



INFLUENCE OF NITROGEN AND PHOSPHORUS FERTILIZERS RATE AND L-TRYPTOPHAN CONCENTRATION ON GROWTH AND PRODUCTIVITY OF DILL PLANT

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ABSTRACT: Two field experiments were conducted on dill (*Anethum graveolens* L.) fertilized by different nitrogen and phosphorus fertilizers rates (0.0, 75 and 100 % of recommended rate) and sprayed by different L-tryptophan (Trp) concentrations (0, 50, 100 and 150 ppm) during 2017/2018 and 2018/2019 seasons at Agric. Res. Farm (Ghazala Farm), Fac. Agric., Zagazig Univ., Egypt, to study the effect of the two factors and their combination treatments on growth, yield components and volatile oil production as well as some chemical constituents of dill. The experimental design was a split-plot arranged in a randomized complete blocks with three replications. The main plots were assigned for three fertilization rate and sub plot were devoted for four tryptophan concentrations. The obtained results referred to that plant height, number of branches per plant and total dry weight 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. Yield components (fruit yield/plant and/feddan) and volatile oil production (volatile oil yield/plant and/feddan) were increased gradually by increased NP fertilizers rate during both seasons. The best combination treatment in this connection was 100% RR of NP fertilizers combined with 150 ppm of Trp acid compared to the other ones under study. The same trend were achieved regard chemical constituents (total chlorophyll a+b, total carbohydrates, total nitrogen percentage and total phosphorus percentage) compared to control.

Key words: *Anethum graveolens*, nitrogen, phosphorus, tryptophan acid, growth, yield, volatile oil.

INTRODUCTION

Dill (*Anethum graveolens* L.) is a aromatic and medicinal annual plant belonging to the Apiaceae family that originally arrived from Mediterranean East, planted as spice in most parts of the world and for several medicinal purposes. Europeans have used this plant as vegetative organ and fruits to treat hemato-vascular and headache diseases. In addition, it is carminative agent, laxative and used too to treat digestion problems and stomachache (Hellal *et al.*, 2011).

From many researchers, it was found that mineral fertilizers application is essential for enhancing plant growth, yield and active ingredients productivity. However, nitrogen is essential for synthesis of amino acids, proteins, chlorophylls and several enzymes in plant. Also, phosphorus is essential for phospholipids, ADP and ATP

formation, phosphor-proteins and root growth (Saxena *et al.*, 2003 and Souza *et al.*, 2008).

Fertilization of dill with N at 90kg/ha + 35 kg/ha increased yield and produced highest oil yield (Al-Sahaf *et al.*, 2006). The highest values of branch number, fresh and dry weights of dill plant were recorded by using 60 kg N/fed (Said-Al Ahl *et al.*, 2015). Fruits weight and yield/fed of dill as well as total carbohydrate content showed significant increase with applied nitrogen fertilizer treatment at 60 kg/fed (Aly *et al.*, 2015).

The growth of the plant and its production of secondary compounds are affected by many factors, including the spraying of amino acids, which is the initiator of hormone formation and growth regulators (Singh, 1999). There is a significant influence of amino acids on the specific and

chemical compounds of the plant as it is a source of energy, carbon and nitrogen. Moreover, L-tryptophan is a known physiological precursor of indole acetic acid (IAA) and its application at appropriate concentrations could have a positive effect on plant growth (Zahir *et al.*, 2000). L-tryptophan may act as an ion transport regulator, osmolyte, modulates stomatal opening in plants (Hussein *et al.*, 2014).

This study aimed at investigation the effect of nitrogen plus phosphorus fertilization rate and L-tryptophan acid concentration on growth, yield and volatile oil production of dill (*Anethum graveolens* L.) plants under Sharkia Governorate conditions.

MATERIALS AND METHODS

These trials were carried in the two consecutive winter seasons of 2017/2018 and 2018/2019 at Agric. Res. Farm (Ghazala Farm), Fac. Agric., Zagazig Univ., Egypt. Aiming to study the effect of three rates of NP fertilization (0.0, 75 and 100 % of recommended rate), four concentrations of L-tryptophan (0, 50, 100 and 150 ppm) and their combinations (15 treatments) on plant growth, yield components, volatile oil production and some chemical constituents of dill plant grown in clay soil. The recommended rate (RR) of NP were N at 60 + P₂O₅ at 32 kg/feddan as 4200 m². The physical and chemical properties of the experimental soil site are shown in Table 1, according to Chapman and Pratt (1978).

Table 1. Physical and chemical properties of experimental soil

			Physical analysis				Soil texture				
Clay (%)		Silt (%)	Fine sand (%)		Coarse sand (%)						
56.36		9.26	17.62		16.76		Clay				
Chemical analysis											
pH	E.C. m.mohs/cm	Organic matter (%)	Soluble cations (meq/L)			Soluble anions (meq/L)			Available (ppm)		
			Mg ⁺⁺	Ca ⁺⁺	Na ⁺	Cl ⁻	HCO ₃ ⁻	SO ₄ ⁻	N	P	K
7.86	0.98	0.58	2.7	1.6	4.1	4.5	1.7	3.5	18	20	71

The plot area was 14.4 m² (3.00 × 4.80 m) included eight ridges. Each ridge was 60 cm wide and three meters length. Fruits of dill (*Anethum graveolens* L.) were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza, Egypt. Fruits of dill plant were sown on 15th of October during both seasons and immediately irrigated (surface irrigation). After three weeks from sowing, seedlings were thinned to be two plants/hill spaced 30 cm in hills on one side of the ridge. The source of L-Tryptophan (Trp) acid [(S)-2-Amino-3-(3-indolyl) propionic acid (C₁₁H₁₂N₂O₂)] was Techno Gene Company (TGC), Dokky, Giza, Egypt. Trp acid was applied as foliar application at 30, 50 and 70 days after sowing. Each experimental unit received 5 letters solution using spreading agent (Super Film at a rate of 1ml /l). The untreated plants were sprayed with tap water with spreading agent (as control).

Experimental design

The experiment was conducted using a split-plot design with three replications. The main plots were assigned for three fertilization rate and sub plot were devoted for four tryptophan concentrations.

All dill plants received normal agricultural practices whenever they needed. All plants were fertilized with nitrogen as ammonium sulphate (20.5%N) as well phosphorus fertilization as calcium super phosphate (15.5% P₂O₅). Phosphorus

fertilizer was added during soil preparation as a soil dressing application, while, nitrogen and potassium (24 kg K₂O/fed.) fertilizers were divided into three equal portions and were added to the soil after 35, 55 and 75 days from sowing. The source of K fertilizer was potassium sulphate (48 % K₂O).

Recorded Data

Plant growth

After 95 days from sowing of dill fruits a sample of 3 plants were randomly taken from each experimental unit and plant growth parameters were recorded: plant height (cm), number of branches and total dry weight/plant (g).

Yield and its components

Inflorescences of dill were harvested at 130 days after sowing and the following data were recorded: fruit yield/plant (g) and yield/faddan (kg).

Volatile oil production

The volatile oil percentage from air-dried fruits (10 g) of dill plant was isolated by hydro distillation for 3 hr., in order to extract the essential oils according to Guenther (1961) and the oil yield per plant (ml) and per feddan (l) were calculated.

Chemical constituents

Total chlorophyll (a + b) contents (mg/gm as fresh weight) were determined in fresh leaves of dill plant according to the method outlined by Cherry (1973). Total carbohydrate percentage in dill fruits

was determined according to the method described by Dubois *et al.* (1956). Also, total nitrogen and total phosphorus percentages in dill fruits were determined according to Chapman and Pratt (1978) at the end of experiment.

Statistical Analysis

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

RESULTS AND DISCUSSION

Plant growth

Effect of NP fertilization rate

Results under discussion in Table 2 indicate that, nitrogen and phosphorus (NP) fertilizers rates significantly increased dill growth compared to control during both seasons. Mostly, the highest values of plant height, branch number per dill plant and total dry weight were achieved by 100 % of recommended rate (60 kg N + 32 kg P₂O₅ /fed.) compared to control and the other one under study.

However, Marschner (1995) reported that N and P play a major role in many physiological and biochemical processes leading to taller, more branches and heaviest weight per dill plant. Similar results were stated by Kumar *et al.* (2009) on *Artemisia pallens* plant, Ahmed (2017) on celery and dill, Said- Al Ahl *et al.* (2015) on dill and Kahsay (2019) on potatoes plants.

Effect of L-tryptophan acid concentration

Also, abovementioned growth parameters of dill (plant height, branch number/plant and total dry weight/plant) gradually increased with increasing tryptophan acid (Trp acid) concentrations in the two seasons (Table 2). The highest values in this connection were obtained by the treatment of Trp acid at 150 ppm during both seasons. Amino acids are well known biostimulant which has positive effects on plant growth of several plants (Sadak *et al.*, 2015). In the same time, Gendy and Nosir (2016) suggested that foliar application of L-tryptophan at 100 ppm gave the highest values of roselle growth parameters as compared with either foliar applications with other amino acids or control plants.

Table 2. Effect of NP fertilizers, L- Tryptophan foliar spray and their combination treatments on growth parameters of dill plant during the two seasons of 2017/2018 and 2018/2019

Treatments		Growth Parameters					
		Plant height (cm)		Branches number		Total dry weight (g)	
		Seasons		Seasons		Seasons	
NP fertilizers (% RR*)	Tryptophan (ppm)	1 st	2 nd	1 st	2 nd	1 st	2 nd
Effect of NP fertilization rate (% RR)							
Control		67.58	64.83	8.17	8.42	14.66	14.87
75		69.71	74.96	8.58	9.42	14.92	16.03
100		76.83	80.71	9.33	10.17	16.27	17.09
LSD at 5 %		1.74	1.52	0.10	0.77	N.S	0.80
Effect of Effect of L-tryptophan concentration ppm							
	0.0	60.44	64.50	6.11	7.00	11.73	12.44
	50	66.06	70.50	7.33	8.11	13.19	14.48
	100	78.00	77.17	9.22	9.89	15.93	16.66
	150	81.00	81.83	12.11	12.33	20.29	20.42
LSD at 5 %		0.93	1.39	0.73	0.39	1.05	0.60
Effect of NP fertilization rate × L-tryptophan concentration							
Control	0.0	58.67	56.50	5.67	6.33	11.28	11.66
	50	59.83	62.83	6.67	7.33	12.70	13.88
	100	73.50	68.17	8.67	9.33	15.78	15.83
	150	78.33	71.83	11.67	10.67	18.91	18.11
75	0.0	59.33	65.33	6.33	7.00	11.60	12.09
	50	63.33	71.17	7.33	8.00	12.84	14.63
	100	77.17	80.33	9.33	10.00	15.32	16.22
	150	79.00	83.00	11.33	12.67	19.92	21.19
100	0.0	63.33	71.67	6.33	7.67	12.30	13.57
	50	75.00	77.50	8.00	9.00	14.04	14.94
	100	83.33	83.00	9.67	10.33	16.68	17.93
	150	85.67	90.67	13.33	13.67	22.05	21.96
LSD at 5 %		2.21	2.57	1.47	0.96	2.25	1.04

* Recommended rate (RR) = 60 kg N/fed. and 32 kg P₂O₅/fed.

Effect of NP fertilization rate × L-tryptophan acid concentration

In addition, the best combination treatment in increase plant height, branch number and total dry weight per dill plant was that 100% of recommended rate (RR) + 150 ppm Trp acid compared to the other combination treatments under study. Generally, increasing Trp acid concentrations under each NP fertilization rate increased dill growth parameters. These results hold true during the first and second seasons. Moreover, as mentioned just before, both NP fertilization rates and L-tryptophan concentration (each alone) increased growth parameters of dill plant, in turn, they together might maximize their effects leading to taller, more branches and heaviest leaves as found by Abd El-wahed *et al.* (2016) on onion plants.

Yield components and volatile oil production

Effect of NP fertilization rate

The data given in Tables 3 and 4 indicate that, the highest values of fruit yield /dill plant

and /feddan as well as volatile oil percentage, volatile oil yield /plant and /feddan were achieved by 100 % RR followed by 75 %RR compared to control during both seasons. Nitrogen and phosphorus fertilizers rates significantly increased dill yield components and volatile oil production parameters to control. Moreover, Aly *et al.* (2015) demonstrated that fruits weight (g/plant) and yield (kg/fed) as well as volatile oil yields of dill showed significant increasing with the treatments of nitrogen fertilizers alone and combined with bio-fertilizers compared with control plants in both seasons and the maximum increments were resulted with the treatment (60 kg N/fed.). Abdollahi *et al.* (2016) indicated that application of 150 kg·ha⁻¹ N increased the number of umbels per plant, 1000 seeds weigh, seed yield and essential oil yield, compared with the control, respectively. The most effective rate was the full recommended dose (N₁₅₀P₂₀₀K₁₀₀), resulting in s positive increase in yield components of dill (Hamad *et al.*, 2017).

Table (3): Effect of NP fertilizers, L- Tryptophan foliar spray and their combination treatments on yield components of dill plant during the two seasons of 2017/2018 and 2018/2019

Treatments		Yield components			
		Fruit yield / plant (g)		Fruit yield / feddan (kg)	
		Seasons		Seasons	
NP fertilizers (% RR*)	Tryptophan (ppm)	1 st	2 nd	1 st	2 nd
Effect of NP fertilization rate (% RR)					
Control		19.53	20.41	911.6	952.3
75		20.47	21.17	955.3	987.9
100		21.82	22.77	1018.3	1062.7
	LSD at 5 %	0.296	0.232	13.797	10.832
Effect of Effect of L-tryptophan concentration ppm)					
	0.0	19.14	19.90	893.1	928.7
	50	20.17	20.84	941.2	972.7
	100	21.10	21.89	984.6	1021.3
	150	22.03	23.17	1028.0	1081.1
	LSD at 5 %	0.322	0.278	15.020	12.981
Effect of NP fertilization rate × L-tryptophan concentration					
Control	0.0	18.40	19.23	858.8	897.6
	50	19.03	19.88	888.2	927.9
	100	20.08	20.64	936.9	963.4
	150	20.62	21.87	962.4	1020.5
75	0.0	19.07	19.72	889.9	920.3
	50	20.25	20.77	945.0	969.4
	100	20.64	21.54	963.2	1005.2
	150	21.92	22.64	1022.9	1056.7
100	0.0	19.94	20.75	930.5	968.3
	50	21.22	21.87	990.3	1020.8
	100	22.58	23.47	1053.7	1095.4
	150	23.54	24.99	1098.7	1166.2
	LSD at 5 %	0.562	0.475	26.243	22.150

* Recommended rate (RR) = 60 kgN/fed. and 32 kg P₂O₅/fed.

Effect of L-tryptophan acid concentration

Data of both seasons in Table 3 reveal that, fruit yield per plant (g) and per feddan (kg) of dill gradually increased with increasing tryptophan acid concentrations in the two seasons. The highest values in this regard were gained by the treatment of Trp acid at 150 ppm during both seasons. Similarly, volatile oil production of dill fruits significantly increased with Trp acid foliar spray compared to control (Table 4). Application of L-Tryptophan may increase yield of plants by positively altering physiological phenomena in plants. These results also found by Rao *et al.* (2012) on maize plant, Youssef (2014) on *Echinacea purpurea* plant and Mohamed *et al.* (2018) on *Triticum aestivum* plants.

Effect of NP fertilization rate × L-tryptophan acid concentration

From data recorded in Tables 3 and 4 it is obvious that, increasing tryptophan concentrations

under each NP fertilization rate increased dill yield (yield per plant and per feddan) and volatile oil production parameters. The best combination treatment in this concern was that 100% RR + 150 ppm Trp acid compared to the other combination treatments under study. In addition, as mentioned just before, both NP fertilization rates and L-tryptophan concentration (each alone) increased yield components of dill plant, in turn, they together might maximize their effects leading to more yield and volatile oil production. The simulative effect of NP at 100 % of RR and foliar spray with Trp acid at 150 pp on yield /plant and total yield/ fed. of dill, may be due to that NP and Trp acid increased plant height, number of branches/plant and total dry weight/plant (Table 2) also increased total chlorophyll in leaf tissues (Table 5). Also, Ahmad *et al.* (2008) found that compost enriched with N and L-tryptophan in the presence of 80 kg N fertilizer significantly increased maize cob and grain yields compared with a full dose of N fertilizer.

Table 4. Effect of NP fertilizers, L- Tryptophan foliar spray and their combination treatments on volatile oil production of dill plant during the two seasons of 2017/2018 and 2018/2019

Treatments		Volatile oil production					
		Volatile oil %		Volatile oil yield /plant (ml)		Volatile oil yield /feddan (l)	
		Seasons		Seasons		Seasons	
NP fertilizers (% RR*)	Tryptophan (ppm)	1 st	2 nd	1 st	2 nd	1 st	2 nd
Effect of NP fertilization rate (% RR)							
Control		2.197	2.263	0.430	0.463	20.057	21.609
75		2.282	2.315	0.468	0.491	21.830	22.899
100		2.371	2.384	0.518	0.544	24.162	25.366
	LSD at 5 %	0.019	0.113	0.009	0.024	0.419	1.126
Effect of Effect of L-tryptophan concentration ppm)							
	0.0	2.211	2.229	0.424	0.444	19.773	20.722
	50	2.270	2.271	0.458	0.474	21.398	22.128
	100	2.314	2.341	0.488	0.513	22.822	23.943
	150	2.339	2.442	0.516	0.565	24.073	26.373
	LSD at 5 %	0.010	0.100	0.008	0.022	0.367	1.009
Effect of NP fertilization rate × L-tryptophan concentration							
Control	0.0	2.110	2.130	0.388	0.410	18.121	19.118
	50	2.173	2.143	0.414	0.426	19.304	19.888
	100	2.237	2.273	0.449	0.469	20.956	21.898
	150	2.270	2.507	0.468	0.547	21.847	25.533
75	0.0	2.207	2.240	0.421	0.442	19.640	20.613
	50	2.267	2.290	0.459	0.476	21.422	22.201
	100	2.307	2.333	0.476	0.503	22.219	23.455
	150	2.350	2.397	0.515	0.543	24.039	25.325
100	0.0	2.317	2.317	0.462	0.481	21.558	22.434
	50	2.370	2.380	0.503	0.521	23.469	24.294
	100	2.400	2.417	0.542	0.567	25.290	26.474
	150	2.397	2.423	0.564	0.606	26.332	28.262
	LSD at 5 %	0.024	0.187	0.015	0.040	0.686	1.871

* Recommended rate (RR) = 60 kgN/fed. and 32 kg P₂O₅/fed.

Chemical constituents

Effect of NP fertilization rate

Data illustrated in Tables 5 and 6 show that, N and P fertilizers rates significantly increased dill leaves chlorophyll content (a+b) and fruits total carbohydrates, nitrogen and phosphorus percentages compared to control during both seasons. Mostly, the highest values of total chlorophyll (mg/100g as fresh weight), total carbohydrate (%), N % and P % were achieved by 100 % of recommended rate compared to control and the other one under study. Furthermore, **Tulukcu and Dan Baba (2019)** reported that, at the end of the experiment chlorophyll content in leaf tissues increased with increasing doses of P₂O₅.

Effect of L-tryptophan acid concentration

Tables 5 and 6 pointed out that, abovementioned chemical constituents of dill gradually increased with increasing tryptophan acid concentrations in the two seasons. The highest values in this concern (total chlorophyll content as well as total carbohydrate, nitrogen and phosphorus percentages) were obtained by the treatment of Trp acid at 150 ppm during both seasons. **Abdel Aziz et al. (2010)** revealed that the three amino acids (Tyrosine, Thiamine and Tryptophan) at 100 ppm, increased essential oil %, essential oil yield / plant and N, P and K % and protein. Also, **Gendy and Nosir (2016)** reported that the better chemical constituents of roselle sepals (nitrogen, phosphorus and carbohydrates contents, also, total chlorophyll content (a+b) in leaves could be obtained by spraying L- tryptophan at 100 ppm.

Table 5. Effect of NP fertilizers, L- Tryptophan foliar spray and their combination treatments on total chlorophyll content (mg/100g) and total carbohydrates percentage of dill plant during the two seasons of 2017/2018 and 2018/2019

Treatments		Total chlorophyll content (mg/100g)		Total carbohydrates (%)	
		Seasons		Seasons	
NP fertilizers (% RR*)	Tryptophan (ppm)	1 st	2 nd	1 st	2 nd
Effect of NP fertilization rate (% RR)					
Control		1.886	1.851	28.464	28.690
75		2.061	1.985	29.007	29.588
100		2.162	2.127	30.438	30.272
	LSD at 5 %	0.011	0.046	0.607	0.647
Effect of Effect of L-tryptophan concentration ppm)					
	0.0	1.896	1.841	28.237	28.591
	50	2.019	1.979	28.523	28.811
	100	2.067	2.030	29.993	29.704
	150	2.164	2.101	30.552	30.961
	LSD at 5 %	0.048	0.036	0.370	0.505
Effect of NP fertilization rate × L-tryptophan concentration					
Control	0.0	1.867	1.740	27.293	28.063
	50	1.863	1.833	27.847	28.150
	100	1.900	1.880	29.143	28.663
	150	1.913	1.950	29.573	29.883
75	0.0	1.863	1.757	27.743	28.220
	50	2.110	1.960	28.353	29.417
	100	2.080	2.080	29.770	29.980
	150	2.190	2.143	30.443	30.737
100	0.0	1.957	2.027	29.673	29.490
	50	2.083	2.143	29.370	28.867
	100	2.220	2.130	31.067	30.470
	150	2.390	2.210	31.640	32.263
	LSD at 5 %	0.072	0.070	0.814	0.988

* Recommended rate (RR) = 60 kg N/fed. and 32 kg P₂O₅/fed.

Effect of NP fertilization rate × L-tryptophan acid concentration

From data presented in Tables 5 and 6 it is clear that, in general, increasing NP fertilization rates under each Trp acid concentration increased dill chemical constituents. These results hold true during the first and second seasons, in most cases. In addition, the best combination treatment in increase total chlorophyll content as well as total carbohydrate, N and P percentages was

that 100% RR + 150 ppm Trp compared to the other combination treatments under study. **El-Awadi *et al.* (2011)** concluded that nitrogen fertilization combined with tryptophan amino acid (100 mg l⁻¹) gave the highest snap bean pod quality (nitrogen percentage). Moreover, **Abd El-wahed *et al.* (2016)** indicated that both nitrogen and tryptophan application significantly promoted the growth criteria, however, the increase in growth criteria was concomitant with increases in photosynthetic pigments and total nitrogen.

Table 6. Effect of NP fertilizers, L- Tryptophan foliar spray and their combination treatments on total nitrogen and total phosphorus percentages of dill fruits during the two seasons of 2017/2018 and 2018/2019

Treatments		Total nitrogen (%)		Total phosphorus (%)	
		Seasons		Seasons	
NP fertilizers (% RR*)	Tryptophan (ppm)	1 st	2 nd	1 st	2 nd
Effect of NP fertilization rate (% RR)					
Control		2.919	3.022	0.368	0.387
75		3.167	3.078	0.382	0.401
100		3.178	3.250	0.461	0.507
	LSD at 5 %	0.020	0.041	0.014	0.012
Effect of Effect of L-tryptophan concentration ppm)					
	0.0	2.840	2.898	0.347	0.367
	50	2.940	3.017	0.390	0.408
	100	3.061	3.189	0.416	0.460
	150	3.312	3.363	0.463	0.492
	LSD at 5 %	0.040	0.066	0.018	0.012
Effect of NP fertilization rate × L-tryptophan concentration					
Control	0.0	2.770	2.850	0.320	0.350
	50	2.847	2.893	0.370	0.383
	100	2.856	3.087	0.363	0.397
	150	3.203	3.260	0.420	0.420
75	0.0	2.873	2.920	0.337	0.353
	50	2.937	2.977	0.367	0.383
	100	2.987	3.103	0.397	0.417
	150	3.270	3.313	0.430	0.450
100	0.0	2.877	2.923	0.383	0.397
	50	3.037	3.183	0.433	0.457
	100	3.340	3.377	0.487	0.567
	150	3.463	3.517	0.540	0.607
	LSD at 5 %	0.064	0.107	0.030	0.021

* Recommended rate (RR) = 60 kgN/fed. and 32 kg P₂O₅/fed.

CONCLUSION

It can be concluded that using 100 % RR (60 kg N/fed. and 32 kg P₂O₅/fed.) from nitrogen and phosphorus and foliar application of L-tryptophan acid at 150 ppm concentration recoded the highest growth, yield components, volatile oil production of dill under Sharkia Governorate condition.

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