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Effect of Phosphate Level and Foliar Application of Amino Acid Mixture on Growth, Yield and Chemical Constituents of Pea (*Pisum sativum* L.)

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Abstract: Two field experiments were carried out on a private farm in Munifia Governorate during the two winter seasons of 2018/19 and 2019/20 to investigate the effect of phosphatic fertilization levels and foliar application of different levels of amino acid (Amino- mix) effects on plant growth, total yield and its components as well as nutrition value of seeds in pea plants c.v. Master B. Three phosphatic fertilization levels 0, 200 and 250 kg fed^{-1} calcium super phosphate (P0, P1 and P2) and other three foliar application of different level of amino acid (Amino- mix): Control (tap water), 1 and 2 cm l^{-1} (Am0, Am1, Am2), as well as their combinations, were evaluated. The results showed significant effects due to P level application on pea morphological characters, *i.e.* plant height, number of leaves fresh and dry leaves plant^{-1}, number of branches plant^{-1} as well as fresh and dry weight plant^{-1} in both seasons. Pea fresh green yield was 2.433, 3.86 and 4.356 t fed^{-1} in 2019 season while the corresponding values were 2.922, 3.770 and 4.180 t fed^{-1} for P application rates P0, P1 and P2, respectively. The relative increase in pea fresh yield due to application was 54.8 and 91.1% over the control treatment in 2019 season while the increase was 29 and 43 % over the control treatment in 2020 season for P1 and P2 levels, respectively. Foliar application of amino acids increased pea number of pods, pod length (cm), number of seeds pod^{-1}, average of weight 10 pods (g) fresh weight 100 seeds (g) and total fresh yield of peas in both seasons of study. Application of amino acid mixture at 2 cm l^{-1} surpassed the control treatment and the lower amino acid mixture1 cm l^{-1} in all morphological and yield characters in both seasons of study. Pea fresh green yield was 3.361, 3.494 and 3.789 t fed^{-1} in 2019 season while the corresponding values were 3.439, 3.624 and 3.809 t fed^{-1} for amino acid mixture application rates 0, 1 and cm 2 l^{-1}, respectively. The relative increase in pea fresh yield due to application was 3 and 13% over the control treatment in 2019 season while the increase was 6 and 11% over the control treatment in 2020 season for 1 and 2 cm l^{-1} application rates, respectively. Average of weight 10 pods (g), Average of seeds weight 10 pods (g) and total fresh yield t fed^{-1} were significantly affected by the interaction between P level and foliar application of amino acid. Total fresh yield t fed^{-1} ranged between 2.200 and 4.533 t fed^{-1} in 2019 season and between 2.667 and 4.317 t fed^{-1} in 2020 season for the treatments P0 × Am0 and P2 × Am2 cm l^{-1}, respectively. Relative yield increase due to the interaction between P level and foliar spray of Amino Acid ranged between 4 and 99% in 2019 season and between 7 and 62% over the control treatments for the treatment P0 × Am0 and P2 × Am2 cm l^{-1} in both seasons, respectively. The synergistic effect for the interaction between P level and foliar application of amino acid in both seasons was evident. Data showed that increasing P level up to 250 kg super phosphate as well as foliar application of (1 and 2 cm l^{-1}) of amino acid

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mixture significantly increased NPK concentrations in green seeds of pea in 2019 and 2020 seasons. Both P levels: P1 and P2 significantly surpassed the amended control treatment. Total protein %, carbohydrates % and total sugar (g/100 g dry weight) in green pea seeds took similar tendency by increasing P level up to 250 kg super phosphate or foliar application of 2 cm amino acid, they significantly increased concentrations of total protein %, carbohydrates % and total sugar (g/100g dry weight) in green seeds of pea in both seasons of study. Only the interaction effect of P level and foliar application of amino acid significantly affected K% and total sugar (g/100g dry weight) in green pea seeds.

Key words: Pea, Amino acids, P, Yield, Chemical constituents

INTRODUCTION

Pea (*Pisum sativum* L.) is the most important vegetable belonging to the family Leguminosae. Besides being rich in proteins, it is a good supplier of several minerals and vitamins. It is grown mainly for green pods and can be consumed raw as well as in cooked form. Peas are also canned, frozen or dehydrated. Phosphorus is one of the most important nutrient required by pea for proper growth and development. Phosphorus is a constituent of adenosine diphosphate (ADP), sugar phosphate, nucleic acid, proteins and several co-enzymes which are of great importance in the energy transformation and metabolic process of plants. Phosphorus deficiency is usually the most important factor for poor nodulation and low yield of leguminous crops. An adequate supply of phosphorus has been reported beneficial for better growth, yield, quality and enormous nodule formation in legumes [1]. The production of pea on more than 30% of the world arable land is limited by P availability [2]. Phosphorus may be a critical constraint for legumes under low nutrient environment because there is a substantial need of phosphorus in the nitrogen fixation process [3]. Phosphorus has an enhancing impact on plant growth and biological yield its importance as energy storage and transfers energy necessary for metabolic processes. Sharma and Chandra [4] reported that one of the advantages of feeding the plants with phosphorus is to create deeper and more abundant roots. Phosphorus is source of metabolic energy and helps in the formation of nodules, root development, better nitrogen and carbon fixation. Sharma *et al*. [5] and Mishra [6] found that pod yield increased by 60 kg P_2O_5 ha^{-1} in pea and cowpea, respectively with no further significant increase at the higher P rate. Application of potassium also enhanced vegetative growth and increased pod yield in pea [7, 8].

Eco friendly substances like amino acids have useful effects of amino acids to increase growth and yield for all crops. It is the essential ingredients for the operation of protein synthesis and exceedingly uses for the biosynthesis of pigments, vitamins, coenzymes, purine and pyrimidine bases [9]. The demand of amino acids in essential quantities is well known as a mean to increase yield and total quality of crops. The application of amino acids for foliar spray is established on their requirement by plants in general and critical stages of growth in special. Also amino acids are basis ingredients in the process of protein synthesis. About 20 important amino acids are implicated in the process of each function [10]. Some researchers pointed out the importance of amino acids in increasing growth, yield and chemical composition of some economic plants. El- Shabas *et al*. [11] reported that spraying garlic plants with a mixture of glycine, alanine, cysteine and arginine (each at 100 ppm) or with 100 ppm of cysteine alone gave significant increases of total yield over the control by (13.96 % and 13.66 %) and (14.40% and 16.65 %) in the first and second seasons, respectively. Amino acids are implicated in the synthesis of other organic compounds, such as protein, amines, alkaloids, vitamins, enzymes and terpenoids [12]. Amino acids are conclusive to stimulating cell growth, act as buffers, provide a source of carbon and energy and protect the cells from ammonia toxicity, with amid formation [13]. The application of amino acids can stimulate the performance of plant [14]. Amino acids have a chelating effect on micronutrients and commercially available amino acid stimulants can improve fertilizer assimilation, increase uptake of nutrients and water, enhance the photosynthetic rate and dry matter divide and hence increase crop yield. Many studies have been demonstrated that amino acids can directly or indirectly affect the physiological activities in plant growth and development. In addition, foliar application of amino acids caused an enhancement in plant growth, fruit yield and its components, El-Shabasi *et al*. [11] on garlic, Awad *et al*. [10] on potato, Abd El-Aal *et al*. [15] on squash and Shafeek *et al.* [16] on onion. In the same respect, Ghaith and Galal [17] reported that, spraying pea plants with mixture of amino acid at 100 ppm significantly increased plant growth characters, total pods yield and pods quality. In addition, Shafeek *et al*. [18] on garlic reported that the biggest bulb yield as t fed^{-1} and better physical possession of bulb (fresh and dry weight), acquired when amino mix spatter three times at high level (2%). Also, the acquired conclusion recorded the highest nutritional amount of garlic bulb tissues were recorded with splash of amino mix at the higher concentration. Also, Shafeek *et al*. [18] on broad bean plant found that foliar application by high concentration of amino mix (2%) significantly improved the most plant growth characters, total yield and its components as well as the seeds contents of the percentage of N, protein, P and K followed in descending order by that plants spraying by 1% followed with the control treatment.

Little is known about the interactive effect of P and amino acid application to pea and the nature of this interaction when the two factors combined with each other. Therefore, the aim of this work is to investigate the effect of prosphatic fertilization levels with foliar application of different levels of amino acid (Amino- mix) effects on plant growth, total yield and its components as well as nutrition value of seeds in pea plants.

MATERIALS AND METHODS

Two field experiments were carried out on a private farm in Munifia Governorate during the two winter season of 2018/19 and 2019/20 to investigate the effect of phosphatic fertilization levels and foliar application of different level of amino acid (Amino- mix) effects on plant growth, total yield and its components as well as nutrition value of seeds in pea plants c.v. Master B. The experimental trails were conducted in silty clay loam soil. Chemical analysis and physical properties of experimental soil was determined according to Jackson [19]. Soil analysis is shown Table (1).

Every experiment included nine treatments which were three posphatic fertilization levels 0, 200 and 250 kg calcium super phosphate (P0, P1 and P2) and other three foliar application of different level of amino acid (Amino- mix): Control (tap water), 1 and 2 cm l fed^{-1} (Am0, Am1, Am2). The chemical constituents of the amino acid mix are presented in Table 2.

Pea seeds were sown on 20 and 22 of October in 2019 and 2020 seasons respectively. The experimental design was split plot with three replications, where posphatic fertilization levels 0, 200 and 250 kg fed^{-1}calcium super phosphate (P0, P1 and P2) were assigned in the main plots and the amino acid treatments (Amino mix) was foliar spraying at three levels, *i.e.* 0, 1 and 2 cm l^{-1} (Am0, Am1, Am2), were devoted to the subplots. The treatments were arranged as follow and randomly distributed in the experimental unites:

- P0 × Am0: Without treatment.
- P0 × Am1: Amino acids at 1 cm l^{-1}.
- P0 × Am2: Amino acids at 2 cm l^{-1}.
- P1 × Am0: posphatic fertilization at 0 kg fed^{-1}
- P1 × Am1: posphatic fertilization at 200 kg fed^{-1} + Amino acids at 1 cm l^{-1}.
- P1 × Am2: posphatic fertilization at 250 kg fed^{-1} + Amino acids at 2 cm l^{-1}.
- P2 × Am0: posphatic fertilization at 0 kg fed^{-1}.
- P2 × Am1: posphatic fertilization at 200 kg fed^{-1} + Amino acids at 1 cm l^{-1}.
- P2 × Am2: posphatic fertilization at 250 kg fed^{-1} + Amino acids at 2 cm l^{-1}.

Table 1: The physical and chemical properties of the experimental soil

1-Mechanical analysis : 0-30 cm

Sand %				
Course > 200u	Fine >200' 20u	Silt 20-2 u%	Clay % < 2 u	Soil texture
7.8	5.6	50.8	35.8	Silty clay loam

2-Chemical analysis

				Soluble cations (meq/l)				Soluble anions (meq/l)			
pH 1:2.5	EC dSm^{-1}	$CaCo_3$	O.M%	Na +	K+	Ca ++	Mg++	CO_3 -	HCO_3 -	Cl -	SO_4 -
8.4	0.49	0.26	0.17	3.37	0.4	0.65	0.48	7.10	1.52	1.78	1.62

Macronutrient (mg/100 g soil)

	Total			Available		
No. Sample	N	P	K	N	P	K
Soil (0-30)	138	62	145	29.3	16.8	30.9

Table 2: The chemical composition of amino acid (Amino-mix)

Elements (g/100 cm^3)	Value	Amino acid	Value	Amino acid	Value	Vitamin (mg/100 cm^3)	Value
Zn	2	Aspartic	249	Methionine	180	B1	0.8
Fe	1.5	Thiamine	45	Isoliocine	52	B2	2.4
Mn	0.5	Serine	56	Therionine	38	B6	1.2
Mg	0.004	Glutamic	55	Lalamine	22	B12	0.82
Cu	0.004	Glycine	50	Histidine	12	Folic	4.2
Ca	0.025	Alanin	100	Liocine	40	Pantothinic	0.52
Br	0.056	Praline	38	Argentine	20	Niacin	0.14
S	0.01	Valine	68	Tryptofan	20	Ascorbic	1.0
Co	0.03	Cyctein	44	-	-	-	-

The experimental unit area was 10.5 m^2 and included five rows (each was 3.5 m length and 60 cm width) and the distance between plants was 10 cm. The normal cultural practices i.e. irrigation; fertilizer and pest control for the pea productions were followed and foliar spraying of amino-mix was achieved after 20 days from sowing date, every 15 day's intervals for three times. Plant samples were taken 60 days after sowing where 10 plants were chosen from each sub plot and the following data were recorded: plant length (cm), number of pods, pod length (cm), number of seeds pod^{-1}, average of weight 10 pods (g), fresh weight of 100 seeds (g) and total fresh yield of pea yield of each sub plot was weighed and expressed as tons per feddan. Chemical analysis *i.e.* the percentage of N, P and k contents, total protein% , carbohydrates% and total sugar (g/100g dry weight) in green pea seeds were determined according to A.O.A.C. [20]. The data were subjected to statistical analysis of variance of split-plot design was carried out using MSTAT-C Computer Software [21]. Means were compared by using the least significant difference (LSD) at 5%.

RESULTS AND DISCUSSION

Effect of P Level and Amino Acid Mixture on Pea Morphological and Yield Characteristics: Data presented in Table (3) reveal significant effects due to P level application on pea morphological characteristics, *i.e.* plant height, number of leaves, fresh and dry leaves plant, number of branches $plant^{-1}$ as well as fresh and dry weight $plant^{-1}$ in both seasons except dry weight $plant^{-1}$ in the second season. Pea response to P was obvious for the above-mentioned characters. From the same Table it is clear that P application increased pea number of pods, pod length (cm), number of seeds pod^{-1}, average of weight 10 pods (g) m fresh weight of 100 seeds (g) and total fresh yield of peas in both seasons of study. Application of P at 250 kg calcium super phosphate fed^{-1} surpassed the control treatment and the lower P application level (200 kg calcium super phosphate fed^{-1}) in all morphological and yield characters in both seasons of study. Pea fresh green yield was 2.433, 3.86 and 4.356 t fed^{-1} in 2019 season while the corresponding values were 2.922, 3.770 and 4.180 t fed^{-1} for P allocation rates P0, P1 and P2, respectively. The relative increase in pea fresh yield due to application was 54.8 and 91.1% over the control treatment in 2019 season while the increase was 29 and 43% over the control treatment in 2020 season for P1 and P2 levels, respectively. Such results were expected and confirmed by many researchers. Sharma *et al*. [5] and Mishra [6] found that pod yield increased by 60 kg P_2O_5 ha^{-1} in pea and cowpea, respectively with no further significant increase at the higher P rate. The positive response of pea to P application could be attributed to the fact that phosphorus is one of the most important nutrients required by pea for proper growth and development. Phosphorus is a constituent of adenosine diphosphate (ADP), sugar phosphate, nucleic acid, proteins and several co-enzymes which are of great importance in energy transformation and metabolic process of plants. Phosphorus deficiency is usually the most important factor for poor nodulation and low yield of leguminous crops. An adequate supply of phosphorus has been reported beneficial for better growth, yield, quality and enormous nodule formation in legume. The production of pea on more than 30% of the world arable land is limited by P availability [2]. Kandil *et al*. [22] reported that the highest number of pods per plant and length of pod were produced when 150 Kg fed^{-1} P in two common bean varieties. Data also clearly indicated that the highest values of pod yield was obtained by 80 Kg P_2O_5 ha^{-1} which increased the yield 26.19%. Similar result were obtained by Agegnehu [23] who found that application of phosphate fertilizer at the rates of 10, 20 and 30 kg P ha^{-1} increased mean grain yields of field pea by 36, 67 and 57%, respectively compared to the control. Also, Kandil [24] came to similar conclusion. Pea plant has many nutritional values which could be affected by phosphorus, application [25, 26]. Sharma and Chandra (2004) [4] reported that one of the advantages of feeding the plants with phosphorus is to create deeper and more abundant roots.

Table 3: Effects of P level application on pea morphological and yield characteristics in 2019 and 2020 seasons

Phosphate level	Plant height (cm)	No. of leaves plant^{-1}	Fresh weight of leaves plant^{-1} (g)	Dry weight of leaves plant^{-1} (g)	No. of branches plant^{-1}	Fresh branches weight plant^{-1} (g)	Dry branches weight plant^{-1} (g)	No. of pod plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	Average of weight 10 pods (g)	Average of seeds weight 10 pods (g)	Fresh weight of 100 seeds (g)	Total fresh yield fed^{-1} (t)	Relative yield increase % over the control
								2018/19 Season							
0 kg fed^{-1} (P0)	69.8	10.9	11.8	8.2	1.0	11.9	8.0	7.9	10.0	5.7	58.5	32.4	43.0	2.433	-
200 kg fed^{-1} (P1)	73.0	13.7	14.7	9.1	1.6	12.7	8.5	10.6	11.2	7.7	65.5	37.7	50.0	3.856	58.4
250 kg fed^{-1} (P2)	79.2	16.3	16.9	9.3	2.0	16.1	8.8	12.8	11.9	8.9	71.1	39.5	56.9	4.356	91.1
LDS at 0.05	2.08	2.64	1.77	0.32	0.66	0.90	0.18	0.50	0.44	0.50	2.13	2.38	4.79	0.251	-
								2019/20 Season							
0 kg fed^{-1} (P0)	64.4	10.6	10.8	1.4	1.0	11.2	1.4	5.9	9.0	4.7	53.0	26.7	40.0	2.922	-
200 kg fed^{-1} (P1)	67.8	12.3	13.6	1.6	1.6	12.3	1.5	8.0	10.9	6.2	60.4	32.3	44.5	3.770	29
250 kg fed^{-1} (P2)	73.1	15.1	15.7	2.0	2.0	14.9	3.0	11.6	11.6	7.9	66.0	34.2	49.2	4.180	43
LDS at 0.05	1.89	0.55	1.32	0.18	0.34	0.44	NS	0.60	0.20	0.54	1.25	1.04	0.84	0.083	-

Table 4: Effects of amino acid mixture on pea morphological and yield characteristics in 2019 and 2020 seasons

Foliar applied amino acids	Plant height (cm)	No. of leaves plant^{-1}	Fresh weight of leaves plant^{-1} (g)	Dry weight of leaves plant^{-1} (g)	No. of branches plant^{-1}	Fresh branches weight plant^{-1} (g)	Dry branches weight plant^{-1} (g)	No. of pod plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	Average of weight 10 pods (g)	Average of seeds weight 10 pods (g)	Fresh weight of 100 seeds (g)	Total fresh yield fed^{-1} (t)	Relative yield increase % over the control
								2018/19 Season							
Control (Am0)	68.89	12.78	10.87	8.31	1.44	11.88	7.95	9.00	10.68	6.89	62.24	34.32	46.49	3.361	-
1 cm l^{-1} (Am1)	74.67	13.67	14.55	8.86	1.56	13.39	8.46	10.44	11.08	7.33	65.96	36.96	50.40	3.494	3
2 cm l^{-1} (Am2)	78.44	14.44	17.94	9.41	1.6	15.42	8.95	11.78	11.33	8.00	66.97	38.28	53.00	3.789	13
LSD at 0.05	1.23	0.46	1.85	0.27	NS	0.73	0.28	0.59	0.40	0.39	0.733	0.84	1.09	0.071	-
								2019/20 Season							
Control (Am0)	63.4	11.8	10.4	1.3	1.4	11.4	1.4	7.3	9.9	5.6	57.0	28.9	38.3	3.439	-
1 cm l^{-1} (Am1)	69.1	12.6	13.2	1.6	1.6	12.6	2.7	8.6	10.6	6.1	60.6	31.5	46.2	3.624	6
2 cm l^{-1} (Am2)	72.8	13.7	16.5	2.1	1.6	14.3	1.8	9.6	11.1	7.1	61.8	32.9	49.2	3.809	11
LSD at 0.05	2.97	0.43	2.61	0.38	0.25	0.97	NS	0.39	0.24	0.66	0.88	0.79	1.94	0.086	-

Data presented in Table (4) reveal significant effects due to foliar application of amino acid mixture on pea morphological characteristics, *i.e.* plant height, number of leaves fresh and dry leaves plant^{-1}, number of branches plant^{-1} as well as fresh and dry weight plant^{-1} in both seasons except dry weight plant^{-1} in the second season. Pea response to amino acid mixture was obvious for the above mentioned characteristics of pea. From the same Table it is clear that foliar application increased pea number of pods, pod length (cm), number of seeds pod^{-1}, average of weight 10 pods (g) fresh weight 100 seeds (g) and total fresh yield of peas in both seasons of study. Application of amino acid mixture at 2 cm l^{-1} surpassed the control treatment and the lower amino acid mixture1 cm l^{-1}) in all morphological and yield characters in both seasons of study. Pea fresh green yield was 3.361, 3.494 and 3.789 t fed^{-1} in 2019 season while the corresponding values were 3.439, 3.624 and 3.809 t fed^{-1} for amino acid mixture application rates 0, 1 and 2 cm l^{-1}, respectively. The relative increase in pea fresh yield due to application was 3 and 13% over the control treatment in 2019 season while the increase was 6 and 11% over the control treatment in 2020 season for 1 and 2 cm l^{-1} application rates, respectively. Similar results were obtained and confirmed by Shafeek *et al*. [27] on onion, they reported that foliar application of amino acid mix treatments significantly improved the nutritional amount of dry onion bulbs *i.e*. (percentage of N, Protein, P and K) in the two experimental seasons. They added that increasing the concentration of amino mix significantly increased nutrition value of seeds tissues of onion bulbs. Moreover, the superiority nutritional value of dry bulbs gained with the application of high levels of amino mix at (2 cm l^{-1}) compared low level (1 cm l^{-1}). Several studies have been confirmed that amino acids can directly or indirectly affect the physiological performance in plant growth and expansion. In addition El-Shabasi *et al*. [11] on garlic, Awad *et al*. [10] on potato, Abd El-Aal *et al*. [15] on squash and Shafeek *et al.* [16] on onion. In the same respect, Ghaith and Galal [17] reported that foliar purpose of amino acids occasion an increase in plant growth, fruit yield and ingredient. In the same respect, Ghaith and Galal [17] inform that, foliar spraying of pea plants with amino acid at 100 ppm significantly improved plant growth characters, total pods yield and pods goodness. However, Shafeek *et al*. [16] found that amino acid concentration of 150 ppm produced the high leaves fresh weight plant^{-1}. In the same respect, amino acid concentration of 150 ppm was the most favorable concentrations for number and weight of bulbs m^{-2}.

Table 5: Effects of the interaction between P level and foliar application of amino acid on pea morphological and yield characteristics in 2019 and 2020 seasons

Treatment	Plant height (cm)	No. of leaves plant^{-1}	Fresh weight of leaves plant^{-1} (g)	Dry weight of leaves plant^{-1} (g)	No. of branches plant^{-1}	Fresh branches weight plant^{-1} (g)	Dry branches weight plant^{-1} (g)	No. of pod plant^{-1}	Pod length (cm)	No. of seeds pod^{-1}	Average of weight 10 pods (g)	Average of seeds weight 10 pods (g)	Fresh weight of 100 seeds (g)	Total fresh yield fed^{-1} (t)	Relative yield increase % over the control
								2018/19 Season							
1- P0 × Am0	64.0	10.3	9.8	7.6	1.0	11.3	7.6	7.0	9.3	5.3	54.3	27.3	36.5	2.200	-
2- P0 × Am1	72.0	10.7	12.3	8.1	1.0	11.9	7.8	7.7	10.0	5.3	59.8	33.8	44.3	2.300	4
3- P0 × Am2	73.3	11.7	13.3	8.9	1.0	12.7	8.6	9.0	10.7	6.3	61.4	36.2	48.1	2.800	27
4- P1 × Am0	68.0	12.3	10.8	8.6	1.3	11.4	7.9	9.3	11.0	7.3	61.9	36.8	48.4	3.717	69
5- P1 × Am1	74.0	14.0	14.8	9.1	1.7	13.1	8.8	10.7	11.3	7.7	66.7	37.9	49.4	3.817	74
6- P1 × Am2	77.0	14.7	18.3	9.5	1.7	13.5	9.0	11.7	11.3	8.0	68.0	38.3	52.3	4.033	83
7- P2 × Am0	74.7	15.7	12.0	8.8	2.0	13.0	8.3	10.7	11.7	8.0	70.6	38.8	54.5	4.167	89
8- P2 × Am1	78.0	16.3	16.5	9.3	2.0	15.2	8.8	13.0	11.9	9.0	71.3	39.2	57.5	4.367	98.5
9- P2 × Am2	85.0	17.0	22.2	9.8	2.0	20.0	9.3	14.7	12.0	9.7	71.5	40.4	58.6	4.533	99
LSD at 0.05	NS	NS	NS	NS	NS	2.4	NS	NS	NS	NS	5.56	4.66	6.45	0.57	-
								2019/20 Season							
1- P0 × Am0	58.33	10.00	9.07	1.12	1.00	10.33	1.29	5.33	8.17	4.00	48.83	22.00	33.80	2.667	-
2- P0 × Am1	66.67	10.33	10.70	1.35	1.00	11.27	1.41	6.00	9.13	4.67	53.83	27.30	41.53	2.867	7
3- P0 × Am2	68.33	11.33	12.73	1.60	1.00	11.87	1.51	6.33	9.80	5.33	56.20	30.77	44.73	3.233	21
4- P1 × Am0	62.33	11.33	10.73	1.30	1.33	11.43	1.43	6.67	10.43	5.67	56.83	31.40	38.33	3.633	36
5- P1 × Am1	69.00	12.33	13.53	1.53	1.67	12.37	1.57	8.33	11.07	5.67	61.57	32.60	45.93	3.800	42
6- P1 × Am2	72.00	13.33	16.47	2.05	1.67	13.00	1.64	9.00	11.33	7.33	62.87	33.00	49.20	3.877	45
7- P2 × Am0	69.67	14.00	11.50	1.44	2.00	12.37	1.52	10.00	10.97	7.00	65.37	33.20	42.73	4.017	51
8- P2 × Am1	71.67	15.00	15.23	1.90	2.00	14.23	5.07	11.33	11.53	8.00	66.33	34.47	51.27	4.207	58
9- P2 × Am2	78.00	16.33	20.42	2.55	2.00	18.00	2.29	13.33	12.27	8.67	66.43	34.83	53.67	4.317	62
LSD at 0.05	NS	NS	NS	NS	NS	3.2	NS	2.2	NS	NS	2.24	5.4	NS	0.636	-

1- P0 × Am0: Without treatment. 2- P0 × Am1: Amino acids at 1 cm l^{-1}. 3- P0 × Am2: Amino acids at 2 cm l^{-1}. 4- P1 × Am0: posphatic fertilization at 0 kg fed^{-1}

5- P1 × Am1: posphatic fertilization at 200 kg fed^{-1} + Amino acids at 1 cm l^{-1}. 6- P1× Am2: posphatic fertilization at 250 kg fed^{-1} + Amino acids at 2 cm l^{-1}.

7- P2 × Am0: posphatic fertilization at 0 kg fed^{-1}. 8- P2 × Am1: posphatic fertilization at 200 kg fed^{-1} + Amino acids at 1 cm l^{-1}.

9- P2 × Am2: posphatic fertilization at 250 kg fed^{-1} + Amino acids at 2 cm l^{-1}.

Data presented in Table (5) show that there were no significant effects due to the interaction between P level and foliar application of amino acid in both seasons on plant height number of leaves dry leaves plant^{-1}, number of branches plant^{-1} and dry weight of branches plant^{-1} (g) while fresh weight of branches was significantly affected by the interaction between P and amino acids in both seasons. Average of weight 10 pods (g), Average of seeds weight 10 pods (g) and Total fresh yield t fed^{-1} were significantly affected by the interaction between P level and foliar application of amino acid. Total fresh yield t fed^{-1} ranged between 2.200 and 4.533 t fed^{-1} in 2019 season and between 2.667 and 4.317 t fed^{-1} in 2020 season for the treatments P0 × Am0 and P2 × Am2, respectively. Relative yield increase due to the interaction between P level and foliar spray of Amino Acid ranged between 4 and 99% in 2019 season and between 7 and 62% over the control treatments for the treatment P0 × Am0 and P2 × Am2 cm l^{-1} in both seasons, respectively. The synergistic effect for the interaction between P level and foliar application of amino acid in both seasons could be attributed to the role of P because phosphorus may be a critical constraint for legumes under low nutrient environment because there is a substantial need of phosphorus in the nitrogen fixation process [3]. Phosphorus has an enhancing impact on plant growth and biological yield through its importance as energy storage and transfers energy necessary for metabolic processes. Also the Amino acids are responsible for the synthesis of other organic compounds, such as protein, amines, alkaloids, vitamins, enzymes, terpenoids [12]. Amino acids are conclusive to stimulating cell growth, act as buffers, provide a source of carbon and energy and protect the cells from ammonia toxicity, with amid formation [13]. The application of amino acids can stimulate the performance of plant [14]. Amino acids have a chelating effect on micronutrient. Many studies have been demonstrate that amino acids can directly or indirectly effect the physiological activities in plant growth and development. In addition, foliar application of amino acids caused an enhancement in plant growth, fruit yield and its components El-Shabasi *et al*. [11] on garlic, Awad *et al*. [10] on potato, Abd El-Aal *et al*. [15] on squash and Shafeek *et al.* [16] on onion. In the same respect, Ghaith and Galal [17] reported that, spraying pea plants with mixture of amino acid at 100 ppm significantly increased plant growth characters, total pods yield and pods quality. In addition, Shafeek *et al*. [18] on garlic reported that the biggest bulb yield as t fed^{-1} and better physical possession of bulb (fresh and dry weight), acquired when amino mix spatter three times at high level (2%). Also, the acquired conclusion recorded the highest nutritional amount of garlic bulb tissues were recorded with splash of amino mix at the higher concentration.

Table 6: Effect of P level on Pea chemical constituents in 2019 and 2020 seasons

Phosphate level	N% dry seeds	P% dry seeds	K% dry seeds	Total protein % dry seeds	% Carbohydrates dry seeds	Total sugar g/100g dry weight
			2018/19 Season			
0 kg fed^{-1} (P0)	1.33	0.61	2.11	8.32	7.76	15.51
200 kg fed^{-1} (P1)	2.01	0.65	2.41	12.58	13.05	39.71
250 kg fed^{-1} (P2)	2.36	0.68	2.77	14.75	18.71	46.18
LDS at 0.05	0.04	0.009	0.055	0.26	1.47	6.32
			2019/20 Season			
0 kg fed^{-1} (P0)	1.20	0.64	1.67	7.50	8.92	14.09
200 kg fed^{-1} (P1)	1.61	0.74	1.94	10.06	19.71	31.43
250 kg fed^{-1} (P2)	1.81	0.79	2.16	11.34	29.16	42.28
LDS at 0.05	0.06	0.02	0.06	0.41	1.40	1.93

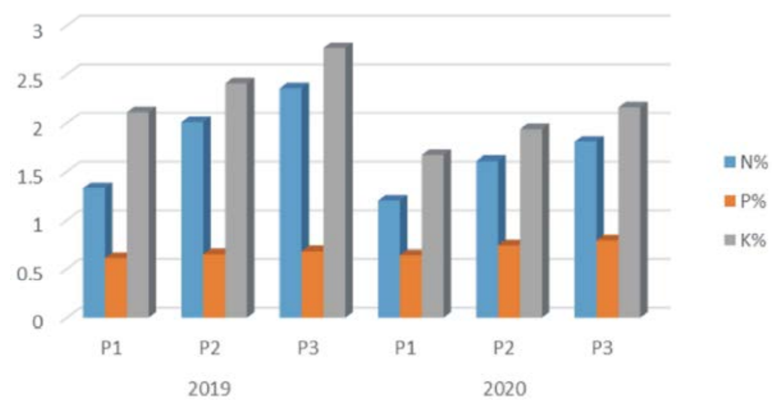

Fig. 1: Effect of P level on N, P and K % of Pea fresh seeds (on dry matter basis) in 2019 and 2020 seasons

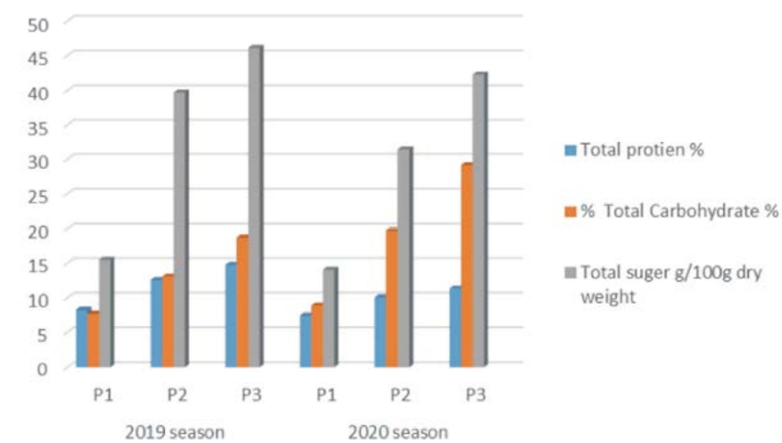

Fig. 2: Effect of P level on total protein, total carbohydrates (%) and total sugars (g/100g) of Pea fresh seeds (on dry matter basis) in 2019 and 2020 seasons

Also, Shafeek *et al*. [18] on broad bean plant found that foliar application by high concentration of amino mix (2%) significantly improved the most plant growth characters, total yield and its components as well as the seeds contents of the percentage of N, protein, P and K followed in descending order by that plants spraying by 1% followed with the control treatment.

Effect of P Level and Amino Acid Mixture on Pea Chemical Constituents: Data presented in Table (6) show the effect of P level application on pea chemical constituents. The results reveal significant effects due to P application. Data show that increasing P level up to 250 kg fed^{-1} super phosphate significantly increased NPK concentrations in green seeds of pea in

Table 7: Effect of foliar application of amino acids on Pea chemical constituents in 2019 and 2020 seasons

Foliar applied amino acids	N% dry seeds	P% dry seeds	K% dry seeds	Total protein % dry seeds	% Carbohydrates dry seeds	Total sugar g/100g dry weight
				2018/19 Season		
Control (Am0)	1.77	0.61	2.34	11.07	10.41	29.77
1 cm l^{-1} (Am1)	1.89	0.65	2.42	11.80	13.05	34.75
2 cm l^{-1} (Am2)	2.04	0.69	2.53	12.78	16.06	36.89
LSD at 0.05	0.04	0.01	0.03	0.23	0.75	1.10
				2019/20 Season		
Control (Am0)	1.48	0.65	1.84	9.26	17.12	21.04
1 cm l^{-1} (Am1)	1.52	0.72	1.93	9.49	19.34	29.63
2 cm l^{-1} (Am2)	1.62	0.81	1.99	10.15	21.33	37.13
LSD at 0.05	0.08	0.01	.0.02	0.54	0.94	1.88

2019 and 2020 seasons (Fig. 1). Both P levels: P1 and P2 significantly surpassed the unamended control treatment. Total protein%, carbohydrates% and total sugar (g/100g dry weight) in green pea seeds took similar tendency increasing P level up to 250 kg fed^{-1} super phosphate significantly increased concentrations of total protein%, carbohydrates% and total sugar (g/100g dry weight) in green seeds of pea in both seasons of study (Fig. 2). The beneficial effect of P application on the chemical constituents of pea seed could be attributed to the metabolic role of P in pea plants. Tsvetkova and Georgiev [3] indicated that Phosphorus has an enhancing impact on plant growth and biological yield through its importance as energy storage and transfers energy necessary for metabolic processes. Also Jakir *et al*. [1] reported that Phosphorus is a constituent of adenosine diphosphate (ADP), sugar phosphate, nucleic acid, proteins and several co-enzymes which are of great importance in energy transformation and metabolic weight plant^{-1}.

Data in Table (7) show the effect of foliar application of amino acids on Pea chemical constituents. The results reveal significant effects due to on foliar application of amino acid mixture. The results reveal significant effects due to foliar application of amino acid mixture on pea NPK concentrations in green seeds of pea in 2019 and 2020 seasons (Fig. 3). Both foliar application rates (1 and 2 cm l^{-1}) of amino acid mixture significantly surpassed control treatment. Total protein%, carbohydrates% and total sugar (g/100g dry weight) in green pea seeds took similar tendency and increasing foliar application rates up to (2 cm l^{-1}) significantly increased concentrations of total protein%, carbohydrates% and total sugar (g/100g dry weight)in green seeds of pea in both seasons of study (Fig. 4). The positive effect of foliar application of amino acid mixture on the chemical constituents of pea seed could be attributed to the metabolic role of amino acid mixture in pea and the suitable effects of foliar spraying amino acids, many researchers have found that, the useful effects of amino acids to increase growth and yield for all crops. It is the essential ingredients for the operation of protein synthesis and exceedingly uses for the biosynthesis of pigments, vitamins, coenzymes, purine and pyrimidine bases [9]. The demand of amino acids in essential quantities is well known as a mean to increase yield and total quality of crops. The application of amino acids for foliar spray is established on their requirement by plants in general and critical stages of growth in special. Also amino acids are basis ingredients in the process of protein synthesis. About 20 important amino acids are implicated in the process of each function [10]. Some researchers pointed out the importance of amino acids in increasing growth, yield and chemical composition of some economic plants.

Data presented in Table (8) show that there were no significant effects due to the interaction between P level and foliar application of amino acid in both seasons. The results reveal significant effects due to interaction between P level and foliar application of amino acid mixture on pea NPK concentrations in green seeds of pea in 2019 Table (8) and (Fig. 5). Both foliar application rates (1 and 2 cm l^{-1}) of amino acid mixture significantly surpassed the control treatment. Total protein%, carbohydrates% and total sugar (g/100g dry weight) in green pea seeds took similar tendency and increasing foliar application rates up to (2 cm l^{-1}) significantly increased concentrations of total protein%, carbohydrates% and total sugar (g/100g dry weight) in green seeds of pea in 2019 (Table 8 and Fig. 6). Only the interaction effect of P level and foliar application of amino acid significantly affected K% and total sugar (g/100g dry weight) in green pea seeds.

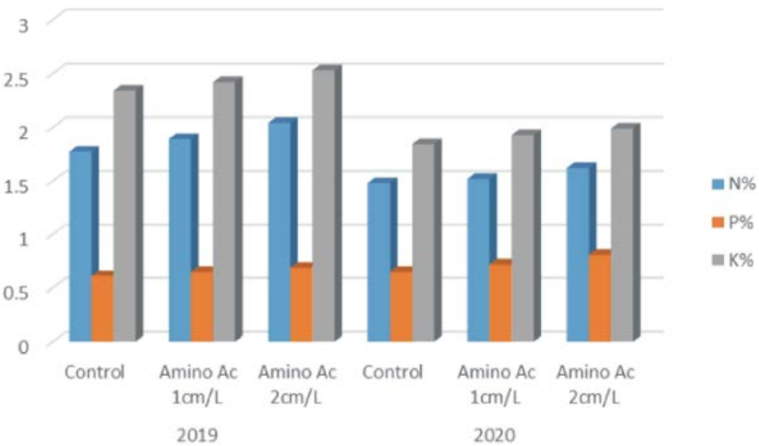

Fig. 3: Effect of foliar application of amino acid concentrations on N, P and K % of Pea fresh seeds (on dry matter basis) in 2019 and 2020 seasons

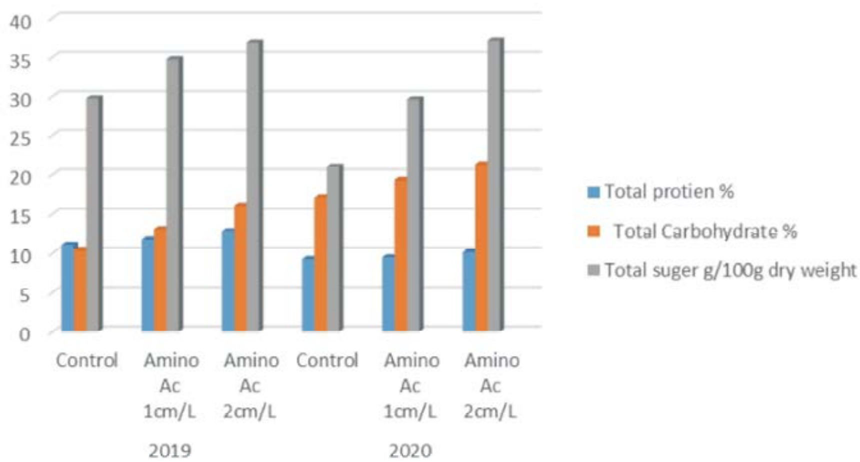

Fig. 4: Effect of foliar application of amino acid concentrations on total protein, total carbohydrates (%) and total sugars) g/100g) of Pea fresh seeds (on dry matter basis) in 2019 and 2020 seasons

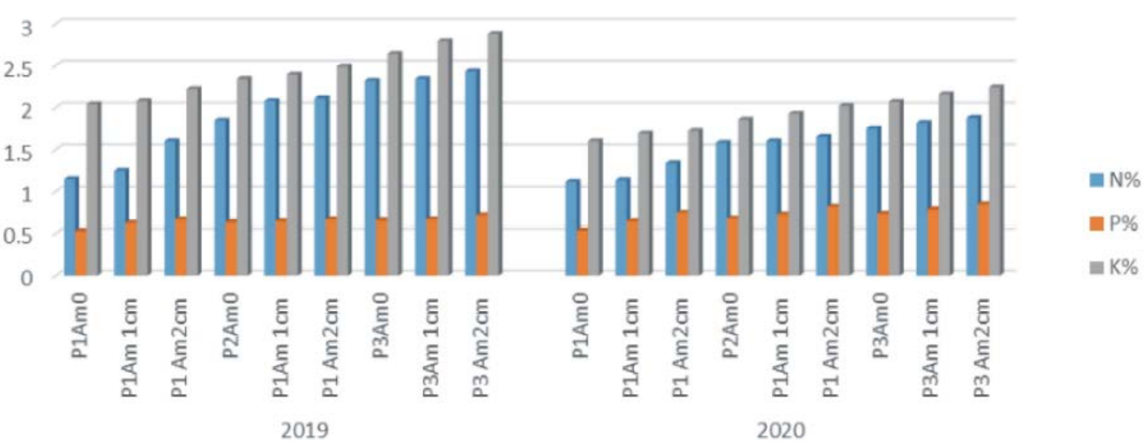

Fig. 5: Effect of the interaction between P level and foliar application of amino acid concentrations on N, P and K % of Pea fresh seeds (on dry matter basis) in 2019 and 2020 seasons

Table 8: Effect of the interaction between P level and foliar application of amino acids on Pea chemical constituents in 2019 and 2020 seasons

Treatment	N% dry seeds	P% dry seeds	K% dry seeds	Total protein % dry seeds	% Carbohydrates dry seeds	Total sugar g/100g dry weight
			2018/19 Season			
1- P0 × Am0	1.15	0.53	2.04	7.17	4.70	11.89
2- P0 × Am1	1.25	0.63	2.08	7.79	7.56	16.52
3- P0 × Am2	1.60	0.67	2.22	10.00	11.02	18.14
4- P1 × Am0	1.85	0.64	2.34	11.56	12.58	36.89
5- P1 × Am1	2.08	0.65	2.39	13.00	13.04	40.49
6- P1 × Am2	2.11	0.67	2.49	13.17	13.53	41.76
7- P2 × Am0	2.32	0.66	2.64	14.48	13.94	40.53
8- P2 × Am1	2.34	0.67	2.79	14.60	18.55	47.23
9- P2 × Am2	2.43	0.72	2.88	14.98	23.63	50.79
LSD at 0.05	0.23	0.061	0.23	1.2	3.4	8.8
			2019/20 Season			
1- P0 × Am0	1.12	0.54	1.60	6.98	6.82	7.56
2- P0 × Am1	1.14	0.65	1.69	7.15	8.67	12.85
3- P0 × Am2	1.34	0.75	1.72	8.38	11.28	21.85
4- P1 × Am0	1.58	0.68	1.86	9.85	17.79	25.44
5- P1 × Am1	1.60	0.73	1.93	9.98	19.20	30.42
6- P1 × Am2	1.65	0.82	2.02	10.33	22.16	38.44
7- P2 × Am0	1.75	0.74	2.07	10.94	26.76	30.11
8- P2 × Am1	1.82	0.79	2.16	11.35	30.16	45.62
9- P2 × Am2	1.88	0.85	2.24	11.73	30.55	51.11
LSD at 0.05	NS	0.087	NS	NS	NS	8.88

1- P0 × Am0: Without treatment. 2- P0 × Am1: Amino acids at 1 cm l^{-1}. 3- P0 × Am2: Amino acids at 2 cm l^{-1}. 4- P1 × Am0: posphatic fertilization at 0 kg fed^{-1}. 5- P1 × Am1: posphatic fertilization at 200 kg fed^{-1} + Amino acids at 1 cm l^{-1}. 6- P1× Am2: posphatic fertilization at 250 kg fed^{-1} + Amino acids at 2 cm l^{-1}. 7- P2 × Am0: posphatic fertilization at 0 kg fed^{-1}. 8- P2 × Am1: posphatic fertilization at 200 kg fed^{-1} + Amino acids at 1 cm l^{-1}. 9- P2 × Am2: posphatic fertilization at 250 kg fed^{-1} + Amino acids at 2 cm l^{-1}.

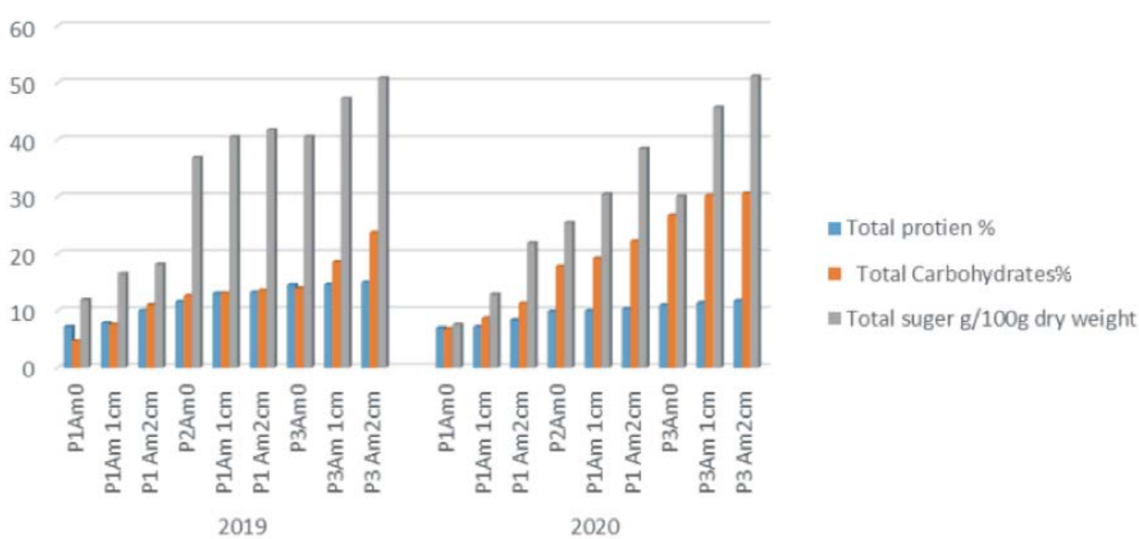

Fig. 6: Effect of the interaction between P level and foliar application of amino acid concentrations total protein, total carbohydrates (%) and total sugars) g/100g) of Pea fresh seeds (on dry matter basis) in 2019 and 2020 seasons

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