and yield, number of active nodules, minerals and protein content were recorded from combination application of 100 mg phosphorus per kg soil and application of ½ of applied phosphorus to the soil and foliar application of other half. **El-Saber *et al.* (2010)** concluded that proline is known to occur widely in higher plants and normally accumulates in large quantities in response to environmental stress. In addition to its role as an osmolyte for osmotic adjustment, proline contributes to stabilizing subcellular structure (e.g. membranes and proteins) scavenging free radicals and buffering cellular redox potential under stress conditions. Certain metabolic processes are triggered in response to stress, which increase the net solute concentration in the cell, thereby helping the movement of water into the leaf resulting in increase in leaf turgor. Large number of compounds is synthesized, which play a key role in maintaining the osmotic equilibrium and in protection of membranes as well as macromolecules.

Table (7). Effect of interaction between different locations, faba bean cultivars and phosphorus fertilizer treatments

	CHLA	CHLB	Carotene	Proline	K	Ca	Mg	N	Protein	S.Y	St.Y	B. Y
L1V1F0	0.8800	0.3867	0.3000	6.210	2.1300	1.443	2.3867	1.649	12.264	1074	2341	3415
L1V1F1	0.9667	0.4433	0.3300	8.517	3.6533	3.323	3.7867	2.376	14.848	1657	3238	4895
L1V1F2	1.1600	0.4530	0.3567	9.380	3.7233	3.393	3.8567	2.637	16.483	1937	4030	5867
L1V2f0	0.8133	0.3667	0.3067	6.170	2.2633	2.013	2.6067	1.880	11.749	2047	2988	5035
L1V2f1	1.0967	0.4433	0.4000	8.593	3.7167	3.280	3.3733	2.440	15.249	2553	3020	5573
L1V2f2	1.2976	0.7300	0.4133	9.270	3.8733	3.643	3.5567	2.832	17.702	3044	3422	6466
L1V3F0	0.7400	0.2833	0.2500	6.207	2.3433	2.183	2.6467	1.943	12.143	1242	2318	3560
L1V3F1	1.2633	0.5800	0.3833	8.500	3.8267	3.493	3.500	2.628	16.426	2098	3102	5200
L1V3f2	1.2800	0.6167	0.4433	9.303	3.7900	3.620	3.7100	2.573	16.082	2881	3588	6469
L1V4f0	1.1767	0.6133	0.2867	6.600	2.2633	2.017	2.5300	2.440	15.248	1107	2490	3597
L1V4F1	1.2567	0.6333	0.4033	9.647	3.8167	3.703	3.7033	2.887	18.041	1580	3844	5424
L1V4F2	1..0700	0.4400	0.4133	9.853	3.8667	3.457	3.6967	3.167	19.791	1997	3989	5986
L2V1F0	0.9000	0.4367	0.3133	6.973	2.3533	2.180	2.9033	1.806	11.285	1194	2487	3681
L2V1F1	1.2800	0.6133	0.5300	9.247	3.4633	3.997	3.800	2.354	14.711	2009	2589	4598
L2V1F2	1.3233	0.696	0.5133	9.620	3.520	3.833	3.5900	2.490	15.563	2596	3841	6437
L2V2F0	0.9600	0.5067	0.3533	7.167	2.3533	2.240	2.4933	2.152	13.452	1095	2816	3911
L2V2F1	1.2867	0.6867	0.4833	9.473	3.900	3.703	3.5067	2.575	16.094	1571	3626	5197
L2V2F2	1.5667	0.737	0.5333	9.820	3.9567	4.093	3.8733	2.926	18.290	2008	4148	6156
L2V3F0	0.9633	0.5100	0.3233	6.587	2.2433	2.227	2.7733	2.171	13.570	1121	2487	3608
L2V3F1	1.2867	0.6400	0.5167	9.280	3.7533	4.080	3.9033	2.776	17.349	1717	3017	4734
L2V3F2	1.370	0.7300	0.5367	9.840	3.8767	4.300	3.7000	2.826	17.660	2285	3340	5625
L2V4F0	0.9667	0.4233	0.3800	6.987	2.2933	2.480	2.5833	2.145	13.403	994	2177	3171
L2V4F1	1.333	0.5833	0.5433	9.833	3.7167	4.357	3.8667	2.669	16.683	1428	3549	4977
L2V4F2	1.3033	0.6533	0.5533	9.940	3.8400	4.297	4.0033	3.059	19.116	1791	3812	5603
LSD5%	0.1005	0.1079	0.0637	0.1878	0.0968	0.201	0.1249	0.222	0.7073	184.4	439.7	387.3

S.Y (seed yield kg.fed), St.Y (straw yield kg.fed), B.Y (biological kg.fed)

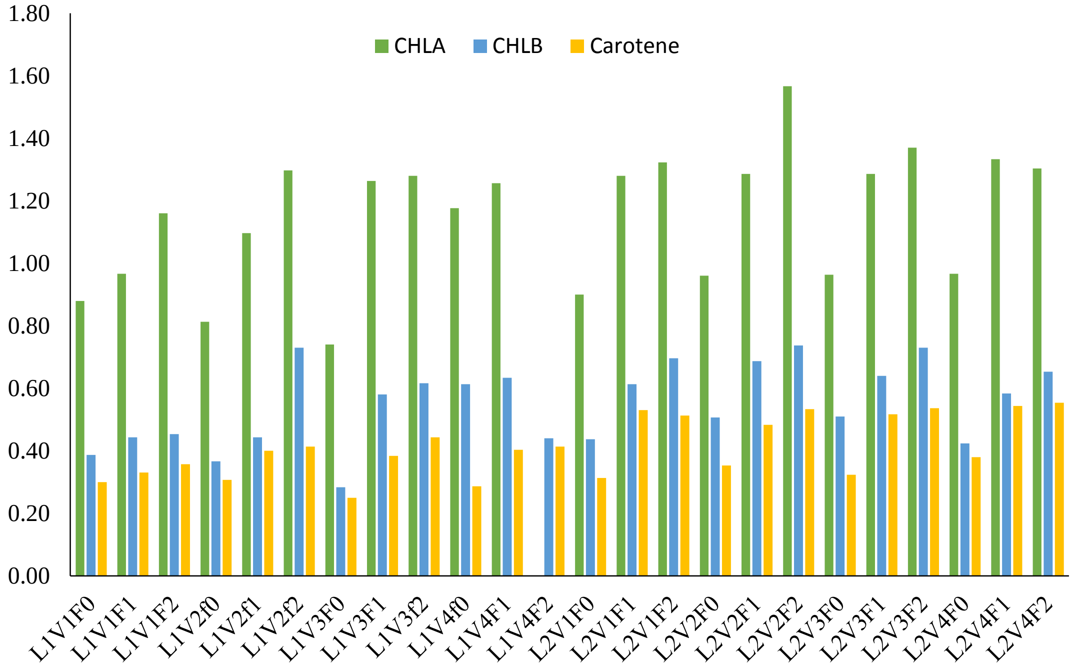

Fig 1. The interaction effects between different Fig **1.** The interaction effects **Fig 1.** The interaction effects between different locations, faba bean cultivars and phosphorus fertilizer on chlorophyll (A, B) and carotene.

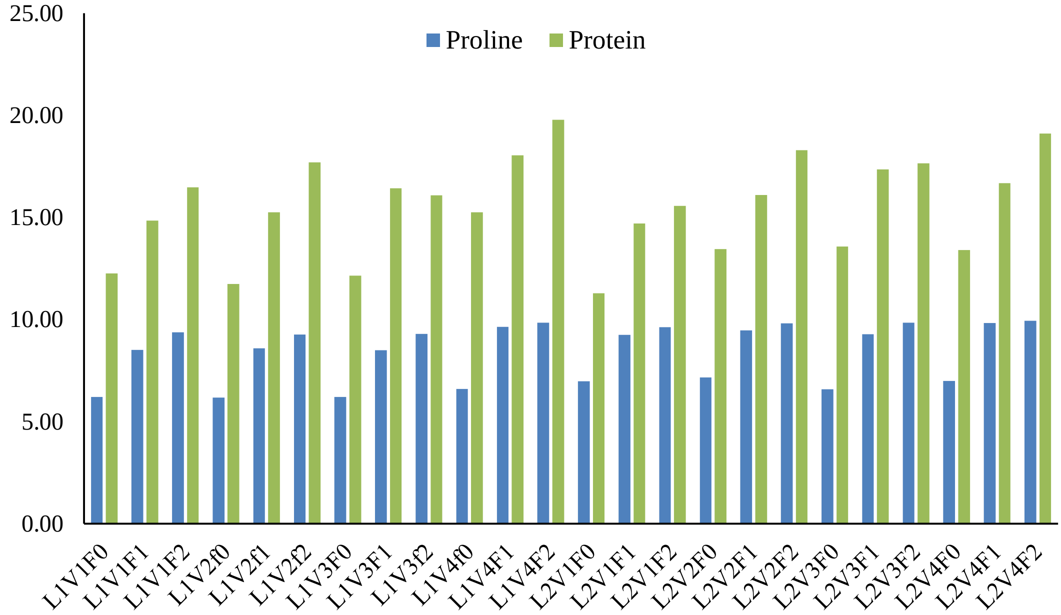

Fig 2. The interaction effects between different locations, faba bean **Fig 2.** The interaction between different location, faba bean cultivars and phosphorus fertilizer on proline and protein levels.

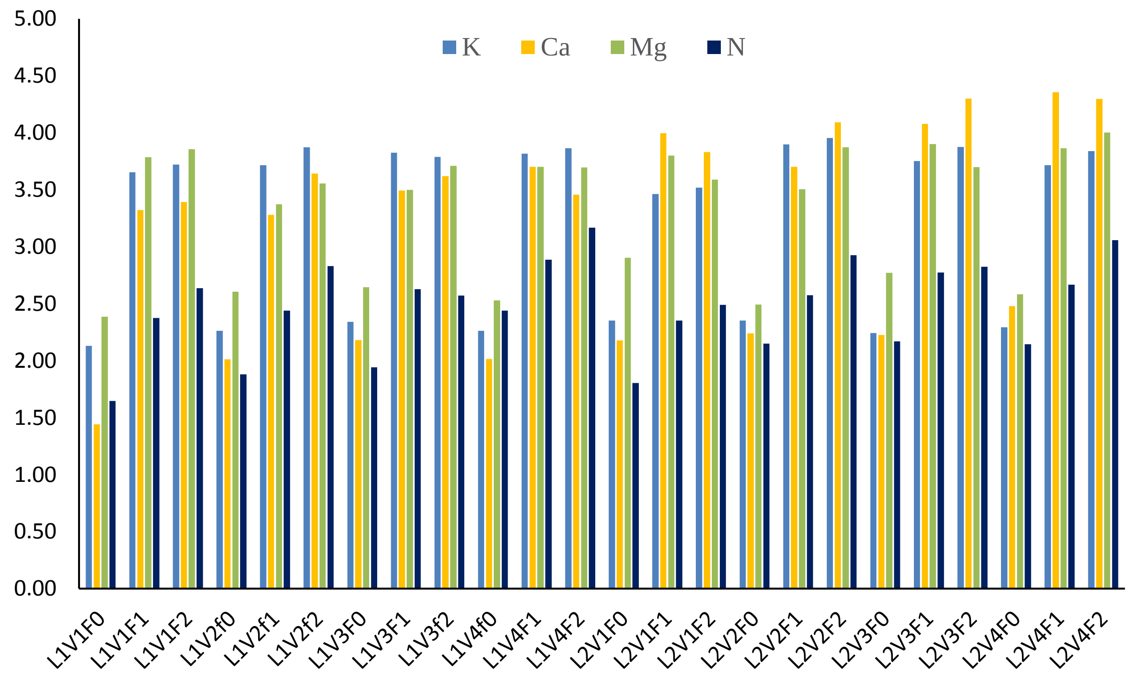

Fig 3. The interaction effects between different locations, faba bean cultivars and phosphorus fertilizer on nitrogen, potassium, magnesium, and calcium levels.

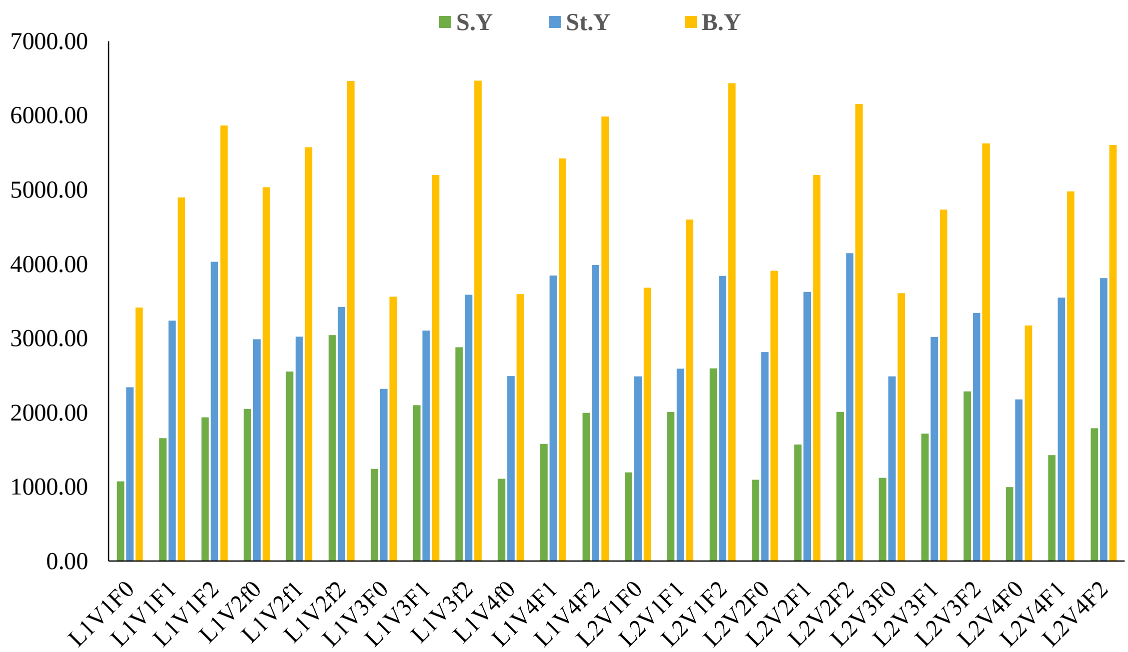

Fig 4. The interaction effects between different locations, faba bean cultivars and phosphorus fertilizer on biological, straw and seed yields.

The heatmap correlation matrix plot

The heatmap correlation matrix plot describing Pearson's correlation coefficient which performed for an evident understanding of relationships between the studied traits of four different broad bean cultivars and three levels of phosphorus at two locations in at both seasons (Figure 5). A positive small correlation ($p<0.01$) was observed among all possible pairs under study. Also, seed yield (kg/fed) had significantly positive correlation with chlorophyll A ($r=0.52$), chlorophyll B ($r=0.47$), carotenes ($r=0.44$), nitrogen ($r=0.49$), protein ($r=0.48$) p value <0.05. However, S.Y kg\fed showed significantly strong positive correlation with proline ($r=0.59$), Potassium ($r=0.67$), Magnesium ($r=0.58$) and calcium ($r=0.57$), with p value <0.001. These results agree with several studies, **Alghamd (2007)** found significant positive correlations were detected between faba bean seed yield and each of number of pods per plant, number of seeds per plant, seed weight per plant and biological yield. **Tadesse and Yayneshet (2011)** indicated 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 positive and significant correlation with clusters per plant, pod length, plant height, branches \ plant, pods \ plant and 100- seed weight.

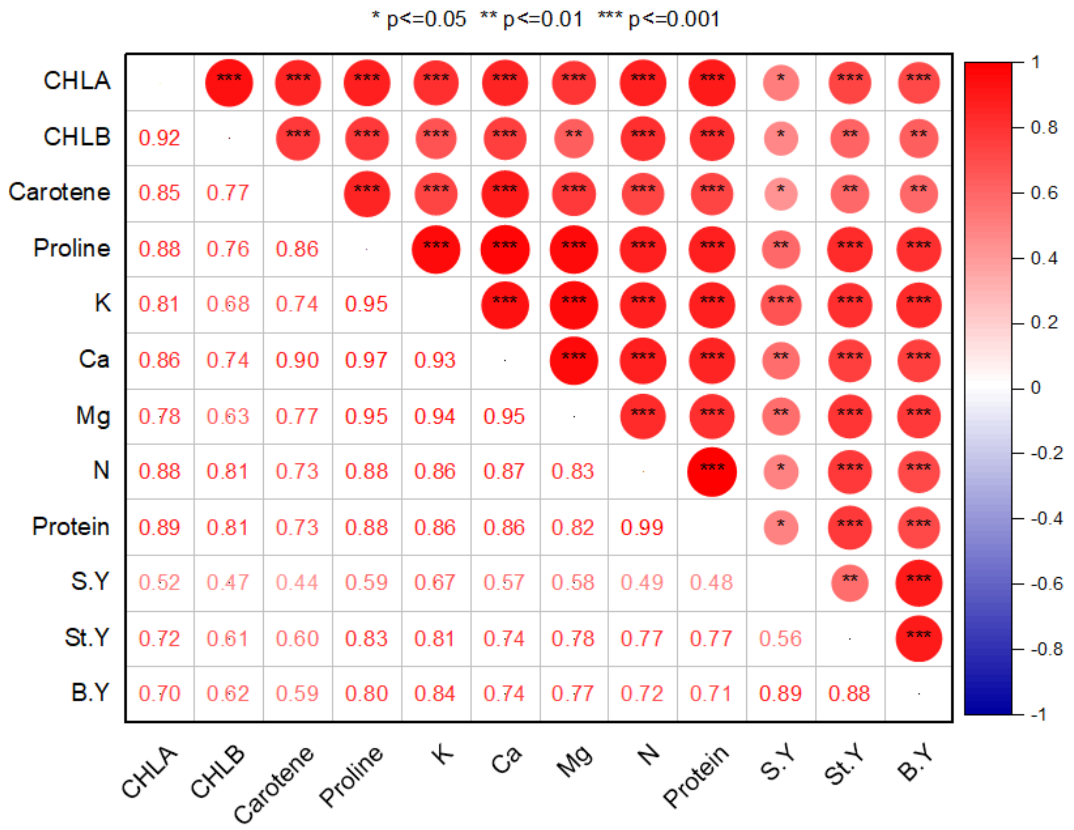

Fig. 5. The correlation matrix plot between the studied traits of faba bean under the interaction effect of four cultivars and three levels of phosphorus at two locations in both seasons. The large and medium blue (negative) and red (positive) circles indicate a significant (*$p \leq 0.05$) or highly significant (**$p \leq 0.01$), while the small blue (negative) and red (positive) circles indicate a non-significant correlation.

CONCLUSION

It can be concluded that, phosphorus fertilizer had an opposite effect on increasing the biochemical studies, chlorophyll a, b, carotenoids, proline, K, Ca, Mg, N, and total protein in all cultivars at two locations. However, cultivar 2 recorded the highest values of CHLA, B and seed, straw and biological yield (kg\fed) when plants applied with F2 in location 2 compared to other treatments. Seed yield (kg/fed) significantly positive correlation with chlorophyll (A, B), carotenes, nitrogen and protein.

However, it was significantly strong positive correlation with proline, potassium, magnesium, and calcium.

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