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INFLUENCE OF FOLIAR SPRAY WITH GLUTAMINE AND TYROSINE ON GROWTH, FRUIT YIELD, VOLATILE OIL PRODUCTION AND CHEMICAL CONSTITUENTS OF FENNEL UNDER DIFFERENT POTASSIUM RATES

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ABSTRACT: Two field experiment was conducted on fennel (*Feoniculum vulgare*, Mill.) during the two successive seasons of 2018/2019 and 2019/2020 in the Experimental Farm of EL-Quassasin Horticultural Research Station, Ismailia Governorate, Egypt. This investigation aimed to study the impacts of spraying fennel plants with glutamine, tyrosine and glutamine+ tyrosine at the rate of 100 ppm beside the control treatment (0.0 ppm) under four levels of potassium fertilization rate**s as** 0.0, 24, 48 and 72 kg K_2O/feddan, on growth, yield components, volatile oil production and some constituents. The results ensured that fertilizing fennel plants with 72 kg K_2O per feddan, regardless amino acid treatments, significantly increased vegetative growth (plant height, branch number and total fresh and dry weights of herb per plant), yield components (number of umbels per plant, fruit yield per plant and per feddan), volatile oil production (volatile oil percentage, volatile oil yield per plant and per feddan) as well as total chlorophyll content (a+b) in leaves, total carbohydrates and potassium percentage in fruits compared to control and the other rates under study. Moreover, applying fennel plants with glutamine + tyrosine at 100 ppm of each, regardless potassium rates treatments, which followed by glutamine at 100 ppm alone significantly improved abovementioned parameters compared to control (sprayed with tap water). Concerning the interaction between fertilization with potassium and amino acids treatments, generally, the combination treatment between the highest rate of potassium fertilization and spraying plants with 100 ppm glutamine + tyrosine is the best treatment for growth, yield components, volatile oil production and pigments of fennel plants under Ismailia Governorate conditions.

Key words: *Feoniculum vulgare*, potassium, amino acid, growth, fruit yield, volatile oil, total chlorophyll.

INTRODUCTION

Fennel (*Feoniculum vulgare*, Mill.) is winter herbaceous plant of the parsley family (Apiaceae). Fennel fruits have a burning sweet taste, spicy odour and pleasant as well as it has food flavoring, perfumery and pharmaceutical utilized (**Wichtel and Bisset, 1994**). It's an aromatic plant whose fruits contain volatile oil which is utilized for several objectives by humans and animals (**Liu *et al.*, 2021; Rather *et al.*, 2016**). The volatile oil of fennel relieves rheumatic and muscular pains, relieves the spasms of intestines and regulates the peristaltic functions of the gastrointestinal tract (**Fathy *et al.*, 2002**). In addition, antimicrobial, insecticidal and antioxidant activity of fennel has also been demonstrated (**Pavela, 2018; Sheweita *et al.*, 2016, Ruberto *et al.*, 2000**).

Potassium (K) is overwhelmingly classified as a primary macronutrient, because its shortage is more common than the secondary macronutrients as calcium, magnesium and Sulphur. K could be a soil exchangeable ion and it is actively absorbed by roots of plant. It a paramount nutrient of the several soils types and is at the latest derived from the weathering of soil parent materials such as soil potassium-aluminum silicates (**Kalavati and Modi, 2012; Wiedenhoeft, 2006**). Potassium influences the function and rates of enzymes engaged in the biosynthesis of carbohydrates (**Hafsi *et al.*, 2015**). It was reported that potassium fertilization enhanced plant growth (**Matsumoto *et al.*, 2013; Mostafa,**

2019), yields (**El-Shayeb *et al*., 2020**) and improved the volatile oil production (**Ezz El-Din *et al*., 2010; Omer *et al*., 2014**) as well as chemical constituents (**El-Sayed *et al*., 2012; Ibrahim and Helaly, 2017**; **Abdelkader and Mostafa, 2019**) of aromatic and medicinal plants.

Amino acids have assignment in the biosynthesis of many organic compounds i.e., vitamins, pigments, terpenoids, alkaloids, purine and pyrimidine bases, enzymes and co-enzymes (**Akram *et al*., 2011; Kamar and Omar, 1987**).

The relationship between metabolism of nitrogen (from amino acids) and internal hormones are obvious. Good feeding plant regiment will contain all the essential elements and trace minerals needed for healthy plant growth. In addition to these, farmers must be use non-plant food elicitors. These elicitors are not actually nutrients, but are additives which enhance plant growth or increase efficiency in various ways **(Koriesh *et al*., 2018).** Three of the most popular non-plant food additives are enzymes, amino acids, and plant hormones **(Zewail, 2014; Ortega *et al*., 1999)**. The application of amino acids significantly enhanced chamomile growth, fresh and dry flower yield, chemical constituents as well as essential oil yield compared to unsprayed plants (**Omer *et al*., 2013**). Moreover, **Wahba *et al*. (2015)** pointed out that application of (tryptophan, tyrosine and glutamic acids) forms significantly raised the growth parameters as well as chemical composition in seeds and herb of *Urtica pilulifera* plant as compared to control. **Ali *et al*. (2020)** indicated that tyrosine or/and glutamine acids significantly increased roselle plant growth and yield components compared to control (sprayed with tap water).

The main target of this study was to obtain the most appropriate rate of potassium fertilizer and type of glutamine or/and tyrosine acids to improve plant growth and yield components as well as volatile oil production of fennel (*Feoniculum vulgare*, Mill.) under Ismailia Governorate conditions.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of EL-Quassasin Horticultural Research Station, Ismailia Governorate, Egypt, during the two consecutive winter seasons of 2018/2019 and 2019/2020. The aim of the current study was to improve the vegetative growth and yield components as well as volatile oil production and some chemical constituents of fennel plants by utilizing both tyrosine (Tyr) or/and glutamine (Gln) acids (each at 100 ppm) and control plants which sprayed with tap water) under different potassium fertilization rates (0.0, 24, 48 and 72 kg K_2O/feddan) and their combination treatments. The mechanical and chemical characteristics of the utilized experimental soil are tabulated in Table 1, according to **(Chapman and Pratt, 1978)**.

Table 1. Physical and chemical characteristics of the utilized experimental farm soil (average of two seasons)

Physical analysis			Soil texture
Clay (%)	Silt (%)	sand (%)	Sandy
20.81	9.39	69.68	

Chemical analysis												
pH	E.C. (dsm^{-1})	Soluble cations (m.mol/l)					Soluble anions (m.mol/l)			Available (ppm)		
		Ca^{++}	Mg^{++}	Na^{+}	Zn^{++}	Mo^{++}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.81	1.25	1.82	0.93	0.33	1.07	1.30	3.02	1.10	0.86	122	39	62

Experimental design

The layout of these experiments was split-plot design with three replicates. Potassium fertilizer rates were assigned to the main plots and glutamine or tyrosine types treatments to the sub plots. The interaction treatments between main factor and sub factor were 20 treatments.

Fruits of fennel were sown on 5th October of both seasons and immediately irrigated. After 20 days from sowing, seedlings were thinned to be two plants /hill. The irrigation system of the experiment was drip irrigation. The experimental unites area was 4.00 × 2.80 m (11.20 m^2) included four rows. The distance between rows 70 cm and the distance between plants was 50.

All fennel plants were fertilized with nitrogen and phosphorus fertilization at the rate of 150 kg /feddan, of ammonium sulfate (20.5 % N) and 200 kg/feddan, of calcium super phosphate (15.5% P_2O_5) as well as phosphorus fertilizer added during soil preparation as a soil dressing application. Nitrogen and potassium fertilizers as was divided into four equal portions and was added to the soil after 30, 45, 60 and 90 days from sowing date. The source of potassium fertilizer was potassium sulfate (48 % K_2O).

The source of glutamine acid ($C_5H_{10}N_2O_3$) and tyrosine acid ($C_9H_{11}NO_3$) were Techno Gene Company (TGC), Dokky, Giza, Egypt. Amino acids types were applied as foliar application at 25, 45, 65, 95 and 115 days after sowing date. Each experimental unit received five letters solution utilizing spreading agent (Super Film at a rate of 1ml /l). The control fennel plants were sprayed with tap water. All fennel plants received normal agricultural practices whenever they needed.

Data recorded

Plant growth: Plant height (cm), branch number/ plant and total plant fresh and dry weights (g) were estimated, at after 120 days from sowing date.

Fruit yield components: At harvest stage, number of umbels/ plant, fruit yield /plant (g) was tabulated, and then fruit yield / feddan (kg) was studied.

Volatile oil production: A sample of fennel dry fruits was possessed randomly of each treatment. Hydro distillation for 3 hr., was utilized to extract the volatile oil percentage from air dried fruits of fennel as described by **Guenther (1961)**. Then, volatile oil yield per plant (ml) and volatile oil yield per feddan (l) was calculated.

Chemical constituents: Total chlorophyll a+b content (mg/100g as fresh weight) in fennel leaves was determined at 120 days after sowing according to **Mazumder and Majumder (2003)**. Furthermore, total carbohydrates percentage of fennel fruits was determined according to the methods substantive through **AOAC (1990)**. Also, potassium percentage was estimated in fennel fruits according to the method reported by **Chapman and Pratt (1978)**.

Statistical Analysis

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

RESULTS AND DISCUSSION

Plant growth

Data of both seasons in Table 2 show that plant height, branch number per plant as well as fresh and dry weights of plant (branches + leaves of plant) of fennel plant were gradually increased with increasing potassium fertilizer rates in both seasons. In addition, the maximum fennel growth values with significant increases were noticed with 72 kg K_2O/feddan, while minimum values were recorded in control treatment. The increases in total dry weight/plant were about 52.05 and 47.37% for 72 kg K_2O/feddan, 20.13 and 14.34 % for 48 kg K_2O/feddan over the control in 1st and 2nd seasons, respectively. In addition, each glutamine or/and tyrosine acids at 100 ppm significantly increased growth parameters of fennel compared to control (sprayed with tap water) in 2018/2019 and 2019/2020 seasons. Moreover, plant height, number of branches/plant as well as total fresh and dry weights/plant of fennel plant were significantly increased with tyrosine + glutamine acids application. The increases in total fresh weight /plant were about 18.38 and 16.00% for Try + Gln acid at 100 ppm as well as 14.00 and 10.74 % for Gln acid alone at 100 ppm over the control in 1st and 2nd seasons, respectively. In the same time, under each amino acids type fennel growth parameters were gradually increased by increasing potassium fertilization rate during both seasons. In addition, the best combination treatment in this regard was 72 kg K_2O/feddan and the Gln+ Tyr acids (100 ppm) compared to the other ones including control.

The enhancement of fennel development and growth may be attributed to the role of potassium it plays a main role in many metabolisms of carbohydrates which reflected in physiological and biochemical processes in plant (**Marschner, 1995**). Furthermore, **Chrysargyris *et al*. (2017)** pointed out that potassium levels significantly impacted plant growth and mainly the root development of *Lavandula angustifolia* plant compared to control. Also, **El-Shayeb *et al*. (2020)** indicated that the highest rate of potassium fertilization (48 kg K_2O/feddan) recorded significant increase in fenugreek growth (Plant height, number of branches / plant and total dry weight/plant) compared to control. Also, **Hegazi *et al*. (2016)** found that foliar spray to garlic plants with glutamine at 200 ppm gave the highest values of plant growth criteria i.e. plant length and number of leaves/ plant as compared to the other treatments (50 and 100 ppm) and control. Likewise, **Ali *et al*. (2020)** on roselle demonstrated that tyrosine and glutamine acids at any concentration (100 or 200 ppm) significantly raised plant growth parameters compared to control (untreated plants). In conclusion, as mentioned above, both potassium fertilization and glutamine or tyrosine types (at 100 ppm) enhanced plant growth of fennel plant, in turn; they together might maximize their influences leading to taller, more branches as well as heaviest fresh and dry weights of plant.

Fruit yield components

The data given in Table 3 show that number of umbels per plant, fruit yield per plant as well as fruit yield per feddan of fennel plant were gradually increased with increasing potassium fertilizer rates from 24 to 72 kg K_2O/feddan in the first and second seasons. The highest values in this connection with significant differences achieved when fennel plants fertilized with 72 kg K_2O/feddan compared to the other rates under study. Generally, all amino acids type treatments significantly increased fruit yield components of *Feoniculum vulgare* compared to

control (Table 3). Furthermore, in the two consecutive seasons, Gln + Tyr followed Gln alone at 100 ppm significantly increased number umbels per plant, fruit yield per plant as well as fruit yield per feddan compared to control. In the matter of the combination, the great influence on fruit yields of fennel were obtained with 72 kg K_2O/feddan combined with amino acid type (Gln + Tyr each at 100ppm) in the two tested seasons. Utilizing Gln + Tyr type at 100 ppm under all potassium fertilization rates significantly increased number of umbels per plant and fruit yield per plant and per feddan as compared to the other combination treatments.

These results also reported by **Hassan *et al*. (2009)** on periwinkle plants. They suggested that potassium fertilizer (50 kg K_2O/feddan) significantly enhanced dry herb yield of periwinkle plants compared to control and the lowest level under study. **Ezz El-Din *et al*. (2010)** applying potassium at the level of 30 kg fed^{-1} led to the highest caraway dry fruits yield compared to control. Also, **Abdelkader and Mostafa** (**2019**) revealed that the highest values of pods number/ guar plant as well as seed yield/plant and per fadden were achieved with the 50 kg K_2O rate of potassium. However, the foliar spray of amino acids can stimulate the plant performance (**Abdel-Mawgoud *et al*., 2011**). In the same time, **Shafeek *et al*. (2012)** reported that number and weight of bulbs/m^2, total yield (ton/fed.) and average weight of bulb (g) of onion plant were increased by amino acid application with concentration of 150 ppm compared to the other ones. **El-sherbeny and Da-Silva (2013)** found that tyrosine at 100 and 200 $mg \cdot L^{-1}$ increased yield components of *Beta vulgaris* plant. Furthermore, the highest rate of amino acids as foliar spray caused a significant enhance in timothy seed yield in comparison with control **(Radkowski and Radkowska, 2018)**.

Table 2. Influence of foliar spray with glutamine (Gln) and tyrosine (Tyr) on growth parameters of *Feoniculum vulgare* under different potassium fertilization rates during the two seasons of 2018/2019 and 2019/2020

Treatments		Plant height (cm)		Number of branches/plant		Total fresh weight/plant (g)		Total dry weight/plant (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (K_2O kg/feddan)									
0.0		125.28	132.69	7.97	8.75	245.90	255.89	33.18	36.27
24		134.81	140.28	9.25	10.22	256.52	261.87	34.68	36.63
48		138.64	142.08	11.22	11.39	272.35	280.49	39.86	41.47
72		141.20	146.97	12.69	13.11	312.59	332.68	50.45	53.45
LSD 5%		**0.62**	**0.63**	**0.51**	**0.45**	**1.82**	**1.52**	**0.65**	**0.49**
Glutamine and tyrosine acids (100 ppm of each one)									
Control		131.14	135.50	9.36	10.06	259.98	265.95	36.50	38.29
Gln		136.22	141.86	10.67	11.14	274.83	289.02	40.33	42.64
Tyr		134.17	140.70	10.03	10.61	269.47	277.92	38.34	40.10
Gln+Tyr		138.39	143.97	11.08	11.67	283.08	298.05	42.99	46.78
LSD 5%		**0.87**	**0.79**	**0.49**	**0.35**	**1.89**	**1.25**	**0.43**	**0.56**
Interaction between potassium fertilization rates and amino acid types									
0.0	**Control**	122.11	130.00	7.44	8.22	240.87	249.60	31.70	34.30
	Gln	125.55	132.78	8.34	9.11	247.93	259.57	33.87	37.30
	Tyr	124.44	132.11	7.78	8.55	246.10	253.43	32.63	35.10
	Gln+Tyr	129.00	135.89	8.33	9.11	248.70	260.97	34.50	38.37
24	**Control**	131.89	135.78	8.34	9.44	247.93	252.87	32.17	34.67
	Gln	136.22	141.89	9.56	10.44	259.73	263.67	35.30	36.73
	Tyr	133.89	140.56	9.00	9.78	256.07	260.10	34.27	35.60
	Gln+Tyr	137.22	142.89	10.11	11.22	262.33	270.83	37.00	39.50
48	**Control**	133.78	136.11	9.89	10.34	262.20	269.93	36.23	36.93
	Gln	140.00	143.78	11.44	11.89	273.37	284.90	40.33	42.17
	Tyr	137.89	141.45	11.11	11.22	268.80	275.53	38.27	39.07
	Gln+Tyr	142.89	147.00	12.44	12.11	285.03	291.60	44.60	47.70
72	**Control**	136.78	140.11	11.78	12.22	288.93	291.40	45.90	47.27
	Gln	143.11	149.00	13.34	13.11	318.27	347.93	51.83	54.37
	Tyr	140.44	148.66	12.22	12.89	306.90	322.60	48.20	50.63
	Gln+Tyr	144.45	150.11	13.44	14.22	336.27	368.80	55.87	61.53
LSD 5%		**1.62**	**1.51**	**0.99**	**0.75**	**3.74**	**2.65**	**0.98**	**1.08**

Table 3. Influence of foliar spray with glutamine (Gln) and tyrosine (Tyr) on yield components of *Feoniculum vulgare* under different potassium fertilization rates during the two seasons of 2018/2019 and 2019/2020

Treatments		Umbels number per plant		Fruit yield/plant (g)		Fruit yield/feddan (kg)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (K_2O kg/feddan)							
0.0		47.72	49.30	19.29	19.63	463.00	471.20
24		51.06	54.08	21.04	22.13	505.00	531.20
48		53.33	57.72	22.52	23.60	540.30	566.44
72		59.70	63.14	23.62	24.63	566.80	591.20
LSD 5%		**1.16**	**0.96**	**0.72**	**0.18**	**17.29**	**4.28**
Glutamine and tyrosine acids (100 ppm of each one)							
Control		47.42	49.19	19.14	19.67	459.30	472.04
Gln		54.11	57.86	21.04	23.08	527.20	553.80
Tyr		51.69	55.14	22.52	22.24	540.30	533.80
Gln+Tyr		58.58	62.06	23.62	25.02	566.80	600.40
LSD 5%		**0.89**	**1.01**	**0.39**	**0.54**	**9.48**	**13.04**
Interaction between potassium fertilization rates and amino acid types							
0.0	**Control**	44.11	41.89	17.53	16.40	420.80	393.60
	Gln	48.22	50.89	19.43	20.30	466.40	487.20
	Tyr	46.11	47.11	19.97	19.40	455.20	465.60
	Gln+Tyr	52.44	56.33	21.23	22.43	509.60	538.40
24	**Control**	46.00	47.33	18.07	18.87	433.60	452.80
	Gln	51.11	54.67	21.27	22.87	510.40	548.80
	Tyr	49.55	53.78	20.87	21.83	500.80	524.00
	Gln+Tyr	57.56	60.56	23.97	24.97	575.20	599.20
48	**Control**	47.78	51.33	19.93	21.00	478.00	504.16
	Gln	54.44	60.00	23.13	24.43	555.20	586.40
	Tyr	51.89	57.11	22.03	23.43	528.80	562.40
	Gln+Tyr	59.22	62.45	24.97	25.53	599.20	612.80
72	**Control**	51.78	56.22	21.03	22.40	504.80	537.60
	Gln	62.67	65.89	24.03	24.70	576.80	592.80
	Tyr	59.22	61.55	23.37	24.30	560.80	583.20
	Gln+Tyr	65.11	68.89	26.03	27.13	624.80	651.20
LSD 5%		**1.91**	**1.10**	**0.99**	**0.96**	**23.76**	**22.99**

Volatile oil production

Table 4 reveals that using potassium fertilization at any rate increased volatile oil %, volatile oil yield per plant and per feddan of fennel plant compared to control in the 2018/2019 and 2019/2020 seasons. Such increase was significant by using 24, 48 and 72 kg K_2O/feddan during both seasons. In the same time, the best values in this regard were obtained from the rate 72 kg K_2O/feddan compared to the other rates under study. The increases in volatile oil yield per feddan were about 39.26 and 29.97% for 72 kg K_2O/feddan, 44.61 and 35.46 % for 48 kg K_2O/feddan over the control in 1st and 2nd seasons, respectively. Furthermore, all amino acids types significantly increased volatile oil production of fennel in both seasons compared to control. Also, the highest values in this concern of *Feoniculum vulgare* plant was achieved by Gln + Tyr at 100 ppm with significant difference between it and the other types under study in the two consecutive seasons. In general, spraying fennel plants five times under the highest rate of potassium fertilization with glutamine + tyrosine acids at 100 ppm gave the highest volatile oil production in comparison to those under potassium fertilization treatments in the two seasons. Moreover, under each amino acids type fennel volatile oil were gradually increased by increasing potassium fertilization rate during both seasons.

Moreover, **Younis *et al.* (2012)** pointed out that fertilized fennel plants with 30 kg K_2O/feddan were effective on raising the productivity of essential oil. Also, **El-Tarawy *et al.* (2012)** noticed the best values number of essential oil productivity when fennel plants fertilized with 75 % NPK + 200 ppm of ascorbic or salicylic acids in comparison to the control. **Helaly and Hegazy (2016)** revealed that K fertilization level at 50 kg K_2O/feddan significantly raised lavender volatile oil production depressed as volatile oil percentage and volatile oil yield/plant of compared to control. Furthermore, using amino acids as foliar spray caused a significant improve in rosemary essential content compared to control (**Foroutan *et al.*, 2014**). In addition, the foliar application of free amino acids can be effective on essential oil content of lemon balm (**Mehrafarin *et al.*, 2014**).

Table 4. Influence of foliar spray with glutamine (Gln) and tyrosine (Tyr) on volatile oil production of *Feoniculum vulgare* under different potassium fertilization rates during the two seasons of 2018/2019 and 2019/2020

Treatments		Volatile oil percentage		Volatile oil yield/plant (ml)		Volatile oil yield/feddan (l)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (K_2O kg/feddan)							
0.0		2.871	2.911	0.554	0.573	13.303	13.749
24		3.106	3.194	0.657	0.711	15.756	17.054
48		3.188	3.281	0.720	0.776	17.290	18.624
72		3.256	3.358	0.772	0.828	18.526	19.882
LSD 5%		**0.009**	**0.031**	**0.023**	**0.007**	**0.55**	**0.16**
Glutamine and tyrosine acids (100 ppm of each one)							
Control		2.917	3.008	0.559	0.595	13.424	14.287
Gln		3.162	3.235	0.697	0.750	16.733	17.989
Tyr		3.110	3.213	0.665	0.718	15.965	17.229
Gln+Tyr		3.235	3.287	0.781	0.825	18.753	19.803
LSD 5%		**0.015**	**0.016**	**0.011**	**0.019**	**0.271**	**0.458**
Interaction between potassium fertilization rates and amino acid types							
0.0	**Control**	2.820	2.807	0.494	0.460	11.867	11.051
	Gln	2.887	2.920	0.561	0.592	13.464	14.226
	Tyr	2.863	2.930	0.543	0.569	13.035	13.641
	Gln+Tyr	2.913	2.987	0.619	0.670	14.846	16.081
24	**Control**	2.870	2.907	0.518	0.548	12.444	13.161
	Gln	3.193	3.310	0.679	0.757	16.298	18.164
	Tyr	3.090	3.223	0.645	0.704	15.474	16.892
	Gln+Tyr	3.270	3.337	0.784	0.833	18.808	19.997
48	**Control**	2.923	3.113	0.582	0.654	13.974	15.699
	Gln	3.263	3.313	0.755	0.810	18.117	19.431
	Tyr	3.210	3.317	0.707	0.777	16.974	18.653
	Gln+Tyr	3.53	3.380	0.837	0.863	20.094	20.712
72	**Control**	3.053	3.207	0.642	0.718	15.413	17.239
	Gln	3.303	3.397	0.794	0.839	19.052	20.135
	Tyr	3.277	3.383	0.766	0.822	18.375	19.731
	Gln+Tyr	3.403	3.443	0.886	0.934	21.264	22.423
LSD 5%		**0.027**	**0.042**	**0.030**	**0.034**	**0.0718**	**0.809**

Chemical constituents

It is evident from the obtained data in Table 5 that total chlorophyll content (mg/10 g as fresh weight) in leaves, total carbohydrates percentage and potassium percentage in fruits of fennel content were gradually increased with as potassium fertilization rates were increased in both seasons. However, maximum chemical constituents' values were recorded with the highest rate (72 kg K_2O/feddan), while minimum values were observed in fennel plants without potassium application. The increases in total chlorophyll content were about 21.21 and 13.25% for 72 kg K_2O over control in 1st and 2nd seasons, respectively. Furthermore, each Gln + Tyr acids at 100 ppm significantly increased fennel chemical constituents compared to control (sprayed with tap water) in first and second seasons. The increases in total carbohydrates percentage were about 9.97 and 8.86 % for Gln +Tyr as well as 8.13 and 4.17% for Gln acid alone over the control in 1st and 2nd seasons, respectively. Generally, the best combination treatment in fennel chlorophyll and total carbohydrates and potassium percentages was that potassium fertilization at 72 kg K_2O/feddan combined with Gln+ Tyr acids at 100 ppm.

Furthermore, total chlorophyll content and potassium percentage of cluster bean were increased by using the rate of 50 kg K_2O /feddan potassium (**Abdelkader and Mostafa, 2019**). Also, **El-Shayeb *et al*. (2020)** noticed that 48 kg K_2O /feddan treatment seems promising in enhancing fenugreek chemical constituents (total chlorophyll content as well as potassium and total carbohydrates percentages) compared to control. Many researchers pointed out those amino acids have various roles in plant metabolism, and exogenous application of amino acids may have benefits and stimulation effects on plant growth which reflected on chlorophyll and active ingredients **(Abd El-Aal and Eid, 2018; Khan *et al*., 2019)**. In the same time, as mentioned above, both potassium fertilization and glutamine or/and tyrosine concentrations (at 100 ppm) increased yield components of fennel plant, in turn; they together might maximize their impacts leading to more chlorophyll content and potassium percentage.

Table 5. Influence of foliar spray with glutamine (Gln) and tyrosine (Tyr) on chemical constituents of *Feoniculum vulgare* under different potassium fertilization rates during the two seasons of 2018/2019 and 2019/2020

Treatments		Total chlorophyll content a +b as (mg/100g, fresh weight)		Total carbohydrates percentage		Potassium percentage	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (K_2O kg/feddan)							
0.0		26.50	29.06	13.78	14.28	1.98	1.98
24		28.20	29.88	14.27	14.38	2.04	2.04
48		28.46	32.41	14.43	14.60	2.09	2.20
72		32.12	32.91	14.75	15.10	2.19	2.25
LSD 5%		**0.48**	**0.63**	**0.22**	**0.12**	**0.04**	**0.01**
Glutamine and tyrosine acids (100 ppm of each one)							
Control		26.96	28.84	13.92	14.14	1.95	2.04
Gln		28.52	31.84	14.49	14.73	2.08	2.15
Tyr		28.48	30.34	13.92	14.37	2.08	2.09
Gln+Tyr		31.33	33.23	14.89	15.11	2.18	2.18
LSD 5%		**0.51**	**0.67**	**0.16**	**0.09**	**0.02**	**0.01**
Interaction between potassium fertilization rates and amino acid types							
0.0	**Control**	25.63	27.63	13.40	13.80	1.85	1.92
	Gln	26.33	30.03	14.03	14.53	1.95	2.02
	Tyr	25.97	28.40	13.30	14.23	2.02	1.95
	Gln+Tyr	28.07	30.17	14.40	14.53	2.08	2.05
24	**Control**	26.47	28.80	13.93	14.13	1.92	2.01
	Gln	27.97	30.17	14.47	14.67	2.07	2.04
	Tyr	27.40	29.13	13.77	13.87	2.03	2.01
	Gln+Tyr	30.97	31.43	14.91	14.83	2.12	2.09
48	**Control**	26.87	29.17	14.07	14.23	1.95	2.10
	Gln	28.10	33.17	14.50	14.20	2.10	2.24
	Tyr	28.43	32.00	14.20	14.63	2.07	2.17
	Gln+Tyr	30.43	35.30	14.93	15.33	2.24	2.28
72	**Control**	28.87	29.77	14.27	14.40	2.05	2.15
	Gln	31.67	34.00	14.97	15.53	2.21	2.31
	Tyr	32.10	31.83	14.43	14.73	2.21	2.24
	Gln+Tyr	35.83	36.03	15.33	15.73	2.29	2.31
LSD 5%		**1.10**	**1.31**	**0.35**	**0.20**	**0.05**	**0.03**

Conclusion

From above mentioned results, it could be concluded that, fertilized fennel plants with72 kg K_2O/feddan rate combined with glutamine + tyrosine acids each at 100 ppm five times per season as foliar spraying is suitable for improve the growth, fruit yield components, volatile oil production as well as total chlorophyll of fennel (*Feoniculum vulgare* Mill.) plant under Ismailia Governorate conditions.

REFERENCES

Abd El-Aal, M. M. M. and R. S. M. Eid (2018). Effect of foliar spray with lithovit and amino acids on growth, bioconstituents, anatomical and yield features of soybean plant. 4th International Conference on Biotechnology Applications in Agriculture (ICBAA), Benha University, Moshtohor and Hurghada, 4-7 April 2018, Egypt.

Abdelkader, M.A.I. and Mostafa, H. Sh. (2019). Response of productivity and chemical constituents of cluster bean (*Cyamopsis tetragonoloba* Taub.) plant to potassium fertilization and humic acid rates. The Future Journal of Biology, 2 (1): 29-38.

Abdel-Mawgoud, A.M.R., El-Bassiouny, A.M.; Ghoname, A. and Abou-Hussein, S.D. (2011). Foliar application of amino acids and micronutrients enhance performance of green bean crop under newly reclaimed land conditions. Aust. J. Basic. Appl. Sci., 5 (6): 51-55.

Akram M.; Asif, M.; Uzair, M. and Khan, A.U. (2011). Amino acids: A review article. Journal of Medicinal Plant Research, 5(17): 3997-4000

Ali, H.K.M.; Awad, A.E. and Abdelkader, M.A.I. (2020). Improving growth and yield of roselle (*Hibiscus sabdariffa* L.) plants by using tyrosine and glutamine acids under different planting dates. Zagazig J. Agric. Res., 47(5): 1165-1174.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

AOAC (1990). Official Methods of Analysis.15th Ed. Association of Official Analytical Chemists, Inc., Virginia, USA.

Chapman, D.H. and Pratt, R.F. (1978). Methods Analysis for Soil, Plant and Water. Univ. of California Div. Agric. Sci. 16: 38.

Chrysargyris, A.; Drouza, C. and Tzortzakis, N. (2017). Optimization of potassium fertilization/nutrition for growth, physiological development, essential oil composition and antioxidant activity of *Lavandula angustifolia* Mill. Journal of Soil Science and Plant Nutrition, 17(2): 291-306.

El-Sayed, A.A.; Shalaby, A.S.; El-Hanafy, H. and Abd El-Razik ,T.M. (2012). Effects of chemical fertilizers on growth and active constituents of *Echinacea paradoxa* L. plants. Journal of Horticultural Science & Ornamental Plants, 4(2): 125-133.

El-Shayeb, S.A.N.; Hassan, H.I.R.; Ahmed, A.M. and Abdelkader, M.A.I. (2020). Evaluation of growth, yield and active ingredients in fenugreek plants under different potassium fertilizer rates and kaolin application. European Journal of Medicinal Plants, 31(9): 28-37.

El-sherbeny, M.R. and Da-Silva, J.A.T. (2013). Foliar treatment with proline and tyrosine affect the growth and yield of beetroot and some pigments in beetroot leaves. Journal of Horticultural Research, 21(2): 95-99.

El-Tarawy, M.A.; El-Mahrouk, E.M.; Ahmed, S.K. and Shala, A.Y.E. (2012). Response of fennel plants to chemical fertilization and ascorbic and salicylic acids treatments. J. Agric. Res. Kafer El-Sheikh Univ., 38(3): 401-419.

Ezz El-Din, A.A.; Hendawy, S.F.; Aziz, E.E. and Omer, E.A. (2010). Enhancing growth, yield and essential oil of caraway plants by nitrogen and potassium fertilizers. International Journal of Academic Research, 2(3): 192-197.

Fathy, M.S.; Shehata, A.M.; Kaleel, A.E. and Ezzhat, S.M. (2002). Anacylated kaempferol glycoside from flavones of *Foeniculum vulgare* and *F. dulce*. Moeclues, 7: 245-251.

Foroutan, N.A.; Mehrafarin, A.; Hadavi, E. and Naghdi, B.H. (2014). The influences of bio-stimulators compounds on growth traits and essential oil content of rosemary (*Rosmarinus officinalis* L.). Journal of Medicinal Plants, 13(5): 1-11.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons Inc., Singapore 680.

Guenther, E. (1961). The Essential Oil D. Von Nostrand Comp., New York, 1: 236.

Hafsi, C.; Debez, A. and Abdelly, C. (2015). Potassium deficiency in plants: effects and signaling cascades. Acta Physiol. Pl., 36: 1055-1070.

Hassan, R.A.; Habib, A.A. and Ezz El-Din, A.A. (2009). Effect of nitrogen and potassium fertilization on growth, yield and alkaloidal content of (*Catharanthus roseus* G. Don). Medicinal and Aromatic Plant Science and Biotechnology, 3(1): 24-26.

Hegazi, A.Z.; Hasan, S.Kh.H. and El-Said, N.A.M. (2016). Response of garlic plants to foliar application of moringa leaves extract, glutamine and cysteine. Journal Plant Production, Mansoura Univ., 7(1): 1 - 6.

Helaly, A.A.E. and Hegazy, A.A. (2016). Effect of lithovit rate as nano-fertilizer on growth and productivity of *Lavandula officinalis* plant under different potassium fertilization levels. Middle East Journal of Agriculture Research, 5(4): 899-908.

Ibrahim, F.R. and Helaly, A.A.E. (2017). Growth and productivity response to nitrogen, potassium and humic acid of fenugreek (*Trigonella foenum-graecum* L.) plant. Middle East Journal of Agriculture Research, 6 (4): 1526-1535.

Kamar, M.E. and Omar, A. (1987). Effect of nitrogen levels and spraying with aminal-forte (amino acids solvation) on yield of cucumber and potatoes. J. Agric. Sci. Mansoura Univ., 12(4): 900-907.

Khan, S.; Yu, H.; Li, Q.; Gao, Y.; Sallam, B.N.; Wang, H.; Liu, P. and Jiang, W. (2019). Exogenous application of amino acids improves the growth and yield of lettuce by enhancing photosynthetic assimilation and nutrient availability. Agronomy, 266 (9): 1-17.

Koriesh E.M.; Abd El-Fattah, Y.M.; Abo-El-Soud, I.H. and Khalil, M. (2018b). Effects of comparison of nutrient solution formulations supplemented with willow bark or jouvinile branches decoction on growth of coleus plants. HortScience J. Suez Canal University. 7(1): 11-19

Liu H.; Li, J.; Lin, S.; Liu, T. and Zheng, C. (2021). Effects of dietary fennel (*Foeniculum vulgare* Mill.) seed powder supplementation on growth performance, nutrient digestibility, small intestinal morphology, and carcass traits of broilers. Food Science and Technology, PubMed 33575119

Marschner, H., (1995). Functions of mineral nutrients: micronutrients. In: Mineral Nutrition of Higher Plants. 2nd Ed., Academic Press, London, pp. 313-404.

Matsumoto, S.N.; Araujo, G.S.; Viana, A.E.S. (2013). Growth of sweet basil depending on nitrogen

and potassium doses. Horticultura Brasileira, 31: 489-493.

Mazumdar, B.C. and Majumder, K. (2003). Methods of Physiochemical Analysis of Fruits. Daya Publishing House Delhi, India.

Mehrafarin, A.; Qavami, N.; Tahmasebi, Z.; Naghdi, B.H.; Abdossi, V. and Seif, S.M. (2015). Phytochemical and Morpho-physiological Responses of Lemon Balm (*Melissa officinalis* L.) to Biostimulants Application. Journal of Medicinal Plants, 14(5): 1-14.

Mostafa, H.Sh. (2019). Impact of NPK fertilization and lithovit rates on growth, yield components and chemical constituents of *Stevia rebaudiana* Bert. plant. Middle East Journal of Applied Sciences, 9(2): 412-420.

Omer, E.A.; Abou Hussein, E.A.; Hendawy, S.F.; Ezz El-din, A.A. and El-Gendy, A.G. (2014). Effect of nitrogen and potassium fertilizers on growth, yield, essential oil and artemisinin of *Artemisia annua* L plant. International Research Journal of Horticulture, 2(2): 11-20.

Omer, E.A.; Said-Al Ahl, H.A.H.; El Gendy, A.G.; Shaban, Kh.A. and Hussein, M.S. (2013). Effect of amino acids application on production, volatile oil and chemical composition of chamomile cultivated in saline soil at Sinai. Journal of Applied Sciences Research, 9(4): 3006-3021.

Ortega, J.L.; Roche, D.; Sengupta-Gopalan, C. (1999). Oxidative turnover of soybean root glutamine synthetase. In vitro and in vivo studies. Plant Physiol., 119: 1483–1496.

Pavela R. (2018). Essential oils from *Foeniculum vulgare* Miller as a safe environmental insecticide against the aphid *Myzus persicae* Sulzer. Environ. Sci. Pollut. Res. Int., 25(11): 10904-10910

Prajapati and Modi (2012). The importance of potassium in plant growth – A review. Indian Journal of Plant Sciences, Vol. 1(02-03), pp.177-186

Radkowski, A. and Radkowska, I. (2018). Influence of foliar fertilization with amino acid preparations on morphological traits and seed yield of timothy. Plant Soil Environ., 64(5): 209-213.

Rather M.A.; Dar, B.A.; Sofi, S.N.; Bhat, B.A. and Qurishib, M.A. (2016). *Foeniculum vulgare*: A comprehensive review of its traditional use, phytochemistry, pharmacology, and safety. Arabian Journal of Chemistry, 9(2): S1574-S1583.

Ruberto, G.; Barattata, M.B.; Deans, S.G. and Dorman, H.D.I. (2000). Antioxidant and antimicrobial activity of *Foeniculum vulgare* and *Crithmum maritimum* essential oils. Planta Medico, 66: 687-693.

Shafeek, M.R.; Helmy, Y.I.; Shalaby, M.A.F. and Omer, N.M. (2012). Response of onion plants to foliar application of sources and levels of some amino acid under sandy soil conditions. Journal of Applied Sciences Research, 8(11): 5521-5527.

Sheweita S.h.A.; El-Hosseiny, L.S. and Nashashibi, M.A. (2016). Protective effects of essential oils as natural antioxidants against hepatotoxicity induced by cyclophosphamide in mice. PLoS One, 11(11): e0165667.

Wahba, H.E.; Motawe, H.M. and Ibrahim, A.Y. (2015). Growth and chemical composition of *Urtica pilulifera* L. plant as influenced by foliar application of some amino acids. J. Mater. Environ. Sci., 6(2): 499-506.

Wichtel, M. and Bisset, N.G. (1994). Herbal Drugs and Phytoparm Aceuticals. Stuttgart: Medpharm Sci. Publi.

Wiedenhoeft, A.C. (2006). Plant Nutrition. Hopkins WG (eds) The Green World, Chelsea House Publisher, New York NY. Pp,16-43.

Younis, S.I.; Rashed, N.M. and Moursi, E.A. (2010). Effect of water stress and potassium fertilizer on the growth, yield and composition of essential oil of fennel plant. J. Plant Production, Mansoura University, 1(7): 931-946**.**

Zewail, R.M.Y. (2014). Effect of seaweed extract and amino acids on growth and productivity and some biocostituents of common bean (*Phaseolus vulgaris* L) plants. J. Plant Production, Mansoura Univ., 5(8): 1441-1453.