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Original Article

HUMIC ACID AND INDOLE ACETIC ACID AFFECT YIELD AND ESSENTIAL OIL OF DILL GROWN UNDER TWO DIFFERENT LOCATIONS IN EGYPT

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ABSTRACT

Objective: The objective of this work was to evaluate the effect of humic acid, indole acetic acid or combination on productivity, essential oil of dill plant cultivated in two different locations. Also, to study the dill straw as a new source of essential oil instead of neglecting this by-product.

Methods: In 2010/2011 and 2011/2012, a field experiment was conducted in Egypt to evaluate the effect of humic acid (0 and 400 ppm), indole acetic acid (0 and 400 ppm) and region (Nile Valley and Delta, Giza governorate and Sinai Peninsula, North Sinai governorate) on dill productivity, oil content and its composition.

Results: Results demonstrated that dill straw can be explored as a new source of essential oil. Generally found that the cultivation of dill in Giza gave the best results from cultivation in the North Sinai. For spraying treatments, there was a disparity in the response studied characters, where spraying by humic acid gave the best results of survival %, plant height, number of branches, number of umbles and seed oil yield (l/fed). While the best values of dill straw (g/plant or kg/fed) and the percentage of oil seed were obtained with indole acetic acid spray. Also, indole acetic acid+humic acid gave the best values of seed weight (g/plant or kg/fed) and straw volatile oil content (% or l/fed). But, non-spraying plants gave lower values of all studied characters. As for interaction treatments, spraying by humic acid gave the best results of plant height, number of branches and number of umbles in both regions and seed oil (% or yield) at Giza as well as straw oil yield at North Sinai. At the same time, indole acetic acid gave the highest straw (g/plant or kg/fed) and seeds oil % at North Sinai. But, indole acetic acid+humic acid gave the highest seeds (g/plant or kg/fed) and straw oil in regions as well as seeds and straw oil yields in North Sinai and Giza, respectively. Overall, indole acetic acid under the conditions of the Giza region gave the best results for straw (g/plant or kg/fed), while spray with humic acid gave the highest values of plant height, number of branches, number of umbles and seed volatile oil (% or yield) in Giza as well as the highest of seed weight (g/plant or kg/fed) and straw volatile oil (% or yield) was obtained by indole acetic acid+humic acid. In view of the components of the volatile oil found that carvone, dihydrocarvone, limonene, dill apiol and piperitone compounds in the seed and α-phellandrene, limonene, β-phellandrene, p-cymene and dill ether compounds in straw was the main compounds. The percentages of these compounds affected by factors under study.

Conclusion: Cultivation of dill in Giza region gave the best results from cultivation in the North Sinai region. Humic acid and indole acetic acid play an important role in plant growth, yield and ameliorate the deleterious effects of salt stress. The content of carvone, dihydrocarvone, limonene, dill apiol and piperitone in the seed oil as major compounds and α-phellandrene, limonene, β-phellandrene, p-cymene, dill ether as major compounds in the straw oil affected by factors under study. Dill straw can be explored as a new source of essential oil.

Keywords: *Anethum graveolens* L., Humic acid, Indole acetic acid, Yield, Essential oil, Chemical composition

INTRODUCTION

Environmental stresses are among the factors most limiting to plant productivity. Soil salinity is a major a biotic stress in plant agriculture worldwide. The responses of plants to stress include growth inhibition, decreased nutrient uptake and lower productivity [1]. Based on this challenge, there has been a call for enhancing crop yields and improving soil fertility through better management practices [2]. Humic substances (HS) recognized as a plant growth promoter by increasing the quality of crop, and enhance plant tolerance against both biotic and a biotic stresses [3]. Humic acid used for plant nutrition, enhance root, plant growth and development as well as yield due to its action on physiological and metabolic processes [4]. The positive effects of humic acid on cell membrane functions by promoting nutrient uptake, respiration, biosynthesis of nucleic acid, ion absorption, enzyme because they are hormone-like substances [5]. Indole acetic acid (IAA) is one of the most physiologically active auxins and helps in the production of longer roots with increased number of root hairs and root laterals which are involved in nutrient uptake [6]. IAA stimulates cell elongation by modifying certain conditions like, increase in osmotic contents of the cell, increase in permeability of water into cell, decrease in wall pressure, an increase in cell wall synthesis, protein synthesis and actively participates in adaptive responses of the plants to different stress factors [1].

Anethum graveolens L. (dill; family *Apiaceae*) is an annual medicinal and aromatic herb, is widely used as a spice and a medicine. Dill is native to Southwest Asia or Southeast Europe [7]. It is indigenous to the Mediterranean, southern USSR, and Central Asia regions. Since Egyptian times, dill has been used as a condiment and also for medicinal purposes [8-10]. Dill fruits have medicinal value as a diuretic, stimulant, and a carminative [11, 12]. Also dill fruits used as antispasmodic, sedative, lactagogue, and to treat haemorrhoids, bronchial asthma, neuralgio, remal colic, dysurea, genital ulcers and dysmenorrhoea [12]. Moreover, dill seed and their essential oil reported as antioxidant, antimicrobial and antifungal activities [13, 14].

Dill has been grown throughout the world as an essential-oil-producing crop with a large portion of the industry or commonly grown in the as a culinary crop. The essential oil quality and productivity of dill and other essential oil crops depend on many factors such as climate, soil conditions, altitude, ontogenetic and genetic factors and other environmental stresses, leading in some cases to the evolution of different chemical variants [15-17].

The climate in the Giza area is suitable for the production of high-quality seeds and dill oil. In order to increase the exports of dill and to leave the fertile lands in Delta and Nile valley for the strategic crops we tried to study the behavior of dill plants in Sinai. In addition to evaluate the success of the cultivation and production of dill under the conditions of El-Tina Plain at the northwestern part of Sinai Peninsula that represents severe soil salinity [18] as a step towards the development of Sinai Peninsula and to face the higher demand as raw material and its products and maximizing the use of dill. Since no reports were traced on dill productivity and also, there has been no evaluation of essential oil productivity and quality of dill cultivated in in Gelbana Village, El-Tina Plain, North Sinai, Egypt.

To the best of our knowledge there has been no study of the involvement of humic acid and IAA in different dill plant tolerance strategies developed against salinity. The objective of this research was to determine the potential to grow dill as an essential oil crop in Gelbana Village, Sahl El-Tina (North Sinai governorate) region comparison with (Giza governorate) and to observe the effect of soil salinity on yields and essential oil composition.

MATERIALS AND METHODS

Plant material and growing conditions

Field experiments was conducted using complete randomized block design with three replications in the 2010/2011 and 2011/2012 cropping seasons at two regions in Egypt: Sinai Peninsula region, North Sinai governorate, Gelbana Village, Sahl El-Tina and Nile Valley region, Giza governorate at the Farm Station of Faculty of Agriculture, Cairo University. Soil samples were taken before land preparation and the physical and chemical properties of the soil samples were determined according to Jackson [19] and Cottenie *et al.* [20] as shown in table (A). The Meteorological data at Giza and North Sinai during the two growing seasons are shown in (table 2). Each individual experimental plot was 3 x 3.5 m area and had five rows.

Table 1: Physical and chemical properties of the studied soils

Physical properties									
Soil	**Crouse sand%**	**Fine sand%**		**Silt%**	**Clay%**	**texture**	**O. M%**		**CaCo3%**
Mean (R1)	3.60	24.20		35.45	36.75	clay	0.85		0.85
Mean (R2)	15.45	61.17		7.96	15.42	Sandy clay	0.62		0.831
Chemical properties									
Soil	**EC (dS/m)**	**pH (1:2.5)**	**Soluble cations (meq/l)**				**Soluble anions (meq/l)**		
			Ca^{+2}	**Mg^{+2}**	**Na^{+}**	**K^{+}**	**$HCO3^{-}$**	**Cl^{-}**	**$SO4^{-2}$**
1stseason(R1)	1.73	7.85	7.51	0.35	6.81	2.53	3.88	10.64	2.68
2nd season (R1)	1.67	7.96	7.25	0.36	6.45	2.50	3.65	10.44	2.47
1st season (R2)	9.77	8.34	34.03	26.20	23.50	12.40	17.33	55.67	23.13
2stseason (R2)	8.74	8.30	31.57	24.08	20.65	10.67	15.00	50.67	21.30

Since: R1= Soil sample of Farm Station of Faculty of Agriculture, Cairo University (Giza governorate); R2= Soil sample of Sahl El-Tina, Gelbana Village (North Sinai governorate).

Table 2: Meteorological data during the two growing seasons

Month	**Giza governorate**						**North Sinai governorate**					
	1st season			**2nd season**			**1st season**			**2nd season**		
	T(°C) Max.	**T(°C) Min.**	**RH %**	**T(°C) Max.**	**T(°C) Min.**	**RH %**	**T(°C) Max.**	**T(°C) Min.**	**RH %**	**T(°C) Max.**	**T(°C) Min.**	**RH %**
October	32.5	21.3	50.4	30.4	20.4	60.1	37.37	14.15	66.00	33.18	13.98	78.00
November	23.10	6.08	48.20	22.80	12.00	38.90	25.76	6.08	73.00	29.85	9.50	82.00
December	19.50	4.55	48.80	21.40	11.50	40.20	25.70	4.55	74.00	26.36	5.15	73.00
January	18.50	10.80	48.30	19.60	10.22	49.30	24.26	3.59	75.00	23.03	3.55	67.00
February	23.90	12.60	55.60	22.30	16.30	50.20	27.62	6.96	72.00	23.58	2.31	67.00
March	27.50	14.40	70.70	28.80	17.70	52.50	30.04	5.81	75.00	20.80	5.88	71.00
April	28.90	14.50	80.50	29.40	18.30	56.30	39.64	8.20	67.00	35.01	11.07	70.00
May	31.40	16.30	88.90	30.50	20.20	74.20	38.25	11.80	68.00	35.50	11.0	74.00

Source: Meteorological data of Giza (CLAC, Egypt), average values; T (°C) Max. and Min. are monthly average, maximum and minimum temperatures; RH is monthly average relative humidity

The seeds of *Anethum graveolens* L. were provided by Medicinal and Aromatic Plants Department, National Research Centre, Dokki, Giza, Egypt. Seeds were sown on 20th October in the two seasons in hills with 20 cm between hills. The seedlings were thinned two months after sowing to leave two plants per hill. The studied treatments at the two regions were: (1) humic acid (0 and 400 ppm as a foliar spray); and (2) indole acetic acid (0 and 400 ppm as a foliar spray) were applied after 60, 90 and 120 d from sowing. The potassium humate used in this study is produced in China having a physical data as follows: appearance (black powders), pH (9-10), and water solubility (>98%). The guarateed analysis were as follows: humic acid (80%), potassium (K_2O) (10-12%), and zinc, iron, manganese, etc., (100 ppm). Dill plants were harvested on 15 May in both seasons at full fruits ripening by uprooting the plants from the soil by hand. The survival plants %, plant height, number of branches, number of umbels, seed and straw yields were measured and recorded. Representative samples from each treatment were air-dried in shade and seed were separated from the straw. The straw material was chopped into pieces 2 to 3 cm long before distillation and kept for essential oil extraction.

Essential oil extraction

Essential oils were extracted from seed and straw of each treatment by water distillation using clevenger apparatus for 2 h according to Guenther [21] and expressed as ml/100g, while essential oil yield was expressed as l/feddan. The extracted essential oil was dehydrated over anhydrous sodium sulphate and stored at freezer till used for gas chromatography-mass spectrometry (GC-MS) analysis.

GC-MS analysis

The GC-Ms analysis of the essential oil of the different treatments was carried out in the second season using gas chromatography-mass spectrometry instrument stands at the Department of medicinal and aromatic plants research, National Research Center with the following specifications. Instrument: a TRACE GC Ultra Gas Chromatographs (THERMO Scientific Corp., USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadruple Mass Spectrometer). The GC-MS system was equipped with a TG-WAX MS column (30 m x 0.25 mm i. d., 0.25 µm film thickness). Analyses were carried out using helium as carrier gas at a flow rate of 1.0 ml/min and a split ratio of 1:10 using the following temperature program: 40°C for 1 min; rising at 4 °C/min to 160 °C and held for 6 min; rising at 6 C/min to 210 °C and held for 1 min. The injector and detector were held at 210 °C. Diluted samples (1:10 hexane, v/v) of 0.2 µL of the mixtures were injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. Compounds were identified by matching of their mass spectra (authentic chemicals, Wiley spectral library collection and NSIT library).

Statistical analysis

Except for the constituents of the essential oil, the data were statistically analyzed according to Cochran and Cox [22], using LSD at level of 5 %.

RESULTS AND DISCUSSION

Survival %, growth parameters, yield and oil content

Effect of location

Data on survival percentage in table (1) reveal that growing dill plants under saline soil (North Sinai) caused a significant reduction in survival percentage compared to non-saline soil (Giza) in both seasons. Similar results were obtained on coriander [15] revealed that growing coriander plants under saline soil (North Sinai) caused a reduction in survival percentage compared to non-saline soil (Giza) in both seasons. An excess of soluble salts in the soil leads to osmotic stress, specific ion toxicity and ionic imbalances [23] and, as a consequence, plant can go to death [24].

Data presented in tables (1-3) showed that plant height, number of branches, number of umbels, weights of seed and straw (g/plant or kg/feddan) as well as both seed or straw essential oil (% or l/feddan) at Giza (non saline soil) was higher than those of North Sinai (saline soil) in both seasons. Moreover, all parameters determined for dill sown at Giza were significantly increased compared to those of dill sown at North Sinai. Said-Al Ahl *et al.* [15] showed that plant height, number of branches, number of umbels, weights of seed and straw (g/plant or kg/feddan) as well as both seed or straw essential oil (% or l/feddan) at Giza (non saline soil) was higher than those of North Sinai (saline soil), except straw essential oil % was lower at Giza in second season. Abu-Darwish *et al.* [25] and Abu-Darwish andAbu-Dieyeh [26] on thyme and Bazaid *et al.* [27] on basil, rosemary, marjoram and rose plants showed that essential oil contents were differed as a result of changing the geographical regions. Several investigators have reported growth, seed yield and yield components reduction as a result of salinity stress [28-31].

Saline conditions reduce the ability of plants to absorb water causing rapid reductions in growth rate, and induce many metabolic changes, also, salt stress with osmotic, nutritional and toxic effects prevents growth in many plant species [32]. Therefore, the reduction in growth was explained by lower osmotic potential in the soil, which leads to decreased water uptake, reduced transpiration, and closure of stomata, which is associated with the reduced growth [33].

The essential oil of dill seeds has been reported to range between 1.75–7.25% [7, 10, 34-38]. There are reports of a decrease in essential oil percentage due to salinity were found on medicinal plants [39, 40]. Salt stress decreased essential oil yield in *Trachyspermum ammi* [41]. This negative effect of salt stress in oil yield was also reported for other medicinal plants [15, 30, 42, 43].

The increase in oil content in some of the salt stressed plants might be attributed to decline the primary metabolites due to the effects of salinity, causing intermediary products to become available for secondary metabolites synthesis [44]. In fact, the effect of salinity on essential oil and its constituents may be due to its effects on enzyme activity and metabolism [45].

Table 3: Effect of indole acetic acid and humic acid on dill growth characters in the two sites

Treatments	Survival %		Plant height (cm)		Branches No./plant		Umbles No./plant	
	1st season	2ndseason	1st season	2nd season	1st season	2nd season	1st season	2nd season
Giza	100±0.0	100±0.0	94.23±2.46	93.9±3.19	10.10±0.42	9.82±0.77	15.55±1.35	15.45±1.35
Sinai	22.27±3.5	24.56±3.44	58.11±2.81	58.54±2.18	4.82±0.71	4.83±0.42	7.67±0.92	7.24±0.77
LSD at 5%	2.24	2.17	2.46	2.44	0.52	0.55	1.05	1.00
F0	57.18±1.15	58.29±1.63	68.88±2.98	67.83±2.52	5.55±0.50	6.02±0.65	9.41±0.98	8.31±1.15
F1	60.05±3.08	62.41±2.04	76.66±4.00	77.62±3.06	7.69±0.77	7.03±0.62	11.17±1.40	11.44±0.86
F2	62.26±2.84	63.61±2.89	83.89±2.44	83.76±2.46	9.82±0.46	9.61±0.69	15.53±1.55	15.01±1.00
F3	65.04±2.82	64.81±3.16	75.25±1.12	75.68±2.70	6.78±0.52	6.65±0.43	10.34±0.62	10.63±1.23
LSD at 5%	3.17	3.07	3.48	3.45	0.74	0.79	1.49	1.42
R1XF0	100.00±0	100.00±0	89.48±3.09	85.91±3.96	7.59±0.56	8.07±0.95	13.19±0.95	11.68±1.51
R1XF1	100.00±0	100.00±0	95.36±3.73	96.32±3.83	10.27±0.59	9.35±0.79	14.68±1.77	15.55±0.57
R1XF2	100.00±0	100.00±0	97.47±2.47	99.68±2.12	13.85±0.24	13.06±0.97	20.54±1.67	20.18±1.63
R1XF3	100.00±0	100.00±0	94.63±0.56	93.71±2.86	8.68±0.29	8.79±0.39	13.79±0.99	14.41±1.70
R2XF0	14.35±1.63	16.57±2.31	48.28±2.86	49.75±1.09	3.50±0.45	3.97±0.35	5.62±1.00	4.93±0.79
R2XF1	20.09±4.36	24.81±2.89	57.97±4.28	58.93±2.29	5.11±0.95	4.71±0.44	7.66±1.02	7.32±1.15
R2XF2	24.53±4.02	27.22±4.09	70.30±2.42	67.85±2.80	5.79±0.68	6.15±0.42	10.51±1.42	9.84±0.38
R2XF3	30.09±3.99	29.62±4.47	55.88±1.67	57.64±2.54	4.88±0.75	4.51±0.48	6.89±0.25	6.85±0.76
LSD at 5%	4.48	4.34	4.94	4.88 NS	1.05	1.12	2.11NS	2.01

Since; R=region, R1=Giza and R2=Sinai; F=foliar application, F0=control, F1=indole acetic acid, F2= humic acid, F3= indole acetic acid+humic acids.

Effect of foliar spraying

From the data in table (1), it is obvious that, spraying dill plants growing at North Sinai (saline soil) with indole acetic acid, humic acid or indole acetic acid+humic acid had a stimulator effect on survival percentage. In the same time, there was a significant increase in this regard between different spraying treatments. However, spraying with indole acetic acid+humic acid resulted in the highest survival percentage followed by spraying with humic acid and then indole acetic acid compared to control plants. Gulser *et al.* [46] and Yousef *et al.* [47] concluded that humic acid had positive effects on pepper and olive seedlings growth, respectively. On the other hand, Kashyap and Sharma [48] found that survival percentage was found to be the best with indole acetic acid treatment of *Mentha arvensis* suckers. This may be due to the effect of humic acid and indole acetic acid in increasing root growth, nutrient uptake and consequently stimulated plant growth [6, 49].

Data presented in tables (1-3) indicated that growing dill plants at Giza (non saline soil) or North Sinai (saline soil) showed significant increase in plant height, number of branches, number of umbels, weight of seeds and straw (g/plant and kg/feddan), seeds and straw essential oil yields (l/feddan) compared to that control (without foliar spray) during two seasons. There was a significant increase in straw oil % by spraying humic acid or indole acetic acid+humic acid only in both seasons and spraying dill plants with indole acetic acid caused a significant reduction in straw essential oil % in the first season and was not affected in second season. Whereas, indole acetic acid+humic acid treatment had a significant reduction effect on seed oil % in both seasons, but indole acetic acid or humic acid separately significantly increased seed oil % in both seasons. Spraying plants with indole acetic acid gave the highest % of seed essential oil followed by humic acid.

However, indole acetic acid+humic acid led to best value of straw essential oil followed by humic acid. In apparent contradiction it found that indole acetic acid gave the less value of straw essential oil and the highest value of seed essential oil and also vice versa, indole acetic acid+humic acid gave the less value of seed essential oil and the highest value of straw essential oil. Plant height, number of branches, number of umbels increased significantly with humic acid followed by indole acetic acid and the mixture of indole acetic acid+humic acid then control in both seasons. While seed weight (g/plant or kg/feddan) increased significantly by humic acid+indole acetic acid followed by humic acid and indole acetic acid, then control in both seasons. Straw weight (g/plant) and (kg/feddan) increased significantly with indole acetic acid followed by humic acid and mixture of indole acetic acid+humic acid then control in both seasons. Similar results were reported by [50-53]. Generally, in a comparison between indole acetic acid, humic acid and indole acetic acid+humic acid we can say that application of indole acetic acid was gave the best for straw weight and less weight of seeds and also gave the highest seed essential oil % and less straw essential oil %. But indole acetic acid+humic acid gave the best in seeds weight, and least in the straw weight. Also, indole acetic acid+humic acid gave the largest %of straw essential oil and less essential oil % in the seed.

Table 4: Effect of indole acetic acid and humic acid on dill productivity in the two sites

Treatments	Seed weight(g/plant)		Seed yield(kg/feddan)		Straw weight(g/plant)		Straw yield(kg/feddan)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Giza	17.29±2.03	17.66±2.45	1250.48±146.16	1274.35±176.96	34.16±2.49	34.10±3.25	2464.5±179.6	2456.6±238.6
Sinai	2.29±0.38	2.59±0.44	37.35±11.49	43.92±5.67	6.01±0.89	6.12±0.42	91.5±22.2	104.0±13.9
LSD at 5%	1.37	1.57	96.59	111.94	1.76	2.12	120.60	156.32
F0	5.66±0.84	6.28±1.02	364.06±51.13	396.27±58.61	12.30±0.86	11.52±1.49	767.5±34.1	733.7±93.9
F1	9.12±0.80	10.11±1.79	605.68±56.21	668.83±117.87	25.37±1.91	26.05±1.27	1614.2±122.3	1657.8±81.5
F2	10.58±0.99	11.49±1.24	706.25±72.40	751.33±85.31	21.95±2.03	23.04±1.80	1372.5±139.3	1426.5±130.5
F3	13.81±2.19	12.63±1.73	899.66±135.56	820.11±103.47	20.70±1.96	19.84±2.79	1357.7±107.9	1303.2±199.1
LSD at 5%	1.94	2.23	136.60	158.31	2.49	3.01	170.55	221.07
R1XF0	9.73±1.37	10.69±1.50	712.60±97.84	771.28±108.02	20.76±0.79	19.86±2.57	1498.1±56.9	1432.7±185.8
R1XF1	16.45±1.46	18.05±3.19	1187.11±105.03	1302.07±230.18	43.40±3.20	44.12±2.01	3131.1±230.7	3183.5±144.9
R1XF2	19.12±1.94	20.11±2.30	1379.27±139.70	1450.94±165.68	36.33±3.57	37.35±3.35	2621.0±257.7	2695.0±241.4
R1XF3	23.88±3.36	21.80±2.83	1722.94±242.07	1573.11±203.95	36.14±2.40	35.07±5.08	2607.7±173.0	2515.3±382.4
R2XF0	1.60±0.31	1.87±0.55	15.52±4.42	21.26±9.20	3.83±0.92	3.18±0.41	37.0±11.2	34.7±2.1
R2XF1	1.79±0.15	2.17±0.40	24.26±7.39	35.59±5.55	7.35±0.63	7.98±0.53	97.3±14.0	132.1±18.1
R2XF2	2.03±0.05	2.87±0.19	33.23±5.10	51.73±4.95	7.58±0.50	8.72±0.25	123.9±21.0	157.9±19.6
R2XF3	3.74±1.02	3.46±0.62	76.38±29.05	67.11±2.99	5.26±1.52	4.62±0.49	107.7±42.7	91.1±15.8
LSD at 5%	2.75	3.15	193.20	223.90	3.52	4.26	241.22	312.66

Since; R=region, R1=Giza and R2=Sinai; F=foliar application, F0=control, F1=indole acetic acid, F2= humic acid, F3= indole acetic acid+humic acids.

With respect to essential oil yield table (3) showed significant differences between spraying treatments. Highest straw essential oil yield were obtained from plants sprayed with indole acetic acid+humic acid followed by indole acetic acid and humic acid and then control plnats which gave the lowest straw oil yield in both seasons. Whereas, humic acid+indole acetic acid gave the highest seed oil yield followed by humic acid or indole acetic acid separately in the first and second seasons, respectively and then control plants which gave the lowest seed oil yield in both seasons.

Essential oil (% or yield) was significantly increased by humic acid in basil [50, 54]. Foliar application of humic acid significantly increased essential oil content in *Satureja hortensis* [53] and *Allium sativum* [55]. Juárez *et al.* [56] observed that essential oil yield was higher in thyme at the highest levels of humic substances. Also, Hamidi *et al.* [57] showed that humic acid increased essential oil content in coriander. Similar results were obtained by [58, 59].

Hazzoumi *et al.* [60] on basil stated that indole acetic acid increased essential oil yield. Khan *et al.* [61] on *Cymbopogon martini* observed that oil content increased significantly by IAA. The same observation was made on *Melissa officinalis* [62] and *Thymus vulgaris* [63].

Humic substances used for plant nutrition, enhance root, plant growth and seed yield [64-67]. However, Sirousmehr *et al.* [68] indicated that humic acid had significant impact on plant height, number of branch, dry weight and yield of basil. Humic acid increase root growth by increasing cell elongation or root cell membrane permeability therefore increased water and nutrients uptake by increase root surface area, so improving plant growth, development and carbohydrates content [69-71]. Khalil and Yousef [72] showed that the plant height, number of branches, number of fruits per plant, fresh and dry weights and seed yield of roselle plants were increased with humic acid application. Moreover, Moraditochaee [73] recommended that humic acid as foliar spraying significantly increased seed yield, straw yield and biological yield of peanut.

Indole-3-acetic acid (IAA) is the major plant growth hormone and is involved in the regulation of almost every step of plant development [74]. It controls vascular tissue development, cell elongation, and apical dominance [75]. IAA promotes stem elongation, cell expansion and growth rate, protein content and increasing photosynthetic activities in plants and also activates the translocation of carbohydrates during their synthesis [76-78]. IAA was reported to stimulate root growth which led to enhanced water and mineral uptake efficiency and thus, significant increment on percentage in plant growth [79-82]. Some studies concluded that, application of IAA for enhancing plant growth, pod numbers and seed yield [62, 63, 83, 84].

Effect of interaction

Table (1) revealed that the interaction treatments between saline soil (North Sinai) and foliar spray treatments caused an increase in survival percentage compared to untreated plants. There was no difference between spraying treatments on survival percentage of dill growing at Giza (non saline soil). Humic acid promote growth seedlings in salty condition [85, 86]. These results are in line with those reported by [85, 87]. Humic acid have been reported to enhance mineral nutrient uptake by plants, because it affects the permeability of membranes of root [85, 87, 88]. Moreover, it was observed that the negative effects of excessive Na in saline soil conditions could partly be eliminated by humic acid applications. This may be attributed to the fact that humic acid application has improved root growth, altering mineral uptake, and decreasing membrane damage, thus inducing salt tolerance in plants. These results are in line with the finding of Çimrin *et al.* [89] who found that humic acid applications to plant growth in the moderate saline conditions increased the growth of both shoots and roots fresh and dry weight, shoot and root lengths, shoot width, cotyledon length and width and hypocotyls length. Humic acid stimulates plant growth by the assimilation of major and minor elements, enzyme activation, changes in membrane permeability, protein synthesis and the activation of biomass production [90].

Table 5: Effect of indole acetic acid and humic acid on dill essential oil content in the two sites

Treatments	Seed essential oil (%)		Seed essential oil yield (L/feddan)		Straw essential oil (%)		Straw essential oil yield (L/feddan)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Giza	2.99±0.08	2.95±0.07	37.04±4.61	37.29±5.02	0.41±0.05	0.41±0.03	10.10±1.54	10.06±1.58
Sinai	2.51±0.13	2.56±0.12	0.92±0.30	1.10±0.18	0.35±0.03	0.38±0.06	0.33±0.10	0.37±0.12
LSD at 5%	0.095	0.092	3.03	3.27	0.043	0.045	1.05	1.08
F0	2.65±0.10	2.68±0.07	10.56±1.32	11.53±1.88	0.35±0.07	0.36±0.04	2.80±0.53	2.82±0.55
F1	3.03±0.09	3.04±0.08	19.65±2.13	21.44±3.78	0.32±0.04	0.36±0.05	5.36±0.60	6.26±0.42
F2	2.93±0.13	3.01±0.13	22.95±2.27	24.54±3.20	0.38±0.05	0.38±0.06	5.09±1.48	5.29±1.42
F3	2.40±0.09	2.28±0.10	22.76±4.10	19.26±1.55	0.48±0.01	0.47±0.03	7.60±0.68	6.49±1.00
LSD at 5%	0.134	0.130	4.29	4.62	0.061	0.064	1.48	1.53
R1XF0	2.92±0.08	2.92±0.06	20.75±2.54	22.54±3.55	0.37±0.08	0.38±0.03	5.48±1.04	5.53±1.08
R1XF1	3.25±0.05	3.22±0.06	38.62±4.01	41.87±7.42	0.33±0.03	0.38±0.03	10.43±1.10	12.18±0.63
R1XF2	3.27±0.08	3.28±0.06	45.04±4.42	47.69±6.13	0.37±0.08	0.37±0.08	9.70±2.84	9.94±2.69
R1XF3	2.53±0.10	2.37±0.13	43.77±7.47	37.06±2.99	0.57±0.03	0.50±0.00	14.78±1.18	12.58±1.91
R2XF0	2.38±0.13	2.45±0.09	0.37±0.09	0.52±0.21	0.33±0.06	0.33±0.06	0.12±0.02	0.12±0.01
R2XF1	2.80±0.13	2.87±0.10	0.69±0.24	1.02±0.13	0.30±0.05	0.33±0.08	0.30±0.09	0.35±0.22
R2XF2	2.60±0.18	2.73±0.20	0.86±0.13	1.40±0.27	0.38±0.03	0.40±0.05	0.48±0.11	0.64±0.16
R2XF3	2.27±0.08	2.18±0.08	1.75±0.72	1.47±0.11	0.40±0.00	0.43±0.06	0.43±0.17	0.39±0.08
LSD at 5%	0.19	0.18	6.07	6.55	0.09	0.09	2.10	2.17

Since; R=region, R1=Giza and R2=Sinai; F=foliar application, F0=control, F1=indole acetic acid, F2= humic acid, F3= indole acetic acid+humic acids.

Data presented in tables (1-3) show that all interaction treatments between foliar spray with indole acetic acid, humic acid and indole acetic acid+humic acid and Giza or North Sinai locations caused a significant increase in plant height, number of branches, number of umbels, weight of seeds and straw (g/plant or kg/feddan) and essential oil yield in both seeds and straw compared to untreated plants of each region alone, except for plant height in the second season and umbles number in the first season where the increase was not significant. However, spraying dill plants by indole acetic acid or humic acid separately caused significant increased in seed essential oil % at Giza and North Sinai locations. As well as, indole acetic acid+humic acid treatment caused significant decreased in seed essential oil % comparing to untreated plants at both locations. Conversely, indole acetic acid+humic acid spraying was influence to increase significantly straw essential oil % comparing other treatments in both Giza and North Sinai locations.

From the tables (1-3), we found that humic acid spraying gave the highest values of plant height, branches number and umbels number in both locations. Indole acetic acid+humic acid gave the highest seed weight (g/plant or kg/fed.), whereas, indole aceti acid or humic acid separately gave the highest weight of straw (g/plant or kg/fed.) in Giza and North Sinai, respectively. Conversely, humic acid or indole aceti acid gave the highest of seed essential oil % in Giza and North Sinai, respectively. But indole acetic acid+humic acid gave the best straw essential oil % in Giza and North Sinai. For the highest oil yield value, humic acid and indole acetic acid+humic acid gave the highest seed oil yield in Giza and North Sinai, respectively and vice in straw oil yield, indole acetic acid+humic acid and humic acid gave the highest straw oil yield in Giza and North Sinai, respectively. Several studies have demonstrated that exogenous humic acid application enhances plant growth and development [46, 65, 66, 88, 89, 91, 92]. Piccolo *et al.* [93] reported that humic acid can be used as a growth regulator to regulate hormone level, improve plant growth and enhance stress tolerance. Spraying oregano plants that irrigated using Nacl with K-humate caused an increase in the essential oil % and yield [58]. IAA is being widely used to counteract the deleterious effects of adverse environmental stresses on plants [48]. Khalid *et al.* [94] found that growth and photosynthesis were significantly reduced by salt stress. However, this reduction was alleviated by foliar application of indole acetic acid (IAA). Also, Kaya *et al.* [95] reported that salt stress reduced the total dry matter, grain yield, chlorophyll content, and relative water content, foliar applications of IAA treatment overcame to variable extents the adverse effects of salt stress on the earlier mentioned physiological parameters. IAA has a regulatory effect on the salinity tolerance of crop plants. The variations in indole ascetic acid (IAA) content under stress conditions appeared to be similar to those of abscisic acid [96].

GC-MS analysis

Tables (4, 5) show the qualitative and quantitative analyses of the main constituents of volatile oils of dill seed and straw during the season of 2012 y. GC-MS analysis of the volatile oils in seed and straw indicated that all identified compounds were detected in the oil of all treatments with different percentages. The known constituents of seeds and straw were grouped into three items, the major components (more than 10%); minor components (less than 10% and more than 1%) and trace ones (less than 1%). In this respect, it is evident that carvone (28.63 to 38.60%), dihydro-carvone (4.69 to 23.16%) limonene (12.56 to 20.66%) dill apiol (11.83 to 18.43 %) and piperitone (0.00 to 11.52%) in seed oil; α-phellandrene (20.18to 27.81%), limonene (10.64 to 14.88%), β-phellandrene (9.63 to 12.01), p-cymene (11.00 to 14.74%) and dill ether (4.57 to 14.85%) in straw oil exhibited as majors in both of seeds and straw, respectively.

Effect of location

The obtained results in table (6) show that limonene, carvone and piperitone percentage in the seeds was higher at North Sinai than that at Giza and vice, dihydrocarvone and dill apiol which representing the largest percentage under Giza conditions. The major components in straw like, β-phellandrene, p-cymene and dill ether was higher under Giza condition and vice, α-phellandrene and limonene which were higher under North Sinai condition. In a similar study on the plant coriander, Said-Al Ahl *et al.* [13] found a difference in the main compounds of essential oil in the seed and straw, where linalool, γ-terpinene and α-pinene in the seed and linalool, γ-terpinene, p-cymene, decanal and limonene in straw is the main compounds.

Table 6: Effect of indole acetic acid and humic acid on dill seed oil composition percentage in the two sites

Compounds	Giza region				Sinai region			
	F0	F1	F2	F3	F0	F1	F2	F3
α-pinene	0.11	0.29	0.24	0.26	0.68	0.48	0.51	1.22
β-thujene	-	0.08	-	0.06	0.10	0.09	0.08	0.18
β-pinene	0.06	-	-	-	-	-	-	-
β-terpinene	-	-	-	-	0.34	0.18	0.18	0.38
sabinene	-	-	-	-	0.12	-	-	0.13
α-phellandrene	2.70	6.76	5.43	8.29	6.43	6.01	5.50	7.24
limonene	20.29	17.58	12.56	14.18	17.40	19.83	20.66	19.34
β-phellandrene	0.38	1.04	1.00	1.44	2.54	1.70	1.66	3.24
2,6-dimethyl-1,3,5,7-octatetraene, E,E-	0.74	0.50	0.29	0.43	0.77	0.65	0.70	0.86
γ-terpinene	-	-	-	-	-	0.09	0.08	0.13
p-cymene	0.37	0.92	1.11	1.07	2.17	1.05	1.38	3.88
nonanal	-	-	-	0.06	-	-	-	-
p-cymenene	0.09	0.08	-	0.09	0.14	0.09	0.11	0.13
cis-limonene oxide	0.18	0.17	0.19	0.19	0.27	0.23	0.23	0.26
dill ether	0.18	0.29	0.68	0.54	2.83	0.69	0.42	1.09
camphor	-	-	-	-	-	1.09	0.92	1.41
α-thujone	-	-	0.48	-	-	-	-	-
trans-caryophyllene	-	-	-	-	0.30	0.19	0.17	0.25
trans-dihydrocarvone	1.87	3.00	4.99	3.88	0.41	0.34	0.37	0.59
dihydrocarvone	17.57	23.16	18.17	20.48	5.96	4.69	5.47	6.13
cryptone	-	-	-	-	0.09	-	-	-
germacrene D	0.07	0.06	0.19	0.14	0.15	0.11	0.11	0.12
trans-2-caren-4-ol	-	0.11	-	-	0.19	0.11	0.09	0.15
piperitone	-	-	0.73	0.14	11.52	9.73	8.37	9.72
carvone	35.01	28.63	31.29	29.19	33.91	38.24	38.60	30.63
cuminal	0.25	0.33	0.24	0.33	0.18	0.13	0.16	0.16
cis-sabinol	0.52	0.55	0.46	0.64	0.42	0.26	0.35	0.32
estragole	-	0.11	0.95	-	-	-	-	0.18
limonene diepoxide	0.39	0.20	0.17	0.23	0.17	0.13	0.14	0.14
α-limonene diepoxide	0.13	-	-	0.06	0.19	0.16	0.15	0.14
p-cymen-8-ol	0.21	0.34	0.63	-	-	0.15	-	-
cis-carveol	-	0.13	0.14	0.19	0.21	-	0.16	0.15
13-tetradecenal	-	-	0.42	-	-	-	-	-
carvacrol	-	-	-	0.08	-	-	-	-
myristcin	0.16	0.09	0.36	0.43	-	0.08	-	-
dill apiol	18.18	15.12	18.43	16.69	12.37	13.41	13.34	11.83
1-heptadecanol	0.07	0.07	0.13	0.17	-	-	-	-
1-tetradecanol	0.17	0.17	0.45	0.58	-	-	-	-

Since; F=foliar application, F0=control, F1=indole acetic acid, F2= humic acid, F3= indole acetic+humic acids.

The percentages of these compound also differences as a result of differing location. Higher carvone and limonene contents and negligible dillapiole content in oil has been reported of good quality [97]. The quality of essential oil is considered better if dillapiole content in the oil varies between 0 to 5%. Dill seed oil trade is based on carvone content in the essential oil. The minimum level of acceptable carvone is 30% [98]. Kruger and Hammer [36] reported limonene (43.7%), carvone (41.2%), dihydrocarvone (3.1%), and myristicin (11.7%) as the main components of dill seed oil. In another analysis of dill seed oil determined carvone (38.89%), apiol (30.81%), limonene (15.93%) and trans-dihydrocarvone (10.99%) [99]. Mahran *et al.* [12] found that limonene (30.3%), dillapiole (26.8%) and carvone (22%) were major and amounted to 79%. piperitone (8.2%) of *Anethum graveolens* L., grown in Egypt. The same result was obtained by Mahran *et al.* [12] confirmed by Said-Al Ahl and Omer [10].

The minor components compounds like, α-pinene, α-phellandrene, β-phellandrene, p-cymene and dill ether in seeds; α-pinene, β-thujene, cryptone, piperitone and carvone in straw were higher under North Sinai condition than Giza. But, others minor in seed; trans-dihydrocarvone and γ-terpinene, trans-dihydrocarvone and dihydrocarvone as well as dill apiol in straw were the highest under Giza conditions region. However, camphor and nonal compounds were disappeared in seeds at Giza location and in straw at North Sinai, respectively.

Whereas, traces i. e. β-thujene, 2,6-dimethyl-1,3,5,7-octatetraene, p-cymenene, cis-cimonene oxide, cermacrene D, trans-2-caren-4-ol, α-cimonene diepoxide and cis-carveol in seeds oil were higher in North Sinai. Cuminal, cis-sabinol, estragole, limonene diepoxide, p-cymen-8-ol and myristcin were higher in seeds at Giza. But, traces components in straw like, β-pinene, undecane, germacrene D, limonene diepoxide, ascaridole and 1-tetradecanol were higher at Giza condition. β-terpinene, terpinolene, (E)-p-mentha-2-en-1-ol and carvacrol were higher in North Sinai condition. β-terpinene, sabinene, γ-terpinene trans-caryophyllene and cryptone were disappeared in seeds at Giza, and β-pinene, nonal, α-thujone, 1-heptadecanol, 1-tetradecanol, 13-tetradecenal, and carvacrol were disappeared in seeds at North Sinai. Camphene, p-cymenene carvenone, cuminal β-curcumene p-cymen-8-ol were disappeared in straw at Giza. But, 2-pentadecanone, 6, 10, 14-trimethyl; p-menth-8-en-2-ol, thymol, estragole and 1-heptadecanol were disappeared in straw at North Sinai. Bazaid *et al.* [27] showed the percentages of the main components of volatile oil in basil, rosemary, marjoram and rose plants were differed as results of changing the geographical regions. Said-Al Ahl and Hussein [58] on oregano indicates that saline water irrigation decreased the mean value of carvacrol and on the contrary there was increased in p-cymene and γ-terpinene mean values by using saline water irrigation.

Effect of foliar spraying

The results presented in table (6) show that spraying dill plants by humic acid gave the highest mean percent of dihydrocarvone and dill apiol in seeds oil as well as limonene and p-cymene in straw oil. Whereas, control plants gave the lowest mean % of dihydracarvone in seed oil and also, α-Phellandrene and β-phellandrene in straw oil. On the contrary, the highest mean percentages of limonene and piperitone were obtained from control plants in seeds oil. Also, the highest mean percentage of carvone was obtained from dill plants spraying with indole acetic acid. Conversely, indole acetic acid gave the lowest mean percentage of dill apiol in seed oil as well as limonene and p-cymene in straw oil. In the same direction, spraying dill plants by indole acetic acid gave the highest mean values of carvone in the seed oil as well as α-phellandrene, β-phellandrene and dill ether in straw oil. On the other hand, humic acid+indole acetic acid treatment gave the lowest mean % of carvone in seed oil, and humic acid alone gave the lowest mean % of limonene and pipertone in seed oil and dill ether in straw oil.

Table 7: Effect of indole acetic acid and humic acid on dill straw oil composition percentage in the two sites

Compounds	Giza region				Sinai region			
	F0	F1	F2	F3	F0	F1	F2	F3
α-pinene	4.84	4.61	4.79	4.26	5.04	4.33	5.25	4.86
β-thujene	1.29	1.11	1.08	0.92	1.03	1.00	1.32	1.20
camphene	-	-	-	-	-	-	-	0.14
β-pinene	0.44	0.39	0.63	0.42	0.37	0.27	0.38	0.23
undecane	-	-	0.54	0.35	-	-	-	0.37
β-terpinene	0.53	0.44	0.40	0.36	0.48	0.44	0.56	0.53
α-phellandrene	27.1	27.20	23.07	26.31	20.18	27.3	25.51	27.81
limonene	10.64	12.44	14.88	13.66	14.19	10.97	11.09	11.80
β-phellandrene	11.22	11.01	9.94	11.03	9.63	12.01	11.64	11.75
γ-terpinene	0.32	0.18	2.03	0.98	0.52	0.20	-	1.27
p-cymene	11.49	11.00	11.42	12.90	13.89	13.28	14.74	11.84
terpinolene	0.39	0.30	-	0.23	0.27	0.30	0.49	0.51
nonanal	0.25	0.30	1.05	0.76	-	-	-	-
p-cymenene	-	-	-	-	0.22	-	-	-
dill ether	9.89	8.58	4.57	5.44	9.76	14.85	12.95	12.59
carvenone	-	-	-	-	0.69	0.37	0.81	0.18
E)-p-Mentha-2-en-1-ol	0.25	0.19	-	-	0.25	0.22	0.34	0.21
trans-dihydrocarvone	0.54	0.56	1.22	0.82	0.20	-	0.43	-
dihydrocarvone	5.38	4.37	4.80	3.25	1.38	0.88	0.23	0.73
cryptone	0.32	0.26	0.35	0.36	1.12	0.46	0.97	0.37
germacrene D	-	0.18	0.54	0.47	-	0.17	-	-
piperitone	-	0.33	0.33	-	2.20	1.56	1.29	1.18
carvone	5.83	5.90	4.68	5.04	9.48	6.38	4.30	6.81
cuminal	-	-	-	-	0.23	-	0.22	-
cis-sabinol	1.91	1.34	1.43	1.59	1.95	1.35	2.59	1.14
estragole	-	-	0.47	-	-	-	-	-
limonene diepoxide	0.47	0.28	-	0.26	-	0.29	0.27	0.18
p-cymen-8-ol	-	-	-	-	0.47	0.18	0.32	0.15
ascaridole	0.40	0.45	0.48	0.56	0.68	0.25	0.57	-
β-curcumene	-	-	-	-	-	-	0.20	-
2-pentadecanone, 6,10,14-trimethyl	-	0.25	0.77	0.67	-	-	-	-
p-menth-8-en-2-ol	0.43	-	-	-	-	-	-	-
thymol	-	-	0.36	0.43	-	-	-	-
carvacrol	0.38	0.36	0.49	0.48	0.79	0.42	0.82	0.28
dill apiol	4.95	7.31	8.10	6.84	4.77	2.39	2.86	3.47
1-heptadecanol	0.27	0.28	0.79	0.68	-	-	-	-
1-tetradecanol	0.49	0.40	0.78	0.91	-	-	-	0.19

Since; F=foliar application, F0=control, F1=indole acetic acid, F2= humic acid, F3= indole acetic+humic acids.

Minor components of seeds and straw essential oil obviously cleared that the highest mean values of α-phellandrene, β-phellandrene and p-cymene in seed oil and also, γ-terpinene in straw oil was obtained by indole acetic acid+humic acid foliar spraying. Whereas, control plants showed the highest percent of dill ether and piperitone in seed oil as well as dihydrocarvone, pipertone and carvone in straw oil. Spraying plants by humic acid gave the highest percentage of trans-dihydrocarvone in seed oil and α-pinene, β-thujene, cis-sabinol and dill apiol in straw oil.

Regarding traces compound, table (6) show that control plants gave the highest mean % of β-pinene, 2,6-dimethyl-1,3,5,7-octatetraene, p-cymenene, cis-limonene oxide, trans-caryophyllene, trans-dihydrocarvone, cis-sabinol, limonene diepoxide and α-limonene diepoxide in seed oil, and also, trans-dihydrocarvone, cuminal, ascaridole, p-menth-8-en-2-ol and carvacrol in straw oil. However, humic acid+indole acetic acid treatment gave the highest mean % of α-pinene, β-thujene, β-terpinene, sabinene, γ-terpinene, camphor, cuminal, cis-carveol and myristcin in seed oil, as well as, thymol and 1-tetradecanol in straw oil. Moreover, spraying dill plants with humic acid gave the highest mean % of α-thujone, germacrene D, cuminal, 13-tetradecenal, p-cymen-8-ol in seed oil. The same treatment gave the highest mean percentages of carvenone, trans-dihydrocarvone, 2-pentadecanone, 6,10,14-trimethyl; 1-heptadecanol, β-curcumene, p-cymen-8-ol, (E)-p-mentha-2-en-1-ol, terpinolene and nonanal in straw oil. On the other hand, the highest mean % of trans-2-caren-4-ol in seed oil as well as germacrene D and limonene diepoxide in straw oil were obtained from spraying dill plants by indole acetic acid.

Juárez *et al.* [56] on thyme found that thymol % was higher when spraying humic substances with 300 and 400 mg L^{-1} than at 100 or 200 mg L^{-1}, while the opposite happened for carvacrol and linalool. Said-Al Ahl and Hussein [58] on oregano concluded that carvacrol, p-cymene and γ-terpinene were increased by application of K-humate. Sangwan *et al.* [100] found that IAA (100 ppm) decreased carvone content in dill essential oil, but increased percentage of dihydrocarvone and the maximum contents of limonene, pinene and dipentene were obtained from plants treated with IAA. Hazzoumi *et al.* [60] revealed that IAA increased methyl chavicol and decreased trans-anethole, but they note the appearance of germacrene-D and disappearance of aristolene in *Ocimum gratissimum*. Da silva *et al.*

[62] observed that IAA spraying resulted in a significant increase of geraniol in *Melissa officinalis*. However, geraniol content increased due to IAA treatment while, geranyl acetate percentage was decreased of palmarosa essential oil [61].

Effect of interaction

Data in tables (4, 5) showed a considerable change in the percentages of seed and straw dill essential oil constituents under foliar application at Giza and North Sinai regions. From the tables (4, 5) it was an inverse relationship between limonene and dill ether with each other where, limonene was increased and dill ether decreased and vice versa. This behavior was also confirmed according to seeds or straw, where limonene was increased in seed oil and decreased in straw oil and vice versa. Dill ether increased in straw oil and limonene decreased in seed oil.

To further emphasis was also on the reverse of the behavior of both limonene and dill ether was to note their percentages under the influence of different locations, where it was found that limonene was less in Giza (non saline soil) and increase in the North Sinai (soil salinity) under the influence of spraying treatments.

Table 8: Effect of indole acetic acid and humic acid on dill oil composition percentage

Compounds	Mean of region				Mean of foliar application							
	Seed		Straw		Seed				Straw			
	Giza	Sinai	Giza	Sinai	F0	F1	F2	F3	F0	F1	F2	F3
α-pinene	0.22	0.72	3.56	4.87	0.39	0.38	0.37	0.74	4.94	4.47	5.02	4.56
β-thujene	0.03	0.11	1.10	1.13	0.05	0.08	0.04	0.12	1.16	1.05	1.20	1.06
camphene	-		-	0.03	-	-	-	-	-	-	-	0.07
β-pinene	0.01		0.47	0.31	0.03	-	-	-	0.40	0.33	0.50	0.32
undecane	-		0.22	0.09	-	-	-	-	-	-	0.27	0.36
β-terpinene	-	0.27	0.43	0.50	0.17	0.09	0.09	0.19	0.50	0.44	0.48	0.44
sabinene	-	0.06	-		0.06	-	-	0.06	-	-	-	-
α-phellandrene	5.79	6.29	25.92	25.20	4.56	6.38	5.46	7.76	23.64	27.25	24.29	27.06
limonene	16.15	19.31	15.52	12.01	18.84	18.70	16.61	16.76	12.41	11.70	12.98	12.73
β-phellandrene	0.96	2.28	10.66	11.26	1.46	1.37	1.33	2.34	10.42	11.51	10.77	11.39
2,6-dimethyl-1,3,5,7-octatetraene, E,E-	0.49	0.74	-	-	0.75	0.57	0.49	0.64	-	-	-	-
γ-terpinene	-	0.07	0.88	0.50	-	0.04	0.04	0.06	0.41	0.19	1.01	1.12
p-cymene	0.87	2.12	11.70	13.44	1.27	0.98	1.24	2.47	12.69	12.14	13.08	12.37
terpinolene	-		0.23	0.39	-	-	-	-	0.33	0.30	0.24	0.37
nonanal	0.01		0.59		-	-	-	0.03	0.12	0.15	0.52	0.38
p-cymenene	0.06	0.12	-	0.05	0.11	0.08	0.05	0.11	0.11	-	-	-
cis-limonene oxide	0.06	0.25	-		0.22	0.20	0.21	0.22	-	-	-	-
dillether	0.42	1.26	7.12	12.54	1.50	0.49	0.55	0.81	9.82	11.71	8.76	9.01
camphor	-	0.85	-	-	-	0.54	0.46	0.70	-	-	-	-
carvenone	-	-	-	0.51	-	-	-	-	0.34	0.18	0.40	0.09
α-thujone	0.12		-		-	-	0.24	-	-	-	-	-
E)-p-mentha-2-en-1-ol	-		0.11	0.25	-	-	-	-	0.25	0.20	0.27	0.10
trans-caryophyllene	-	0.23	-		0.15	0.09	0.08	0.12	-	-	-	-
trans-dihydrocarvone	3.43	0.43	0.78	0.16	1.14	1.67	2.68	2.23	0.37	0.28	0.82	0.41
dihydrocarvone	19.84	5.56	4.45	0.80	11.76	13.92	11.82	13.30	3.38	2.62	2.51	1.99
cryptone	-	0.02	0.32	0.73	0.04	-	-	-	0.72	0.36	0.66	0.36
germacrene D	0.11	0.12	0.30	0.04	0.11	0.08	0.15	0.13	-	0.27	0.27	0.235
trans-2-caren-4-ol	0.03	0.13	-	-	0.09	0.11	0.04	0.07	-	-	-	-
piperitone	0.22	9.83	0.16	1.56	5.76	4.865	4.55	4.93	1.10	0.94	0.81	0.59
carvone	31.03	35.345	5.36	6.74	34.46	33.43	34.94	29.91	7.65	6.14	4.49	5.92
cuminal	0.29	0.16	-	0.11	0.21	0.23	0.20	0.24	0.11	-	0.11	-
cis-sabinol	0.54	0.34	1.57	1.72	0.47	0.40	0.40	0.38	1.93	1.34	1.94	1.36
estragole	0.26	0.04	0.12	-	-	0.05	0.47	0.09	-	-	0.23	-
limonene diepoxide	0.25	0.14	0.25	0.18	0.28	0.16	0.15	0.18	0.23	0.28	0.16	0.22
α-limonene diepoxide	0.047	0.16	-	-	0.160	0.080	0.075	0.100	-	-	-	-
p-cymen-8-ol	0.29	0.04	-	0.28	0.10	0.24	0.31	-	0.23	0.09	0.43	0.07
cis-carveol	0.11	0.13	-	-	0.10	0.06	0.15	0.17	-	-	-	-
ascaridole	-	-	0.47	0.37	-	-	-	-	0.54	0.35	0.52	0.28
β-curcumene	-	-		0.05	-	-	-	-	-	-	0.10	-
13-tetradecenal	0.10	-	-		-	-	0.21	-	-	-	-	-
2-pentadecanone, 6,10,14-trimethyl	-	-	0.42	-	-	-	-	-	-	0.12	0.38	0.33
p-menth-8-en-2-ol	-	-	0.11		-	-	-	-	0.21	-	-	-
thymol	-	-	0.20		-	-	-	-	-	-	0.18	0.21
carvacrol	0.02	-	0.43	0.58	-	-	-	0.04	0.58	0.39	0.61	0.38
myristcin	0.26	0.02	-		0.08	0.08	0.18	0.21	-	-	-	-
dill apiol	17.09	12.74	6.80	3.37	15.27	14.25	15.88	14.26	4.86	4.85	5.48	5.15
1-heptadecanol	0.11	-	0.50		0.03	0.03	0.06	0.08	0.13	0.14	0.39	0.34
1-tetradecanol	0.34	-	0.64	0.05	0.08	0.08	0.22	0.29	0.24	0.20	0.39	0.55

Since; F=foliar application, F0=control, F1=indole acetic acid, F2= humic acid, F3= indole acetic+humic acids.

Conversely in dill ether, where the % was increased in Giza and less in North Sinai under the influence of spraying treatments.

Humic acid gave the highest % of limonene and lowest % of dill ether in North Sinai location. However control plants at North Sinai gave the highest % of dill ether and lowest of limonene % in seed oil. Also, spraying indole acetic acid gave the highest % of dill ether and lowest of limonene at Giza. However, at North Sinai location, control plant gave the highest % of dill ether and lowest of limonene. Exactly vice versa, was found in dill straw oil, humic acid gave the highest % of limonene and lowest % of dill ether in Giza location. Moreover, control plants at North Sinai gave the highest % of limonene and lowest of dill ether % in straw oil. Also, spraying indole acetic acid gave the highest % of dill ether and lowest of limonene at North Sinai, but at Giza location, control plant gave the highest % of dill ether and lowest of limonene.

Data in tables (4, 5) showed that minor compounds were α-phellandrene; β-phellandrene; p-cymene; dill ether; camphor and trans-dihydrocarvone in seed oil. Also, α-pinene; β-thujene; γ-terpinene; nonanal; trans-dihydrocarvone; dihydrocarvone; cryptone; piperitone; carvone; cis-sabinol and dill apiol in straw oil. In the seed, α-phellandrene; β-phellandrene; p-cymene and trans-dihydrocarvone compounds had the same behavior where increased by spraying treatments comparing to control at Giza location. But, these compounds was decreased by spraying indole acetic acid or humic acid separately, except the treatment (indole acetic acid+humic acid) which led to increase α-phellandrene; β-phellandrene; p-cymene and trans-dihydrocarvone compared to control at North Sinai. Conversely, dill ether in seed oil and dihydrocarvone in straw oil; dill ether was increased under all foliar application treatments in both Giza and North Sinai, whereas, dihydrocarvone was decreased under all foliar application treatments in both Giza and North Sinai. Conversely, carvone was decreased by spraying treatments comparing to control at Giza. But, spraying dill plants by indole acetic acid or humic acid separately led to increase carvone % except indole acetic acid+humic acid, which led to decrease carvone % compared to control at North Sinai. In straw oil, α-pinene and cis-sabinol had the same behavior where decreased these % by spraying treatments comparing to control at Giza location. But, these compounds was decreased by spraying indole acetic acid or indole acetic acid+humic acid separately, except the treatment humic acid which led to increase α-pinene and cis-sabinol % compared to control at North Sinai. Moreover, camphor in seed oil and nonanal in straw disappeared in Giza and North Sinai locations, respectively. Dill apiol in straw oil was increased by all spraying treatments compared to control at Giza, but spraying treatments led to decrease apiol % compared to control at North Sinai. In straw oil, β-phellandrene was decreased at Giza and vice increased at North Sinai by foliar treatments comparing to control plants. Dihydrocarvone was decreased by foliar treatments comparing to control plants in both Giza and North Sinai. Also, in straw oil, β-phellandrene was decreased at Giza and vice increased at North Sinai by foliar treatments comparing to control plants. Dihydrocarvone was decreased by foliar treatments comparing to control plants in both Giza and North Sinai.

Moreover, traces components of seed essential oil likes; α-pinene; β-thujene; β-pinene; β-terpinene; sabinene; 2,6-dimethyl-1,3,5,7-octatetraene; γ-terpinene; nonanal; p-cymenene; cis-limonene oxide; trans-caryophyllene; cryptone; germacrene D; trans-2-caren-4-ol; cuminal; cis-sabinol; α-thujone; estragole; limonene diepoxide; α-limonene diepoxide; p-cymen-8-ol; cis-carveol; 13-tetradecenal; carvacrol; myristcin; 1-heptadecanol and 1-tetradecanol. However, camphene; β-pinene; undecane; β-terpinene; terpinolene; p-cymenene; c; (E)-p-mentha-2-en-1-ol; germacrene D; cuminal; estragole; limonene diepoxide; p-cymen-8-ol; ascaridole; β-curcumene; 2-pentadecanone, 6,10,14-trimethyl; p-Menth-8-en-2-ol; thymol; carvacrol; 1-heptadecanol; and 1-tetradecanol considered as traces in straw oil.

With regard to the major component in seed oil as in table (4), the highest % of dihydrocarvone and dill apiol were obtained from plants cultivated at Giza location and sprayed by IAA and humic acid, respectively. While the highest % of limonene and carvone were obtained from plants cultivated at North Sinai location and sprayed by humic acid. For piperitone component, cultivated dill plants at North Sinai location without spraying treatments gave the highest % of piperitone. On the contrary, cultivated dill at Giza and sprayed with humic acid gave the lowest % of limonene, but dill plants cultivated at North Sinai gave the lowest of dill apiol when treated by IAA+humic acid, and treated with IAA gave the lowest % of carvone and dihydrocarvone. Meanwhile, plants without spraying treatment gave the lowest of piperitone.

As shown in table (5) cleared the major components of straw oil, found that the highest % of limonene was obtained from plants cultivated at Giza location and sprayed by humic acid, but spraying dill plants at North Sinai by IAA gave the highest % of β-phellandrene and dill ether and also, spraying by humic acid gave the highest % of p-cymene in North Sinai. Moreover, indole acetic acid+humic acid gave the highest % of α-phellandrene when dill plants cultivated at North Sinai. Furthermore, nonsprayed plants gave the lowest % of α-phellandrene and β-phellandrene at North Sinai and the lowest % of limonene at Giza. However, spraying with indole acetic acid gave the lowest of p-cymene and the lowest of dill ether at North Sinai was obtained by humic acid spraying.

CONCLUSION

Dill straw can be explored as a new source of essential oil. Cultivation of dill in Giza region gave the best results from cultivation in the North Sinai region. Humic acid and indole acetic acid play an important role in plant growth yield and ameliorate the deleterious effects of salt stress. Spraying by humic acid gave the best results of survival %, plant height, number of branches, number of umbels and seed oil yield (l/fed.). While the best values of dill straw (g/plant or kg/fed.) and the percentage of oil seed were obtained with indole acetic acid spray. Also, indole acetic acid+humic acid gave the best values of seed weight (g/plant or kg/fed.) and straw volatile oil content (% or l/fed.). But, non-spraying plants gave lower values of all studied characters. As for interaction treatments, spraying by humic acid gave the best results of plant height, number of branches and number of umbels in both regions and seed oil (% or yield) at Giza as well as straw oil yield at North Sinai. At the same time, indole acetic acid gave the highest straw (g/plant or kg/fed.) and seeds oil % at North Sinai. But, indole acetic acid+humic acid gave the highest seeds (g/plant or kg/fed.) and straw oil in regions as well as seeds and straw oil yields in North Sinai and Giza, respectively. Overall, indole acetic acid under the conditions of the Giza region gave the best results for straw (g/plant or kg/fed.), while spray with humic acid gave the highest values of plant height, number of branches, number of umbels and seed volatile oil (% or yield) in Giza as well as the highest of seed weight (g/plant or kg/fed.) and straw volatile oil (% or yield) was obtained by indole acetic acid+humic acid. In view of the components of the volatile oil found that carvone, dihydrocarvone, limonene, dill apiol and piperitone compounds in the seed and α-phellandrene, limonene, β-phellandrene, p-cymene and dill ether compounds in straw was the main compounds. The percentages of these compounds affected by factors under study.

CONFLICT OF INTERESTS

Declared none

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