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EFFECT OF SOME AMINO ACIDS CONCENTRATION ON GROWTH AND YIELD OF LAVENDER (*Lavandula officinalis*, CHAIX) PLANT UNDER DIFFERENT NPK FERTILIZATION LEVELS

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ABSTRACT: Two field experiments were conducted at the experimental farm, Faculty of Agriculture, Zagazig University, Egypt during the two consecutive summer seasons of 2018 and 2019. They study aimed to investigate the effect of different NPK fertilization levels (0.0, 25, 50, 75 and 100% of recommended rate), amino acid concentrations (control, L-tryptophan acid at 50 and 100 ppm as well as phenylalanine acid at 150 and 300 ppm) and their interactions on growth and yield components of lavender (*Lavandula officinalis*, Chaix) plant. The NPK recommended rates (RR) were 61.5, 31 and 24 kg of N, P_2O_5 and K_2O/faddan, respectively. The obtained results pointed out that the maximum value for each of plant height, number of branches/plant, fresh and dry weights of roots/plant and root length as well as fresh and dry weights of lavender herb/ plant and /faddan were recorded when lavender plants were fertilized with 100% RR of NPK. Also, increasing NPK fertilization levels gradually increased abovementioned parameters. Foliar spray with L-tryptophan at 100 ppm, significantly increased lavender growth parameters and yield components compared to spraying with the other amino acid concentrations and control (untreated plants), in most cases. Generally, the best interaction treatment in this connection was obtained by the treatment of 100% recommended rate of NPK and spraying with 100 ppm of L-tryptophan acid.

Key words: Lavender, NPK, L-tryptophan, phenylalanine, growth, yield components.

INTRODUCTION

Lavender (*Lavandula officinalis*, Chaix) is an evergreen bushy semi shrub with straight and woody branches, the lower of which are leafless and putting out numerous herbaceous stems (**Chiej, 1984**). *L. officinalis* is a native of Southern Europe and the Mediterranean region **(Wichtl, 1994)**. Vegetative body and flowers of lavender are used as medicine. Treatments of some skin diseases such as improving burns, wounds, minor scratches and psoriasis treatment are seen by the plant; Moreover, its oil is recommended for anxiety, restlessness and insomnia **(Najafi *et al.*, 2014)**. Furthermore, **Cooke (1972)** reported that the major nutrients required by the crop are Nitrogen (N), Phosphorus (P) and Potassium (K). The macronutrients, N, P, and K, are often classified as 'primary' macronutrients, because deficiencies of N, P and K are more common than the 'secondary' macronutrients, Ca, Mg, and S. Most of the macronutrients are represent 0.1 to 5%, or 100 to 5000 parts per million (ppm), of dry plant tissue (**Wiedenhoeft, 2006**). NPK fertilizer plays important roles in different physiological processes in the plant which were reported by **Lambers *et al.* (2000)**. The role of nitrogen in protoplasm formation and all proteins *e.g.* amino acids, nucleic acid, many enzymes and energy transfer materials ADP and ATP **(Russel, 1973)**, the role of phosphorus as a major nutrient element, where phosphorus compounds are of absolute necessity for all living organisms, nucleo proteins constituting the essential substances of the cell and for cell division and development of meristematic tissues. Potassium is important for growth and elongation probably due to its function as an

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osmaticum and may react synergistically with IAA. Moreover, it promotes CO_2 assimilation and translocation of carbohydrates from the leaves to storage tissues **(Mengel and Kirkby, 1987)**. In addition, amino acids as organic nitrogenous compounds are the building blocks in the synthesis of proteins, **Davies (1982)**. Amino acids are particularly important for stimulation cell growth. They act as buffers which help to maintain favorable pH value within the plant cell, since they contain both acid and basic groups; they remove the ammonia from the cell. The regulatory effect of amino acids on growth could be explained by the notion that some amino acids *e.g.* L-Tryptophan (Trp.) is known to be a physiological precursor of auxins in higher plants. It is investigated that L-Tryptophan has more positive effect on plant growth and yield as compared to pure auxins (**Zahir *et al.*, 1999**). L-Tryptophan is an amazing amino acid. It may act as an osmolyte, ion transport regulator, modulates stomatal opening and detoxify harmful effects of heavy metals (**Rai, 2002**). Phenylalanine (Phe.) can affect plant growth and development through their influence on gibberellins biosynthesis (**Walter and Nawacki, 1978**).

The present study was carried out to investigate the effect of different levels of NPK and concentrations of L-tryptophan and phenylalanine acids on vegetative growth, and yield components of lavender plant under Sharkia Governorate conditions.

MATERIALS AND METHODS

Two field experiments were carried out at Experimental Farm, Faculty of Agriculture, Zagazig University, Egypt during the two summer consecutive seasons of 2018 and 2019. This work was conducted to investigate the effect of different levels of NPK fertilization (0.0, 25, 50, 75 and 100% of recommended rate), amino acids concentrations [control as tap water spray, L-tryptophan (Trp) acid at 50 and 100 ppm as well as phenylalanine (Phe) acid at 150 and 300 ppm] and their interaction treatments on plant growth and yield components of lavender plant (*Lavandula officinalis*, Chaix). The physical and chemical properties of the experimental soil site are shown in Table 1, according to (**Chapman and Pratt, 1978**).

This experiment was set up in a split-plot design with three replicates. The main plots were occupied by five NPK fertilization levels. The sub plots were entitled to five amino acids concentrations. The interaction treatments between NPK fertilization and amino acids were 25 treatments.

The lavender seedlings were obtained from private nursery in Belbas District, Sharkia Governorate, Egypt. All seedlings were similar in growth and 10 cm in length. Seedlings were planted in the experimental plots on 15th April and 7th May during the first and second seasons, respectively. The experimental unit area was 3×3 m containing five ridges, with 60 cm between them. The distance between plants in the ridge was 50 cm, so each plot area contained 30 plants, under surface irrigation system.

The NPK recommended rates (RR) were 61.5, 31 and 24 kg of N, P_2O_5 and K_2O/faddan, respectively. Sources of NPK were ammonium sulphate (20.5% N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48.5% K_2O), respectively. All amount of phosphorus fertilizer was applied during soil preparation. While, nitrogen and potassium fertilizers were divided into three equal doses and were added to the soil at 30, 55 and 80 days after transplanting. The source of L-Tryptophan acid [(S)-2-Amino-3-(3-indolyl) porpionic acid ($C_{11}H_{12}N_2O_2$)] and phenylalanine acid [(S)-2-Amino-3-phenylporpionic acid ($C_9H_{11}NO_2$)] were TECHNO GENE Company, Dokky, Giza, Egypt. The amino acid treatments were applied as foliar application at 40, 55 and 70 days after transplanting. Each experimental unit received 5 letters solution using spreading agent (Super Film at a rate of 1ml/l). The untreated control plants were sprayed with tap water with spreading agent. Also, all normal agricultural practices of growing lavender plants were done when ever needed.

Data Recorded

After 165 days from transplanting, 3 plants were randomly chosen from each plot to determine the following parameters:

Plant growth parameters

plant height (cm), number of branches/plant, fresh and dry weights of roots/plant (g) and root length (cm) were determined in both seasons.

Table 1. Physical and chemical properties of experimental soil

Physical analysis				Soil texture
Clay (%)	Silt (%)	Fine sand (%)	Coarse sand (%)	Clay
41.39	19.26	15.62	23.73	

Chemical analysis												
pH	E C m.mohs/cm	Organic mater (%)	Soluble cations (meq./ L)				Soluble anions (meq. /L)			Available (ppm)		
			Mg^{++}	Ca^{++}	K^{+}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.82	0.98	0.58	2.7	1.5	1.6	3.9	4.5	1.7	3.5	17	8.3	71

Herb yield and its components

Herb yield per plant and per faddan as fresh and dry forms were determined.

Statistical Analysis

Collected data were analyzed according to **Gomez and Gomez (1984)**. Least significance difference (LSD) was used to differentiate means at 5% level of probability. The means were compared using computer program of Statistix version 9 (**Analytical software, 2008**).

RESULTS AND DISCUSSION

Effect of NPK Fertilization and Amino Acids on Plant Growth

Plant height (cm)

Results recorded in Table 2 show that, nitrogen, phosphorus and potassium (NPK) fertilizers levels significantly increased lavender plant height compared to control during both seasons. Moreover, plant hieght was gradually increased by increasing NPK fertilization level. The best treatment in this concern was that 100% of recommended rate (RR) of NPK compared to the other levels under study. Plant height gradually increased with increasing each Trp acid or Phe acid concentrations in the two seasons. The highest value in lavender plant height was obtained by the treatment of Trp acid at 100 ppm during both seasons. Furthermore, 100% NPK of recommended rate + 100 ppm Trp acid significantly increased lavender height compared to the other interaction treatments under study in both seasons. Generally, increasing NPK fertilization level under each amino acid concentration increased lavender height. These results hold true during the two consecutive seasons.

Number of branches/plant

Results presented in Table 3 suggest that, the highest value in branch number per plant was observed with the highest level of NPK (100% RR) in both 2018 and 2019 seasons. In general, all NPK fertilization levels, significantly increased number of branches per lavender plant compared to control. In addition, using all amino acids (L-tryptophan and phenylalanine) concentrations increased lavender branch number /plant compared to unsprayed plants (control). Whenever, using 100 ppm followed by 50 ppm of Trp acid recorded higher values in this regard compared to the two concentrations of Phe acid and control in both seasons. In the same time, the best interaction effect in increasing number of branches per plant was that of 100% RR of NPK plus 100 ppm of Trp acid. The increases in number of branches per lavender plant by this treatment were about 40.28 and 43.47% over the control in 1st and 2nd seasons, respectively.

Fresh weight of roots/plant (g)

The results tabulated in Table 4 indicate that, the lowest value in fresh weight of roots per lavender plant was recorded with control (without NPK fertilization) in both seasons. However, 100% RR of NPK fertilization level

Table 2. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on plant height (cm) of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	32.22	36.33	39.22	36.22	38.55	**36.51**
25%	31.56	41.22	42.78	38.56	40.00	**38.82**
50%	35.11	45.11	46.22	39.89	42.33	**41.73**
75%	37.22	49.55	52.00	47.78	49.44	**47.20**
100%	42.22	51.22	55.11	48.89	52.78	**50.04**
Mean (B)	**35.67**	**44.69**	**47.07**	**42.27**	**44.62**	
LSD at 5%	For (A)= 0.50		For (B)= 0.75		For (A×B)= 1.57	
			2019 season			
0.0%	34.78	38.44	38.22	37.33	40.78	**37.91**
25%	36.22	41.78	41.89	38.78	40.33	**39.80**
50%	39.22	43.78	47.00	39.78	41.67	**42.29**
75%	40.55	48.55	50.33	44.89	48.11	**46.49**
100%	42.89	52.11	57.22	47.55	49.78	**49.91**
Mean (B)	**38.73**	**44.93**	**46.93**	**41.67**	**44.13**	
LSD at 5%	For (A)= 0.85		For (B)= 0.68		For (A×B)= 1.60	

* Recommended rate (RR): 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

Table 3. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on number of branches/plant of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	49.11	53.44	57.89	50.78	51.78	**52.60**
25%	50.78	55.89	56.55	53.22	53.89	**54.07**
50%	53.11	59.56	60.78	53.78	56.44	**56.73**
75%	56.11	62.89	67.22	57.89	58.89	**60.60**
100%	57.22	65.11	68.89	58.78	60.55	**62.11**
Mean (B)	**53.27**	**59.38**	**62.27**	**54.89**	**56.31**	
LSD at 5%	For (A)= 0.77		For (B)= 0.65		For (A×B)= 1.51	
			2019 season			
0.0%	47.78	53.89	58.67	53.22	55.00	**53.71**
25%	49.11	55.11	58.78	55.22	56.22	**54.89**
50%	51.44	58.55	59.78	56.89	56.78	**56.69**
75%	53.11	60.11	64.78	57.89	59.22	**59.02**
100%	56.00	63.22	68.55	58.78	59.78	**61.27**
Mean (B)	**51.49**	**58.18**	**62.11**	**56.40**	**57.40**	
LSD at 5%	For (A)= 0.99		For (B)= 0.62		For (A×B)= 1.59	

* Recommended rate (RR): 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

Table 4. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on fresh weight of roots/plant (g) of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.		Phe.		
	0.0	50	100	150	300	
			2018 season			
0.0%	18.07	21.58	22.28	18.23	19.55	**19.94**
25%	18.11	22.22	23.90	19.96	20.19	**20.88**
50%	18.49	23.09	25.35	20.50	21.46	**21.78**
75%	20.43	25.41	28.69	24.39	25.31	**24.85**
100%	21.42	25.56	29.81	24.79	26.69	**25.65**
Mean (B)	**19.30**	**23.58**	**26.01**	**21.57**	**22.64**	
LSD at 5%	For (A)= 0.76		For (B)= 0.55		For (A×B)= 1.33	
			2019 season			
0.0%	15.68	21.37	23.37	18.86	20.33	**19.92**
25%	16.82	23.06	25.10	19.69	20.81	**21.10**
50%	17.86	24.29	26.65	20.46	21.52	**22.16**
75%	22.80	27.51	30.16	25.17	26.40	**26.41**
100%	23.07	26.94	30.63	27.36	26.97	**26.99**
Mean (B)	**19.25**	**24.64**	**27.18**	**22.31**	**23.21**	
LSD at 5%	For (A)= 0.76		For (B)= 0.35		For (A×B)= 1.03	

* Recommended rate: 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

significantly increased fresh weight of roots/ plant (g) compared to the other NPK levels under study in the two seasons. Likewise, the highest concentration of L-tryptophan acid (100 ppm) significantly increased fresh weight of roots per plant compared to the other amino acid concentrations under study. Using amino acids with any concentration increased the abovementioned parameter compared to control. These results were hold true in both seasons. The best interaction treatment in this concern was that of 100 followed by 75% RR of NPK fertilization interacted with 100 ppm Trp acid with no significant differences between them in the second season.

Dry weight of roots /plant (g)

Results in Table 5 reveal that, increasing NPK fertilization level from 25 to 100% of recommended rate, gradually increased dry weight of roots per plant. Moreover, 100%RR of NPK significantly increased lavender root dry weight compared to the other ones under study. Furthermore, increasing amino acid concentration from 50 to 100 of Trp acid as well as 150 to 300 ppm of Phe acid, gradually increased dry weight of roots per plant. Generally, the best treatment in this connection was that of 100 ppm of Trp acid in both seasons. Similarly, using NPK fertilization at 100% RR + 100 ppm of Trp acid as interaction treatment recorded the best results regarding dry weight of roots per plant during the first and second season.

Root length (cm)

It is evident from the obtained results in Table 6 that, 100% RR of NPK fertilization level, significantly increased lavender root length compared to the other levels under study in both seasons. The increases in this regard were about 18.02 and 24.64% over the control in the first and second seasons, respectively. Since, all NPK fertilization levels (except that of 25% RR in the first season) significantly increased root length compared to control during the two seasons. Also, 100 ppm of Trp acid significantly

Table 5. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on dry weight of roots/plant (g) of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	7.87	9.50	9.99	8.26	9.06	**8.94**
25%	7.99	10.14	10.86	9.01	9.40	**9.47**
50%	8.55	11.51	11.96	10.60	10.15	**10.55**
75%	9.57	13.89	16.92	11.73	12.04	**12.83**
100%	11.77	14.16	19.18	13.12	12.55	**14.16**
Mean (B)	**9.15**	**11.84**	**13.78**	**10.54**	**10.64**	
LSD at 5%	For (A)= 0.19		For (B)= 0.30		For (A×B)= 0.63	
			2019 season			
0.0%	7.29	9.49	10.50	8.56	9.30	**9.03**
25%	7.58	10.57	11.74	8.97	10.11	**9.79**
50%	7.96	11.43	12.88	10.75	10.71	**10.75**
75%	11.81	14.10	18.40	11.77	12.86	**13.79**
100%	12.52	14.83	18.36	12.76	13.27	**14.35**
Mean (B)	**9.43**	**12.08**	**14.38**	**10.56**	**11.25**	
LSD at 5%	For (A)= 0.35		For (B)= 0.28		For (A×B)= 0.66	

* Recommended rate: 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

Table 6. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on root length (cm) of *Lavandula officinalis* plant during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	18.67	22.56	26.78	21.33	22.22	**22.31**
25%	19.00	23.22	27.55	22.11	21.67	**22.71**
50%	19.89	23.44	28.22	22.67	23.44	**23.53**
75%	20.78	26.56	28.78	25.11	26.00	**25.44**
100%	21.78	27.55	30.56	25.44	26.33	**26.33**
Mean (B)	**20.02**	**24.67**	**28.38**	**23.33**	**23.93**	
LSD at 5%	For (A)= 0.57		For (B)= 0.40		For (A×B)= 0.98	
			2019 season			
0.0%	16.44	21.67	26.44	22.11	24.33	**22.20**
25%	19.66	24.22	28.44	22.89	24.34	**23.91**
50%	20.67	25.78	29.44	23.66	25.33	**24.98**
75%	23.22	27.44	30.00	25.22	27.11	**26.60**
100%	25.00	28.44	31.11	25.89	27.89	**27.67**
Mean (B)	**21.00**	**25.51**	**29.09**	**23.95**	**25.80**	
LSD at 5%	For (A)= 0.90		For (B)= 0.61		For (A×B)= 1.51	

* Recommended rate: 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

increased root length of lavender plant compared to the other concentrations of amino acids under study. The increases in this regard were about 41.76 and 38.52% over the control in the first and second seasons, respectively. However, the best interaction treatment in this concern was that of 100% NPK of recommended rate + 100 ppm Trp acid in both seasons. Generally, increasing NPK fertilization level under each amino acid concentrations increased lavender root length. These results hold true during the two consecutive seasons.

However, **Marschner (1995)** indicated that N, P and K play a major role in many physiological and biochemical processes leading to taller plants, more branches, heaviest root and taller root plants (as obtained in lavender plant). Nitrogen and phosphorus are a constituent part of protein and component of protoplasm as well as energy transfer materials ADP and ATP, which increases the chlorophyll contents in leaves. All these factors led to cell multiplication, cell enlargement and cell differentiation, which have resulted in increasing of plant growth (**Parmer, 2007**). Also, **Hassan *et al*. (2015)** on sweet basil, showed that 100% of recommended rate of NPK gave the highest value for each of plant height and number of branches per plant. **Mohamed *et al*. (2015)** found that the applied treatments of NPK fertilizers, significantly increased sweet basil growth parameters *i.e.* plant height, number of branches as well as fresh and dry weights of plant (g). Moreover, the highest value for each of dragonhead plant height, number of branches/plant and fresh and dry weights/plant was recorded with 100% RR of NPK fertilization (**Mostafa *et al*., 2019**).

Studies have proved that amino acids can directly or indirectly affect the physiological activities of plant development and vegetative growth. Many studies found that the foliar application of amino acids caused an improvement in plant (**Awad *et al*., 2007)** on potato. **Omer *et al*. (2013)** reported that amino acids in different doses, significantly increased plant height, number of branches as well as fresh and dry weights of chamomile compared to untreated plants. Amino acids is well known biostimulant which has positive effects on plant growth of several plants (**Sadak *et al*., 2015**). Similar results were stated by **Gendy and Nosir (2016)** on roselle plant.

Moreover, as mentioned just before, both NPK fertilization and amino acid concentration (each alone) increased plant height, number of branches per plant, fresh and dry weights of roots per plant and root length of *Lavandula officinalis* plant, in turn, they together might maximize their effects leading to the best growth parameters. **El-Awadi *et al*. (2011**) stated that fertilized snap bean plants with the highest nitrogen dose increased the vegetative growth, yield and quality. Tryptophan (100 $mg.l^{-1}$) improved vegetative growth. Similar results were obtained by **Seadh *et al*. (2017**) on bread wheat plants. Also, **Fahmy and Mohsen (2020)** indicated that plant height, number of branches per plant and total dry weight of dill, significantly increased by using each NP fertilizers at 100% RR or tryptophan acid at 150 ppm concentration as well as in combination compared to control.

Effect of NPK Fertilization and Amino Acids on Herb Yield Components

Fresh herb yield /plant (g)

As shown in Table 7 that, all NPK fertilization levels (25, 50, 75 and 100% RR) significantly increased fresh herb yield per plant compared to control in both seasons. Moreover, 100% RR of NPK recorded the higher values in this connection compared to the other levels under study. The increases in lavender fresh yield per plant were about 17.69 and 14.24% for 100% over the control in the first and second seasons, respectively. Using all concentrations of L-tryptophan or phenylalanine, significantly increased fresh herb yield per plant compared to unsprayed plants in both seasons. 100 ppm of Trp acid recorded about 20.56 and 18.68% increases in this regard over the control in the first and second seasons, respectively. The increases in fresh herb yield/lavender plant were about 48.95 and 30.05% for the interaction between NPK at 100% RR and Trp acid at 100 ppm, 42.40 and 29.08% for the interaction between NPK at 75% RR and Trp acid at 100 ppm and 42.51 and 27.97% for the interaction between NPK at 100%RR and Trp acid at 50 ppm over the control in 1st and 2nd seasons, respectively.

Table 7. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on herb fresh weight/plant (g) of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	101.21	125.37	130.48	112.04	122.92	**118.40**
25%	116.63	129.73	132.71	120.73	124.69	**124.90**
50%	117.74	137.03	140.76	127.12	129.06	**130.34**
75%	118.89	141.56	144.12	128.91	138.23	**134.34**
100%	125.14	144.23	150.75	133.63	142.99	**139.35**
Mean (B)	**115.92**	**135.58**	**139.76**	**124.48**	**131.58**	
LSD at 5%	For (A)= 1.63		For (B)= 1.74		For (A×B)= 3.84	
			2019 season			
0.0%	131.45	146.19	152.06	132.97	138.85	**140.30**
25%	133.84	150.73	157.49	138.25	143.44	**144.75**
50%	138.36	153.63	160.57	145.56	151.49	**149.92**
75%	139.05	164.98	169.67	152.95	163.15	**157.96**
100%	140.44	168.22	170.95	156.97	164.82	**160.28**
Mean (B)	**136.63**	**156.75**	**162.15**	**145.34**	**152.35**	
LSD at 5%	For (A)= 2.74		For (B)= 1.93		For (A×B)= 4.72	

* Recommended rate (RR): 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

Fresh herb yield /faddan (kg)

Results of both seasons in Table 8 show that, the highest value in fresh herb yield per faddan was observed with the highest level of NPK (100% RR) in both seasons. The increases in lavender fresh yield per faddan were about 3.73 and 1.47% for 100% RR of NPK compared to NPK level at 75% RR in the first and second seasons, respectively. In general, all NPK fertilization levels significantly increased fresh herb yield per faddan compared to control. However, using different amino acid (L-tryptophan and phenylalanine) concentrations increased lavender fresh herb yield per faddan compared to control. In addition, using 100 ppm followed by 50 ppm of Trp acid recorded the highest values in this respect in the two consecutive seasons. In the same time, the best interaction treatment in increasing fresh herb yield per faddan was that 100% RR of NPK + 100 ppm of Trp acid.

Dry herb yield /plant (g)

Table 9 reveals that, increasing NPK fertilization level from 25 to 100% of recommended rate, gradually increased dry herb yield per plant. Moreover, 100%RR of NPK significantly increased lavender dry herb yield compared to the other ones under study. Similarly, increasing amino acid concentration from 50 to 100 of Trp acid as well as 150 to 300 ppm of Phe acid, gradually increased dry weight of herb per plant. Also, the best treatment in this connection was that of 100 ppm of Trp acid in both seasons. Similarly, using NPK fertilization at 100% RR + 100 ppm of Trp acid as interaction treatment recorded the best results in dry herb yield per plant during the first and second seasons. The increases in dry herb yield/ plant of *Lavandula officinalis* plants were about 75.57 and 56.67% for the interaction between NPK at 100% RR and Trp acid at 100 ppm, 64.66 and 55.10% for the interaction between NPK at 75% RR and Trp acid at 100 ppm

Table 8. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on herb fresh yield/faddan (kg) of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	1416.90	1755.10	1826.70	1568.50	1720.90	**1657.10**
25%	1632.90	1816.30	1858.00	1690.20	1745.70	**1748.60**
50%	1648.40	1918.40	1970.70	1779.60	1806.80	**1824.80**
75%	1664.50	1981.90	2017.60	1804.70	1935.30	**1880.80**
100%	1752.00	2019.20	2110.50	1870.80	2001.80	**1950.90**
Mean (B)	**1622.90**	**1898.20**	**1956.70**	**1742.80**	**1842.10**	
LSD at 5%	**For (A)= 22.87**		**For (B)= 24.40**		**For (A×B)= 53.82**	
			2019 season			
0.0%	1840.30	2046.70	2128.80	1861.60	1943.90	**1964.30**
25%	1873.80	2110.20	2204.80	1935.50	2008.10	**2026.50**
50%	1937.10	2150.90	2248.00	2037.90	2120.90	**2098.90**
75%	1946.70	2309.70	2375.40	2141.30	2284.10	**2211.50**
100%	1966.20	2355.10	2393.30	2197.50	2307.40	**2243.90**
Mean (B)	**1912.80**	**2194.50**	**2270.10**	**2034.80**	**2132.90**	
LSD at 5%	**For (A)= 38.32**		**For (B)= 27.03**		**For (A×B)= 66.15**	

* Recommended rate (RR): 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

Table 9. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on herb dry weight/plant (g) of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	32.17	41.12	44.20	35.62	38.90	**38.40**
25%	36.44	43.99	44.90	39.94	42.20	**41.49**
50%	37.71	47.12	48.91	41.76	44.03	**43.91**
75%	38.34	52.16	52.97	46.71	47.55	**47.54**
100%	40.48	54.13	56.48	47.22	51.10	**49.88**
Mean (B)	**37.03**	**47.70**	**49.49**	**42.25**	**44.76**	
LSD at 5%	**For (A)= 0.67**		**For (B)= 0.91**		**For (A×B)= 1.93**	
			2019 season			
0.0%	41.80	46.84	49.28	44.05	44.88	**45.37**
25%	42.55	48.39	49.22	45.87	47.49	**46.70**
50%	44.51	54.15	61.13	46.10	48.34	**50.85**
75%	45.35	62.63	64.83	49.46	60.65	**56.58**
100%	47.75	63.62	65.49	55.39	60.99	**58.65**
Mean (B)	**44.39**	**55.13**	**57.99**	**48.17**	**52.47**	
LSD at 5%	**For (A)= 0.84**		**For (B)= 0.68**		**For (A×B)= 1.60**	

* Recommended rate (RR): 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

and 68.26 and 52.20% for the interaction between NPK at 100% RR and Trp acid at 50 ppm over the control in 1st and 2nd seasons, respectively.

Dry herb yield /faddan (kg)

Results presented in Table 10 show that, the higher values in dry yield of herb per faddan of lavender were recorded with NPK fertilization at 100% RR compared to the other levels of NPK under study in both seasons. The increases in this regard were about 29.90 and 29.27% over the control in the first and second seasons, respectively. However, all NPK fertilization levels significantly increased dry herb yield/ faddan (kg) compared to control in the two seasons. Also, the highest concentration of L-tryptophan acid (100 ppm) significantly increased dry herb yield per faddan compared to the other amino acid concentrations under study in both seasons. Moreover, using amino acids at any concentration increased the abovementioned parameter compared to control. These results were hold true in both seasons. The best interaction treatment in this concern was that of 100% RR of NPK fertilization interacted with 100 ppm Trp acid compared to the other ones under study in the 2018 and 2019 seasons. The increases in dry herb yield per faddan due to this treatment were about 75.58 and 56.65% over the control in 1st and 2nd seasons, respectively.

The increasing in lavender yield components by the treatment of NPK fertilization could be ascribed to increasing in herb fresh and dry weights (Tables 7 and 9) due to increasing uptake of N, P and K which resulted in increasing total herb fresh and dry yields per faddan (Tables 8 and 10). The better growth parameters improved lavender herb yield and its components. In this respect many investigators found that increasing application of NPK fertilization level increased the yields of fennel **(Dadkhah, 2012)**, chilli (**Akram *et al.*, 2017**), and stevia **(Benhmimou *et al.*, 2018)**. However, the most effective rate was the full recommended dose ($N_{150}P_{200}K_{100}$), resulting in

Table 10. Effect of NPK fertilization levels (A) and amino acid concentrations (B) as well as their interactions (A×B) on herb dry yield/faddan (kg) of *Lavandula officinalis* plant at 165 days after planting during 2018 and 2019 seasons

NPK fertilization level (% RR*)	Amino acid concentrations (ppm)					Mean (A)
	Control	Trp.			Phe.	
	0.0	50	100	150	300	
			2018 season			
0.0%	450.38	575.68	618.80	498.68	544.60	**537.63**
25%	510.11	615.81	628.55	559.21	590.85	**580.91**
50%	527.99	659.68	684.74	584.69	616.42	**614.70**
75%	536.71	730.19	741.53	653.89	665.65	**665.60**
100%	566.67	757.82	790.77	661.13	715.45	**698.37**
Mean (B)	**518.37**	**667.84**	**692.88**	**591.52**	**626.59**	
LSD at 5%	**For (A)= 9.36**		**For (B)= 12.71**		**For (A×B)= 27.07**	
			2019 season			
0.0%	585.25	655.71	689.87	616.65	628.37	**635.17**
25%	595.75	677.41	689.08	642.18	664.81	**653.85**
50%	623.14	758.15	855.82	645.40	676.81	**711.86**
75%	634.95	876.77	907.57	692.44	849.10	**792.17**
100%	668.50	890.10	916.81	775.46	853.86	**821.07**
Mean (B)	**621.52**	**771.75**	**811.83**	**674.43**	**734.59**	
LSD at 5%	**For (A)= 11.74**		**For (B)= 9.54**		**For (A×B)= 22.37**	

* Recommended rate (RR): 61.5 kg N + 31 kg P_2O_5 + 24 kg K_2O per faddan

positive increase in yield components of dill **(Hamad *et al.*, 2017)**. Application of L-Tryptophan as well as phenylalanine acids may increase yield of lavender plants by positively altering physiological phenomena in plants as presented in plant growth in this work. These results also were found by **Youssef (2014)** on *Echinacea purpurea* plant and **Mohamed *et al.* (2018)** on *Triticum aestivum* plants.

The best interaction treatment in lavender yield components was that of 100% RR of NPK fertilization interacted with 100 ppm Trp acid compared to the other ones under study (Tables 7, 8, 9 and 10). In addition, **Fahmy and Mohsen (2020)** found that yield components (fruit yield/plant and/faddan) of dill plant were increased gradually by increased NP fertilizers rate during both seasons. Also, they reported that the best combination treatment in this connection was 100% RR of NP fertilizers combined with 150 ppm of Trp acid compared to control.

Conclusion

The above results stated that the lavender plant growth and yield components were increased by using NPK fertilization levels and amino acid concentrations. In general, the level of NPK fertilization at 100% RR and 100 ppm of L-tryptophan gave the highest values of plant growth and productivity of lavender *(Lavandula officinalis* Chaix) plants grown in clay soil under Sharkia Governorate conditions.

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تأثير تركيز بعض الأحماض الأمينية على نمو ومحصول نبات اللافندر تحت مستويات مختلفة من التسميد النيتروجيني والفوسفاتي والبوتاسي

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أجريت تجربتان حقليتان في المزرعة التجريبية بكلية الزراعة، جامعة الزقازيق، مصر خلال موسمي الصيف المتتاليين لعامي ٢٠١٨ و ٢٠١٩، وذلك لدراسة تأثير المستويات المختلفة للتسميد بالنيتروجين والفسفور والبوتاسيوم (صفر و ٢٥ و ٥٠ و٧٥ و١٠٠% من المعدل الموصى به)، وتركيزات الأحماض الأمينية (الكنترول، وحمض التربتوفان بتركيز ٥٠ و١٠٠ جزء في المليون وكذلك حمض الفينيل ألانين بتركيز ١٥٠ و٣٠٠ جزء في المليون) والتفاعل بينهما على صفات النمو والمحصول لنبات اللافندر، المعدل الموصى به من النيتروجين والفسفور والبوتاسيوم هو ٦١,٥ و ٣١ و ٢٤ كجم من ن، فو٢أ٥ وبو٢أ، على التوالي، أوضحت النتائج التي تم الحصول عليها أنه تم تسجيل أعلى القيم لكل من ارتفاع النبات وعدد الأفرع/ النبات والأوزان الطازجة والجافة للجذور/النبات وطول الجذر وكذلك الأوزان الطازجة والجافة للعشب/نبات وفدان لنبات اللافندر عند معاملة النباتات بالتسميد الثلاثي (النيتروجين والفسفور والبوتاسيوم) بمعدل ١٠٠% من المعدل الموصى به، أيضا، أدى زيادة معدل التسميد بالنتروجين والفوسفور والبوتاسيوم إلى زيادة تدريجية في الصفات المذكورة أعلاه، أدى الرش الورقي بالتربتوفان بتركيز ١٠٠ جزء في المليون إلى زيادة كبيرة في صفات نمو نبات اللافندر والمساهمات المحصولية مقارنة بالرش بتركيزات الأحماض الأمينية الأخرى والكنترول (النباتات غير المعاملة)، في معظم الحالات، بشكل عام، تم الحصول على أفضل معاملة تفاعل في هذا الصدد عن طريق التسميد بالنتروجين والفوسفور والبوتاسيوم بمعدل ١٠٠% من المعدل الموصى به والرش بتركيز ١٠٠ جزء في المليون من حمض التريبتوفان.

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