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Research Article
Effects of Humic Acid Treatments of Yield, Morphological Characteristics and Essential Oil Components of Coriander (*Coriandrum sativum* L.)

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Abstract
Background: The present study was conducted to determine the effects of humic acid treatments on yield, morphological characteristics and essential oil components of coriander. **Materials and Methods:** The present study was carried out over the experimental fields of Erciyes University Agricultural Research and Implementation Center during the summer growing season of 2014. Experiments were conducted in randomized blocks split plots experimental design with 4 replications over 40 plots with two different coriander cultivars and different humic acid doses and yield, morphological characteristic analyzed with MSTAT-C statistic program that have been ANOVA (Analysis of variance). **Results:** Current findings revealed that different humic acid doses had different impacts in coriander cultivars. In general, 400 g day^{-1} was considered as the most effective dose had better impacts on yield and other parameters coriander cultivars compared to control treatment. **Conclusion:** Significant changes ($p<0.05$) were not observed in yield and other parameters over this dose and even negative impacts were observed on plant growth and development in some cases at doses. After this results, humic acid treatments has a great effect on yield, morphological characteristics and essential oil components of coriander.

Key words: Humic acid, coriander, biological yield, morphological characteristics, harvest index

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is a medicinal plant belonging to Apiaceae family and it is known with kisnis, asotu, kuzbere-like local names in Turkey[1,2]. Coriander leaves have pain reliever, sedative and tonic impacts or fruits have infusion effects and coriander powders have antipyretic, appetizing, digestive system regulation, carminative, parasite dropping and diuretic impacts[3,4]. Coriander fruits contain about 0.2-1.5% essential oils[5]. There are more than 20 components of coriander essential oil mainly including linalool, geraniol, geranylacetate, borneol, p-cymol, α-pinene, borenilacetate, decilaldehyde, citronellal and thymol[4,6]. The primary component, linalool with its slight flowery and fruity smell is used in artificial food aromas, perfume and cosmetics. It is also used in various drug preparate to eliminate the malodor[7].

A corner in world markets requires production of good complying with international standards. Such a compliance with international norms and standards will only be possible with the identification of proper ecologies, breeding of superior species and improvement of agro-technical practices. Therefore, as it was in all kinds of plant production activities, proper fertilizers should be used, proper species should be selected based on local climate conditions and proper soil conditions should be provided in coriander culture to have sufficient yield and quality[8].

Organic fertilizers embody plant nutrients as organic compounds, rehabilitate soil physical and chemical structure and facilitate nutrient uptake. They are commonly produced from plant and animal waste materials or their by-products. In recent years, the fertilizers used in organic farming have greatly been diversified. Among them, humic acid, fulvic acid and compost-like materials are commercially available in markets. Humic acid has various positive impacts on reducing soil salinity, improvement of soil color and plant nutrient uptake. It also improves aggregate stability through compounding with clay minerals, disintegrates unfertile clay clods and turns them into fertile lands. It prevents soil compaction in time and allows the soils to be more spacious and bulky[9]. Coriander has a great potential as a medicinal plant in Turkey and the present study was conducted to determine the effects of humic acid treatments on yield, morphological characteristics and essential oil components of coriander.

MATERIALS AND METHODS

Arslan and Gürbüz coriander species registered by Ankara University Agricultural Faculty Field Crops Department were used as the plant material of the experiments.

Climate and soil characteristics of the research site: Soil analysis revealed that the research site had slightly alkaline loamy soils with excess lime, medium organic matter, phosphorus and high potassium content and without any salinity problems. Monthly temperature (°C), relative humidity (%) and precipitation (mm) values of the experimental year 2014 and long-term averages are provided in Table 1.

Humic acid treatments: Commercial humic acid with 52.75% organic matter content was used as the humic acid source. Plots were created after field preparations. Humic acid was applied in a powder form (pure potassium humate) at different doses (control, 400, 800, 1200 and 1600 g day^{-1}). For humic acid treatments, 3.2 g powder humic acid was dissolved in 5 L distilled water for 400 g treatment; 6.4 g powder was dissolved in 5 L distilled water for 800 g treatment, 9.6 g for 1200 g treatment and 12.8 g for 1600 g treatment. Treatments were applied to plots before sowing.

Sowing and harvest: Sowing was performed at the most proper time between 1-15 April, 2014 through monitoring the weather forecasts. Experiments were conducted in randomized blocks split plots experimental design with

Table 1: Meteorological datas in Kayseri (Turkey) during experiment

	Monthly avarage temperature (°C)		Monthly average relative humidity (%)		Monthly total precipitation (mm)	
Months	2014	Long years	2014	Long years	2014	Long years
January	2.0	-1.8	72.8	76.5	31.6	33.3
February	4.7	0.0	57.3	73.9	17.6	34.4
March	8.1	5.0	57.1	67.5	88.9	42.1
April	14.1	10.7	44.3	62.6	2.9	54.8
May	16.7	15.1	50.4	60.8	39.7	52.0
June	19.7	19.1	46.8	55.3	52.9	39.1
July	25.2	22.6	33.7	49.5	-	10.3
August	25.1	22.0	37.4	49.8	47.4	5.3

Table 2: Soil properties of experiment area at the end of harvest

Humic acid doses	pH	Organic matter (%)	Total nitrogen (%)	EC (mmhos cm^{-1})
Initial soil	8.10	2.76	0.138	0.41
Arslan cultivar				
Control	7.80	2.03	0.1015	0.30
400	8.25	2.64	0.1320	0.40
800	7.82	2.19	0.1095	0.50
1200	7.90	2.17	0.1085	0.50
1600	8.18	2.43	0.1215	0.40
Gürbüz cultivar				
Control	8.01	2.86	0.1430	0.55
400	8.23	3.24	0.1620	0.50
800	8.13	2.68	0.1340	0.32
1200	8.11	3.11	0.1555	0.50
1600	8.11	2.96	0.1480	0.54

4 replications. Two registered coriander species (Arslan and Gürbüz) were placed in main plots and humic acid doses were placed in sub-plots. Each block was composed of two main plots and each main plot was composed of 5 sub-plots, so there were 40 plots (4×2×5 = 40) in this study. To prevent interactions among humic doses, 50 cm space was provided between the sub-plots and 2 m space was provided between the blocks. Each sub-plot was composed of 5 rows 40 cm apart. Plot length was 4 m. Two side rows and 50 cm from the top and bottom of the plots were left as side-effects and harvest was performed from 3.6 m^2 plot area (3×0.4×3 = 3.6 m^2). Considering the spaces left between the sub-plots and the blocks, total experimental site was 510 m^2 and each plot was 8 m^2. For sowing, 4 kg seeds were used per decare and 6.4 g coriander fruits were sown in each row. As base fertilizer, 3 kg day^{-1} DAP was applied together with sowing. Following the plant emergence, 5 kg day^{-1} urea was applied to inter-rows as dressing fertilizer and incorporated into the soil with a hand hoe. Plants were harvested until 1 Augusts, 2014 and harvested plants left over nylon plastics for drying. Then the dried plants were placed into a thresher, cleaned and made ready for analysis.

Statistical analysis: Experimental data were subjected to variance analysis with MSTAT-C software in accordance with randomized blocks split plots experimental design with 4 replications. Duncan's multiple range test was used to separate the means[10].

RESULTS AND DISCUSSION

Effects of humic acid treatments on soil characteristics: Significant variations were observed in soil pH levels with humic acid treatments in different doses. While the soil pH was 7.80 in control group of Arslan cultivar, increasing pH levels were observed with increasing humic acid doses. However, the greatest pH level was observed in 400 g day^{-1} humic acid treatment and 5.45% was increased in pH compared to control treatment. Soil pH was 8.01 in control group of Gürbüz cultivar and again increasing pH levels were observed with increasing humic acid doses. Again the highest pH level in Gürbüz cultivar was also observed in 400 g day^{-1} humic acid treatment (Table 2). There was 2.67% increase in pH compared to control treatment. Increasing humic acid doses increased alkaline cations and thus soil pH levels (Table 2).

Organic matter contents in control groups of Arslan and Gürbüz cultivars were respectively observed to be 2.03 and 2.86% and increasing organic matter contents were observed with increasing humic acid doses. The greatest organic matter content was observed in 400 g day^{-1} humic acid treatment and the increase in organic matter contents was respectively observed to be 23.11 and 11.73% compared to control treatment.

Soil EC levels increased in Arslan cultivar but significant changes were not observed in soil EC levels of Gürbüz cultivar. Soil EC value in control treatments of Arslan cultivar was measured as 0.30 mmhos cm^{-1} and increasing EC values were observed with increasing humic acid doses. The greatest EC levels were observed in 800 and 1200 g day^{-1} humic acid treatments and the increase was 40% compared to control treatment (Table 2).

Effects of humic acid treatments on coriander yield and morphological characters: Variance analysis revealed that species were significant with regard to plant height ($p<0.05$). Species x humic acid interaction was found to be significant with regard to number of side branches per plant ($p<0.05$). On the other hand, species, humic acid doses and species x humic acid interaction were not found to be significant with regard to number of umbels per plant (umbels per plant), number of fruits per umbel (fruit per umbel), biological yield (kg day^{-1}), fruit yield (kg day^{-1}), shoot thickness (mm), first

Table 3: Impacts of different humic acid application doses on investigated factors

HA	Plant height (cm)			No. of side branches per plant			No. of umbels per plant			No. of fruits per umbel			Shoot thickness (mm)			First side branch height (cm)		
(g day^{-1})	A	G	Ort.	A	G	Ort.	A	G	Ort.	A	G	Ort.	A	G	Ort.	A	G	Ort.
Control	40.61	40.50	40.56	4.03^{ab}	3.95^{ab}	3.99	8.05	7.65	7.85	20.92	21.78	21.35	1.75	1.83	1.79	5.85	6.63	6.24
400	40.14	41.93	41.03	4.13^{ab}	4.25^{a}	4.19	7.63	8.78	8.20	19.85	23.49	21.67	1.55	2.11	1.83	5.65	6.23	5.94
800	41.58	44.43	43.00	3.83^{b}	4.30^{a}	4.06	7.95	7.75	7.85	22.19	22.76	22.48	2.13	2.12	2.12	6.10	6.75	6.43
1200	38.40	45.03	41.71	3.83^{b}	4.13^{ab}	3.98	8.03	7.65	7.84	21.35	21.23	21.29	1.90	2.16	2.03	5.53	6.90	6.21
1600	37.30	46.98	42.14	4.15^{ab}	3.90^{ab}	4.03	8.00	8.30	8.15	24.57	21.33	22.95	1.91	2.23	2.07	5.48	6.75	6.11
Ort.	39.61^{A}	43.77^{B}		3.99	4.11		7.93	8.03		21.78	22.12		1.85	2.09		5.72	6.65	

HA	Biological yield (kg day^{-1})			Fruit yield (kg day^{-1})			Harvest index (%)			Thousand seed weight (g)			Essential oil content (%)			Fixed oil content (%)		
(g day^{-1})	A	G	Ort.	A	G	Ort.	A	G	Ort.	A	G	Ort.	A	G	Ort.	A	G	Ort.
Control	85.42	120.84	103.13	28.51	25.21	26.86	35.57	21.97	28.77	10.97	7.35	9.16	0.24	0.31	0.28	7.42	5.23	6.33
400	101.56	95.83	98.70	30.02	28.38	29.20	33.02	35.94	34.48	11.11	7.81	9.46	0.23	0.33	0.28	7.45	6.75	7.10
800	77.09	92.71	84.90	23.55	24.31	23.93	39.32	27.06	33.19	10.45	8.61	9.53	0.21	0.32	0.27	6.47	6.66	6.57
1200	90.09	113.53	101.81	25.22	31.12	28.17	28.85	27.19	28.02	9.64	7.33	8.49	0.21	0.28	0.24	6.82	6.30	6.56
1600	86.99	116.66	101.83	21.82	28.69	25.26	29.37	24.63	27.00	9.44	7.53	8.49	0.23	0.30	0.26	6.77	6.00	6.38
Ort.	88.23	107.92		25.82	27.54		33.23	27.36		10.32	7.73		0.22	0.31		6.99	6.19	

HA: Humic acid application dose, A: Arslan cultivar, G: Gürbüz cultivar, lowercase letters show significance in columns, uppercase letters show significance in rows

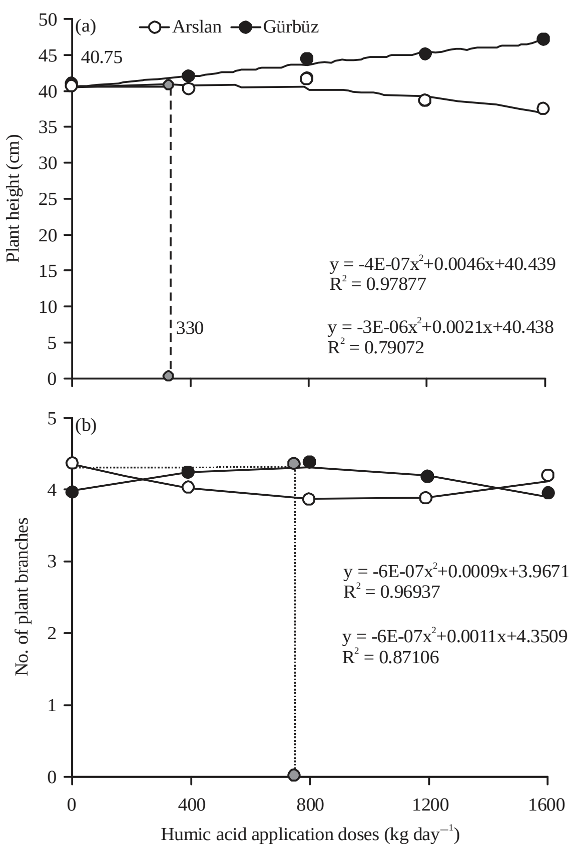

Fig. 1(a-b): Effects of different doses of humic acid applications on (a) Plant height and (b) Number of branches per plant

branch height (cm), harvest index (%), thousand seed weight (g), essential oil content (%) and fixed oil content (%) ($p>0.05$).

Plant height (cm): The greatest plant height in Arslan cultivar (41.58 cm) was obtained from 800 g day^{-1} humic acid treatment and the greatest plant height in Gürbüz cultivar (46.98 cm) was obtained from 1600 g day^{-1} humic acid treatment (Table 3). The lowest value in Arslan cultivar (37.30 cm) was obtained from 1600 g day^{-1} humic acid treatment and the lowest value in Gürbüz cultivar (40.50 cm) was obtained from the control treatment (0 g day^{-1}). While a regular increase was observed in plant heights of Gürbüz cultivar with increasing humic acid doses, a decrease was observed in Arslan cultivar with increasing humic acid doses (except for 800 g day^{-1} treatment). The regression analysis revealed that optimum plant height in Arslan cultivar (40.76 cm) was obtained from 330 g day^{-1} treatment dose. An optimum dose was not able to be specified for Gürbüz cultivar because of increasing plant heights with increasing humic acid doses (Fig. 1).

Current findings on plants heights of Arslan cultivar (37.30-41.58 cm) were parallel to values reported by Tuncturk[11] and lower than the values reported by Gok[12] and Gucuk[13]. Similarly, current plant heights of Gürbüz cultivar (40.50-46.98 cm) were similar to values reported by Tuncturk[11] and lower than the values reported by Gok[12] and Gucuk[13].

Number of side branches per plant: The greatest number of side branches per plant in Arslan cultivar (4.15) was obtained from 1600 g day^{-1} humic acid treatment and the greatest value in Gürbüz cultivar (4.30) was obtained from 800 g day^{-1} humic acid treatment (Table 3). The lowest value in Arslan cultivar (3.83) was obtained from 800 and 1200 g day^{-1} humic acid treatments and the lowest value in Gürbüz cultivar (4.30) was obtained from the 1600 g day^{-1} humic acid treatment. The regression analysis revealed that optimum number of side branches per plant in Gürbüz cultivar (4.30) was obtained from 750 g day^{-1} treatment dose. An optimum dose was not able to be identified for Arslan cultivar because of high variations with increasing humic acid doses (Fig. 1).

Current finding on number of side branches per plant for Arslan cultivar (3.83-4.15) were parallel to findings of Gok[12], lower than the values reported by Erdogdu[14] and Tuncturk[11] and higher than the values reported by Gucuk[13]. However, the values obtained for Gürbüz cultivar (3.90-4.30) were similar to values reported by Gok[12], lower than the findings of Erdogdu[14] and Tuncturk[11] and higher than the values reported by Gucuk[13].

Number of umbels per plant and number of fruits per umbel: The greatest number of umbel per plant in Arslan cultivar (8.05) was obtained from the control (0 kg day^{-1} humic acid) treatment and the greatest value in Gürbüz cultivar (8.78) was obtained from 400 g day^{-1} humic acid treatment (Table 3). The lowest number of umbel per plant in Arslan cultivar (7.63) was obtained from 400 g day^{-1} humic acid treatment and the lowest value in Gürbüz cultivar (7.65) was obtained from the control (0 g day^{-1}) and 1200 g day^{-1} humic acid treatments. Current findings on number of umbel per plant for Arslan cultivar (7.63-8.05) were lower than the values reported by Tuncturk[11] and higher than the values reported by Gucuk[13]. Current findings on number of umbel per plant for Gürbüz cultivar (7.65-8.78) were again lower than the values reported by Tuncturk[11] but were similar to values reported by Gucuk[13].

The highest number of fruits per umbel in Arslan cultivar (24.57) was obtained from 1600 kg day^{-1} humic acid treatment and the highest value in Gürbüz cultivar (23.49) was obtained from 400 g day^{-1} humic acid treatment (Table 3). The least number of fruits per umbel in Arslan cultivar (19.85) was obtained from 400 g day^{-1} humic acid treatment and the smallest value in Gürbüz cultivar (21.23) was obtained from 1200 g day^{-1} humic acid treatment. Current findings on number of fruits per umbel (19.85-24.57) were higher than the values reported by Gok[12] and lower than the values reported by Erdogdu[14] and Tuncturk[11]. Current findings on number of fruits per umbel for Gürbüz cultivar (21.23-23.49) were again higher than the values reported by Gok[12] and lower than the values reported by Erdogdu[14] and Tuncturk[11].

Shoot thickness and the first side branch height: The greatest shoot thickness in Arslan cultivar (2.13 mm) was obtained from 800 kg day^{-1} humic acid treatment and the greatest value in Gürbüz cultivar (2.23 mm) was obtained from 1600 g day^{-1} humic acid treatment. The lowest shoot thickness in Arslan cultivar (1.55 mm) was obtained from 400 g day^{-1} humic acid treatment and the lowest value in Gürbüz cultivar (1.83 mm) was obtained from the control (0 g day^{-1}) treatment. A regular increase was observed in shoot thickness of Gürbüz cultivar with increasing humic acid doses (Table 3). Current findings on shoot thickness of Arslan cultivar (1.55-2.13 mm) were lower than the values reported by Erdogdu[14]. Current findings on shoot thickness of Gürbüz cultivar (1.83-2.23) were again lower than the values reported by Erdogdu[14].

With regard to height of the first side branch, the greatest value in Arsan cultivar (6.10 cm) was observed in 800 g day^{-1} humic acid treatment and the highest value in Gürbüz cultivar (6.90 cm) was observed in 1200 g day^{-1} humic acid treatment. The lowest values in Arslan (5.48 cm) and Gürbüz (6.23 cm) cultivar were respectively observed in 1600 and 400 g day^{-1} humic acid treatments.

In a study carried out by Erdogdu[14], height of the first side branch was reported to be between 6.50-9.70 cm for Arslan cultivar and between 8.20-13.70 cm for Gürbüz cultivar. The current findings on height of the first branch of Arslan (5.48-6.10 cm) and Gürbüz (6.23-6.90 cm) cultivars were lower than the values reported by Erdogdu[14].

Biological yield: The highest biological yield in Arslan cultivar (101.56 kg day^{-1}) was obtained from 400 g day^{-1} humic acid treatment and the greatest value in Gürbüz cultivar (120.84 kg day^{-1}) was obtained from the control (0 g day^{-1}) treatment. The lowest biological yield in Arslan cultivar (85.42 kg day^{-1}) was obtained from the control (0 g day^{-1}) treatment and the lowest value in Gürbüz cultivar (92.71 kg day^{-1}) was obtained from 800 g day^{-1} humic acid treatment (Table 3).

Current findings on biological yield of Arslan cultivar (77.09-101.56 kg day^{-1}) were parallel to the values reported by Gok[12] and lower than the values reported by Erdogdu[14] and Tuncturk[11]. Current findings on biological yield of Gürbüz (92.71-120.84 kg day^{-1}) were again parallel to the values reported by Gok[12] and again lower than the values reported by Erdogdu[14] and Tuncturk[11].

Fruit yield: The greatest fruit yield in Arslan cultivar (30.02 kg day^{-1}) was obtained from 400 g day^{-1} humic acid treatment and the greatest value in Gürbüz cultivar (31.12 kg day^{-1}) was obtained from 1200 g day^{-1} humic acid treatment. The lowest fruit yield in Arslan cultivar (21.82 kg day^{-1}) was obtained from 1600 g day^{-1} humic acid treatment and the lowest value in Gürbüz cultivar (24.31 kg day^{-1}) was obtained from 800 g day^{-1} humic acid treatment (Table 3).

Current findings on fruit yield of Arslan cultivar (21.82-30.02 kg day^{-1}) were similar to the values reported by Gok[12] and lower than the values reported by Erdogdu[14], Tuncturk[11] and Gucuk[13]. Current findings on fruit yield of Gürbüz (24.31-31.12 kg day^{-1}) were again parallel to the values reported by Gok[12] and again lower than the values reported by Erdogdu[14], Tuncturk[11] and Gucuk[13].

Harvest index and thousand seed weight: The greatest harvest index in Arslan cultivar (39.32%) was obtained from 800 g day^{-1} humic acid treatment and the greatest value in Gürbüz cultivar (35.94%) was obtained from 400 g day^{-1} humic acid treatment. Current findings on harvest index of Arslan cultivar (28.85-39.32%) were similar to the values reported by Erdogdu[14] and Gok[12] and higher than the values reported by Gucuk[13]. Current findings on harvest index of Gürbüz cultivar (21.97-35.94%) were parallel to the values reported by Erdogdu[14] and Gok[12] and higher than the values reported by Gucuk[13].

The greatest thousand seed weight in Arslan cultivar (11.11 g) was obtained from 400 g day^{-1} humic acid treatment and the greatest value in Gürbüz cultivar (8.61 g) was obtained from 800 g day^{-1} humic acid treatment (Table 3). Current findings on thousand seed weight of Arslan cultivar (9.44-11.11 g) were similar to the values reported by Gok[12], lower than the values reported by Erdogdu[14] and Tuncturk[11] and higher than the values reported by Gucuk[13]. Current findings on thousand seed weight of Gürbüz cultivar (7.33-8.61 g) were parallel to the values reported by Gok[12] and Tuncturk[11] and lower than the values reported by Erdogdu[14] and Gucuk[13].

Essential and fixed oil contents: The greatest essential oil content in Arslan cultivar (0.24%) was obtained from the control (0 g day^{-1}) treatment and the greatest value in Gürbüz cultivar (0.33%) was obtained from 400 g day^{-1} humic acid treatment (Table 3). Current findings on essential oil content of Arslan cultivar (0.21-0.24%) were lower than the values reported by Gucuk[13], Gok[12] and Tuncturk[11]. Current findings on essential oil content of Gürbüz cultivar (0.28-0.33%) were parallel to the values reported by Gok[12] but lower than the values reported by Gucuk[13] and Tuncturk[11].

The greatest fixed oil content in Arslan cultivar (7.45%) was obtained from the control 400 g day^{-1} humic acid treatment and the greatest value in Gürbüz cultivar (6.75%) was obtained from 400 g day^{-1} humic acid treatment (Table 3). Yurum[15] reported fixed oil contents of some coriander cultivars as between 15.47-17.80%. Current findings on essential oil content of Arslan cultivar (6.47-7.45%) and Gürbüz cultivar (5.23-6.75%) were lower than the values reported by Yurum[15].

Essential oil components: In control treatment (0 g day^{-1}) of Arslan cultivar, linalol (88.56%), geraniol (2.56%) and geranyl acetate (2.47%) were identified as the major components (Table 4). They were followed by camphor (1.63%) and γ-terpinene (1.33%). In control (0 g day^{-1}) treatment of Gürbüz cultivar, linalol (87.53%), geraniol (2.30%) and geranyl acetate (2.62%) were identified as the major components and they were followed by γ-terpinene (2.10%) and camphor (1.50%). In 400 g day^{-1} humic acid treatment of Arslan cultivar, linalol (89.94%), geraniol (2.46%) and geranyl acetate (2.28%) were identified as the major components and they were followed by camphor (1.79%) and γ-terpinene (1.12%). In 400 g day^{-1} humic acid treatment of Gürbüz cultivar, linalol (91.66%), geraniol (2.45%) and geranyl

Table 4: Components of essential oil detected at different humic acid doses in Arslan and Gürbüz cultivars (%)

		Humic acid doses (g day^{-1})									
		Arslan cultivar					Gürbüz cultivar				
RT	Components	Control	400	800	1200	1600	Control	400	800	1200	1600
9.63	α-pinene	0.19	0.22	0.67	0.21	0.57	0.45	0.08	0.20	0.15	0.38
13.60	p-cymene	0.48	0.43	0.72	0.44	0.79	0.84	0.19	0.43	0.31	0.48
13.78	Limonene	0.23	0.19	0.35	0.20	0.39	0.45	0.11	0.23	0.14	0.25
15.21	γ-terpinene	1.33	1.12	1.59	1.15	1.94	2.10	0.64	1.27	0.84	1.33
17.39	Linalol	88.56	89.94	88.22	89.42	88.44	87.53	91.66	90.42	90.30	89.76
19.22	Camphor	1.63	1.79	1.78	1.80	1.87	1.50	1.55	1.48	1.48	1.45
20.77	Terpinene-4-ol	0.25	0.25	0.23	0.20	0.18	0.20	0.20	0.18	0.21	0.20
21.41	α-terpineol	0.36	0.35	0.32	0.34	0.30	0.28	0.31	0.27	0.32	0.29
22.13	n-decanal	0.26	0.15	0.44	0.15	0.14	0.12	0.12	0.26	0.15	0.09
24.37	Geraniol	2.56	2.46	2.32	2.72	2.12	2.30	2.45	2.16	2.64	2.59
30.05	Geranyl acetate	2.47	2.28	2.12	2.40	2.29	2.62	2.14	2.09	2.44	1.98
	Total (%)	98.32	99.18	98.76	99.03	99.03	98.39	99.45	98.99	98.98	98.80

RT: Retention time

acetate (2.14%) were identified as the major components and they were followed by camphor (1.55%) and γ-terpinene (0.64%).

In 800 g day^{-1} humic acid treatment of Arslan cultivar, linalol (88.22%), geraniol (2.32%) and geranyl acetate (2.12%) were identified as the major components and they were followed by camphor (1.78%) and γ-terpinene (1.59%). In 800 g day^{-1} humic acid treatment of Gürbüz cultivar, linalol (90.42%), geraniol (2.16%) and geranyl acetate (2.09%) were identified as the major components and they were followed by camphor (1.48%) and γ-terpinene (1.27%). In 1200 g day^{-1} humic acid treatment of Arslan cultivar, linalol (89.42%), geraniol (2.72%) and geranyl acetate (2.40%) were identified as the major components and they were followed by camphor (1.80%) and γ-terpinene (1.15%).

In 1200 g day^{-1} humic acid treatment of Gürbüz cultivar, linalol (90.30%), geraniol (2.64%) and geranyl acetate (2.44%) were identified as the major components and they were followed by camphor (1.48%) and γ-terpinene (0.84%).

In 1600 g day^{-1} humic acid treatment of Arslan cultivar, linalol (88.44%), geraniol (2.12%) and geranyl acetate (2.29%) were identified as the major components and they were followed by camphor (1.87%) and γ-terpinene (1.94%). In 1600 g day^{-1} humic acid treatment of Gürbüz cultivar, linalol (89.76%), geraniol (2.59%) and geranyl acetate (1.98%) were identified as the major components and they were followed by camphor (1.45%) and γ-terpinene (1.33%).

Current findings on linalol content of Arslan cultivar (88.22-89.94%) were higher than the values reported by Gucuk[13], Gok[12] and Beyzi and Gurbuz[16]. Geranyl acetate content of Arslan cultivar (2.12-2.47%) were parallel to findings of Gok[12] and higher than the values reported by Beyzi and Gurbuz[16]. Geraniol content of Arslan cultivar (2.12-2.72%) were lower than the values reported by Gok[12] and higher than the values reported by Beyzi and Gurbuz[16].

Current findings on linalol contents of Gürbüz cultivar (87.53-91.66%) were higher than the values reported by Gucuk[13], Gok[12] and Beyzi and Gurbuz[16]. Geranyl acetate contents of Gürbüz cultivar (1.98-2.62%) were similar to values reported by Gok[12] and Beyzi and Gurbuz[16]. Geraniol contents of Gürbüz cultivar (2.16-2.64%) were parallel to the values reported by Gok[12] and Beyzi and Gurbuz[16].

CONCLUSION

Previous studies revealed that humic acid treatments had different impacts on different plants. Such treatments even had different impacts on different species of the same cultivars. Therefore, the present study was conducted to determine the effects of humic acid treatments on two different coriander cultivars, which haven't been experimented before. Present humic acid doses had different impact levels in Arslan and Gürbüz cultivars.

The central hypothesis of this study was tested and considering the effects of different humic acid doses on yield, yield parameters, essential oil and some soil characteristics of Arslan and Gürbüz coriander cultivars, the most effective dose in general was found to be 400 g day^{-1} in both Arslan and Gürbüz cultivar. The researchers speculate that significant changes were not observed in yield and other parameters over this dose and even negative impacts were observed on plant growth and development in some cases at doses over 400 g day^{-1}.

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