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Changes in Yield, Yield Components and Linalool Composition of Coriander (*Corriandrum sativum* L.) Under Different Seed Amount and Row Spacing.

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ABSTRACT

A field study was conducted to evaluate the agronomic response of coriander (*Corriandrum sativum* L.) on the Harran Plain (Southeastern Anatolia, Turkey) to four seed rate (10, 20, 30 and 40 kg ha^{-1}) and two row spacing (15 cm and 30 cm), in two growing seasons. The experiment was set up according to randomized complete block design with split plot. Seed yield, essential oil yield, essential oil ratio, 1000-seed weight, number of seed per umbel, number of branch per plant, number of umbel per plant and Linalool ratio were significantly affected seed amount and row spacing. The treatment of 15 cm x 20 kg ha^{-1} in which the highest seed yield and essential oil yield were obtained, was found to be the most appropriate. The *Linalool* was determined the main component (61.59-70.14 %) under all treatments and it was determined the highest values from the 15 cm row spacing and 20 kg ha^{-1} seed amounts.

Keywords: Coriander (*Corriandrum sativum* L.), sowing rate, plant populations, seed yield, essential oil components

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INTRODUCTION

Coriander (*Corriandrum sativum* L.) is a member of *Apiaceae* family, is one of species plants using common in the worldwide. It is a native to the East Mediterranean Region of Turkey. Its seeds and oil have economical importance in the world exchanges as both medicinal and spice. It is cultivated throughout the world including the temperate countries of central and Western Europe, the Mediterranean region, North and South America and India [1]. India has been one of the major producers of this spice. Dry fruits as well as fresh green leaves of coriander are used as spices and condiments. Coriander fruit is commercially known as "coriander seed". The coriander essential oil is used extensively in perfumery, liquor industry and tobacco flavoring [2]. Additionally, fresh herbs are consumed as fresh vegetable and spice in USA, Chine, India and Turkey. The composition of the essential oil, which determines the odor and flavor properties, has been under particular investigation by several researches [2, 3, 4]. The researches indicate that linalool is the main component in coriander essential oil [1, 3, 5, 6, 7, 8]. The essential oil has potential usage as antispasmodic [4], antibacterial [9], antinociceptive [10], hypoglycemic, anti-inflammatory, hypolipidemic, analgesic, sedative, anxiolytic, antimutagenic, antihypertensive, diuretic, antioxidant, antimicrobial, carminative, [11] and is also used in perfumery and liquor industry [2]. α-pinene, γ-terpinene geranyl acetate, p-cymene and hexadeconoic acid in the coriander essential oil are also other important components [2, 3, 11]. The amount and quality of the coriander product depend on genetic structures and external factors (ecological conditions and agricultural practices) affecting the plant [7, 12, 13, 14]. Agricultural practices have critical effects on yield and quality characters of coriander. The effects of sowing date [15, 16], genotypes [7, 17], fertilization [18, 19, 20], harvesting stage [1, 4] and plant populations [21, 22] have been studied on seed yields of coriander by some researchers.

Determination of the optimal plant population density necessary for optimal yield is a major agronomic goal. Sowing at a seed rate that result in optimal plant population density may reduce seed costs, lodging, and ameliorate disease problems. A Major factor influencing plant populations for any particular environment is seed amount and row spacing, and there is a little information concerning the study of seed amount - row spacing interaction.

Plant density of coriander has an importance for plant characteristic and developing, addition to known competition effect. As all *Umbelliferae* family plants, in coriander, generative developing starts firstly at flower (umbel) that is on the end of the main stem, and continues towards auxiliary branches, related to plant growth. In this case, a coriander plant has seeds which have various sizes, are in different maturation stages, and are matured at various times. Therefore, the more auxiliary branch occurs, the more umbel per plant increase. One of the most important factors which determinate the branching out of coriander is plant density. Plant density can change according to amount of planted seeds, and row space.

This study was carried out to determine the effects of various seed amounts and row spaces on coriander (*Corriandrum sativum* L.) yield and essential oil composition.

MATERIALS AND METHODS

Field studies

The Mardin population of coriander (*C. sativum* L.), obtained from local growers, was used in the study as the experimental material. The experiment was conducted at the research farm of the Agricultural Faculty of Harran University at Şanlıurfa, Turkey, during 2005 and 2006 vegetation periods, as two years. The experimental field was located in South-eastern Anatolia region (in the Harran Plain) where semi-arid climate conditions are prevail, and some climatic data for the area are showed in Figure 1.

As seen in Figure 1, it was observed significant differences at climate between growing seasons, according to temperature and precipitation. In the first year of the experiment, a regular and totally 269.5 mm of precipitation and warm weather occurred. In the second year, an irregular and totally 199.7 mm precipitation and warm weather occurred. In the second year, the precipitation was much lower than the first year, observed on May. When grain filling period of coriander was not precipitation in both years. Relative humidity was similar at the two growing seasons. The soil of the research field belonged to Harran I series and had A, B and C horizons, flat and/or flat-like slope, alluvial main material and a deep profile. According to soil analysis carried out prior to sowing, the soil of the research area had levels of chalk, pH, salt and organic matter of 17%, 7.84, 0.08% and 1.37%, respectively, and had a clay texture.

A split-plot design with row spaces (15 cm and 30 cm) as the main plots and four seed amounts (10, 20, 30 and 40 kg ha^{-1}) as subplots was used in a randomized complete-block design with three replicates. Each experimental plot consisted of four rows and the plot length was 5.0 m long. The coriander seeds were sown by hand drill in February 8, 2005 and February 1, 2006. At the pre-sowing, nitrogen (50 kg ha^{-1}) and phosphorus (50 kg ha^{-1}) were fertilized, and at the beginning of April, nitrogen (50 kg ha^{-1}) was applied to all plots. The plant emergence was observed on March 4, in both years, and first blooming was occurred on April 22, 2005 and May 1, 2006, respectively. From sowing until harvest, the weed control was done when needed, by hoeing. When the plants started to turn yellow and umbels turned brown, plants were harvested by hand on June 1, 2005 and June 11, 2006. Harvested plants were threshed after dried under shade conditions. The observations and plant samples were taken at random from each plot on a per unit area basis. Seed yield (kg ha^{-1}) and other plant measurements, essential oil yield (l ha^{-1}), essential oil ratio (%), 1000 seed weight (g), number of seed (number $umbel^{-1}$), number of umbel (number $plant^{-1}$) and number of branch (number $plant^{-1}$) were recorded as according to Özel *et al.* [13].

Essential Oil isolation

Plants from each plot were dried off at room temperature after harvesting. Samples taken from the blended coriander seeds were grinded and the sample (50 g) was subjected to hydrodistillation for 120 min before essential oils were measured and the resulting essential oil was subsequently analyzed. The essential oil samples were stored at 4 °C until GC analysis.

GC-FID Analysis

Analytical gas chromatography was carried out on a ThermoQuest-Finnigan Trace GC gas chromatography equipped with a flame ionization detector (FID) and a AS 2000 auto sampler. A polyethylene glycol ZB-wax capillary column (30 m x 0.25 mm, 0.25 μm film thickness) was used. The flow of the carrier gas (He) was 1.5 ml min^{-1}. The split ratio was 60:1. The analysis was performed using the following temperature program; oven temps isotherm at 70 °C, from 70 to 220 °C at the rate of 3 °C min^{-1} and from 220 to 240 °C at the rate of 1 °C min^{-1}. Both temperatures of injector and detector were held at 240 °C. The injection volume was 1 μl.

Compounds identification

Identification of the essential oil components was performed on the basis of their peak areas on wax column. The identification of the essential organic compounds was archived through retention indices and comparing the peaks of the samples with standards standards [α-Pinene (Fluka, 80605), p-Cymene (Fulka, 30039) γ-Terpinene (Fulka, 86476), Linalool (Fluka, 74856), Camphor (Fluka, 21293), Geraniol (Fluka, 48798) ve Geranyl acetate (Fluka, 45896)].

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using randomized complete block design with split plot combined over years. The significance of differences among the treatments was determined using with the LSD Test (P<0.005). All statistical analysis was carried out by applying MSTAT-C© software.

RESULTS AND DISCUSSION

Considering the parameters investigated, significant differences were noted between treatments and the growing seasons. The differences between the growing seasons may be due to the differences in average temperature and irregularity in precipitation (Figure 1). The results which were significant according to interaction between row spacing and seeds amount were illustrated in Figure 2, 3, and 4. Other characters were given in Table 1, 2, 3, 4, and 5.

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Table 1. The seed yield and essential yield of coriander under different row spacing (RS) and seed amount (SA) on during the 2005 and 2006 growing periods

	Seed Yield (kg ha^{-1})						Essential Oil Yield (l ha^{-1})					
	1. Year			2. Year			1. Year			2. Year		
SA \ RS	**15 cm**	**30 cm**	**Ort.**	**15 cm**	**30 cm**	**Ort.**	**15 cm**	**30 cm**	**Ort.**	**15 cm**	**30 cm**	**Ort.**
10 kg ha^{-1}	2887.67 abc	2807.00 bc	2847.33	2469.67 cd	1557.67 f	2013.67	8.67 a	8.65 a	8.66	9.47 b	5.20 d	7.33
20 kg ha^{-1}	3106.33 a	2877.33 abc	2991.83	3034.00 a	2063.00 e	2548.50	9.31 a	7.49 b	8.40	13.13 a	7.20 c	10.17
30 kg ha^{-1}	2983.33 abc	2732.33 c	2857.83	2457.00 cd	2659.33 bc	2558.17	8.56 a	8.89 a	8.72	9.47 b	8.80 b	9.13
40 kg ha^{-1}	3038.67 ab	1526.33 d	2282.50	2396.00 d	2715.67 b	2555.83	8.60 a	4.68 c	6.64	8.80 b	10.00 b	9.40
Mean	3004.00	2485.50		2589.17	2248.92		8.79	7.43		10.22	7.8	
Lsd (%5)	268.30			206.10			1.03			1.42		
RS	*			**			-			*		
SA	**			**			**			**		
RSxSA	**			**			**			**		

Table 2. The 1000-seed weight and seed number of coriander under different row spacing (RS) and seed amount (SA) on during the 2005 and 2006 growing periods

	1000-Seed Weight (g)						Seed Number (number.umbel^{-1})					
	1. Year			2. Year			1. Year			2. Year		
SA \ RS	**15 cm**	**30 cm**	**Ort.**	**15 cm**	**30 cm**	**Ort.**	**15 cm**	**30 cm**	**Ort.**	**15 cm**	**30 cm**	**Ort.**
10 kg ha^{-1}	10.67	10.57	10.62 a	9.01	9.26	9.14	59.67 a	41.37 b	50.51	52.63	50.50	51.57 a
20 kg ha^{-1}	10.37	10.65	10.51 a	9.50	9.12	9.31	44.17 b	46.00 b	45.08	44.10	49.53	46.82 b
30 kg ha^{-1}	10.58	10.76	10.67 a	9.35	9.00	9.18	46.60 b	39.63 b	43.12	57.57	53.10	55.33 a
40 kg ha^{-1}	10.28	10.24	10.26 b	9.56	9.15	9.35	41.13 b	23.57 c	32.35	42.07	47.60	44.83 b
Mean	10.47	10.56		9.36	9.13		47.89	37.64		49.09	50.18	
Lsd (%5)	1.27			-			7.00			4.37		
RS	-			-			**			-		
SA	*			-			**			**		
RSxSA	-			-			**			-		

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Table 3. Mean value of the essential oil components of coriander under different row spacing and seed amounts.

Row Spacing	Essential Oil Components 1*	2	3	4	5	6	7	Total
15 cm	13.62	1.99 a	1.86 a	68.42 a	2.33 a	1.17 b	1.97 b	91.16
30 cm	13.66	1.79 b	1.70 b	63.48 b	2.19 b	1.37 a	3.04 a	87.23
Seed Amounts								
10 kg ha^{-1}	12.95 c	1.64 b	1.61 c	61.59 b	2.13c	1.28 b	2.80 b	84.00
20 kg ha^{-1}	13.93 ab	2.08 a	1.90 b	70.14 a	2.40 a	0.96 d	1.42 c	92.83
30 kg ha^{-1}	14.06 a	2.12 a	2.01 a	69.37 a	2.20 c	1.03 c	1.37 c	92.16
40 kg ha^{-1}	13.62 b	1.71 b	1.60 c	62.73 b	2.29 b	1.81 a	4.43 a	88.19
Mean	13.64	1.89	1.78	65.96	2.26	1.27	2.50	89.30
Lsd (%5)	0.42	0.09	0.04	1.59	0.07	0.07	0.20	

* **1**. *α-Pinene*, **2.** *p-Cymene*, **3.** *γ-Tterpinene*, **4.** *Linalool*, **5.** *Camphor*, **6.** *Geraniol*, **7.** *Geranyl acetate*

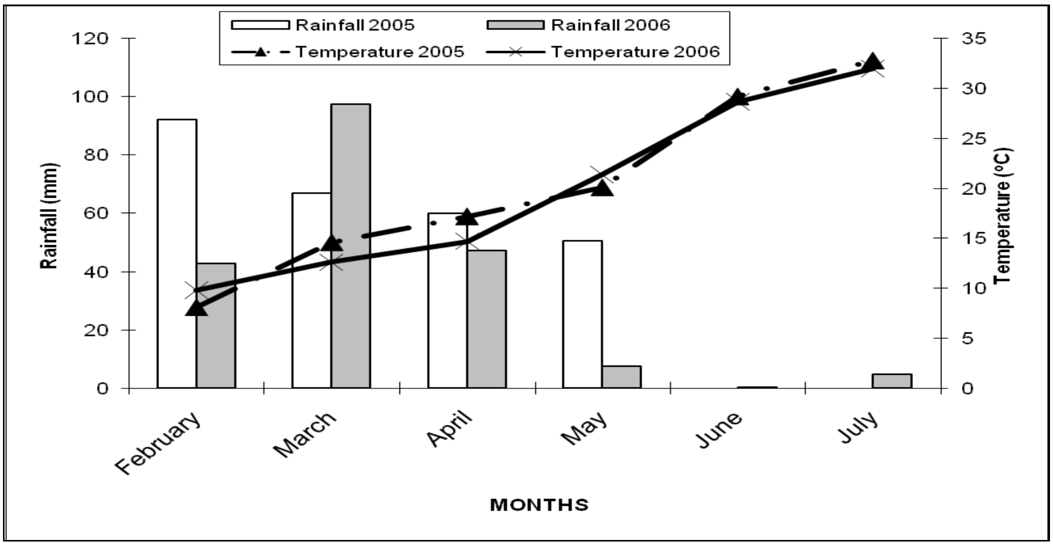

Figure 1. Rainfall and temperature data of the study area during coriander growing season of 2005 and 2006

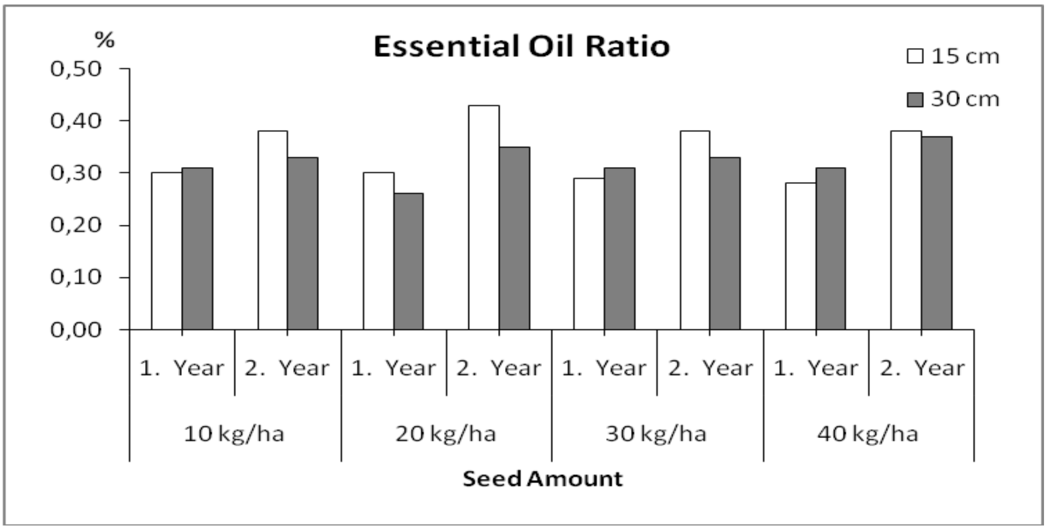

Figure 2. The essential oil ratio of coriander under different row spacing and seed amount on during the 2005 and 2006 growing periods

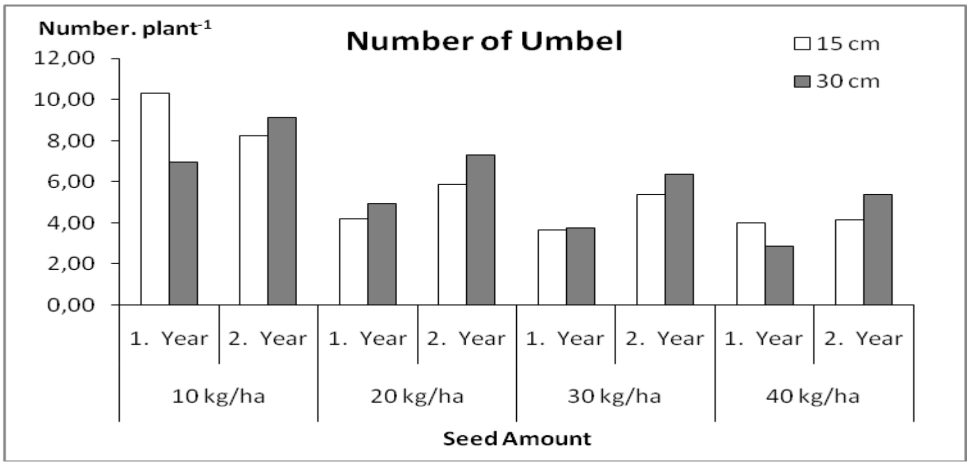

Figure 3. The umbel number of coriander under different row spacing and seed amount on during the 2005 and 2006 growing periods

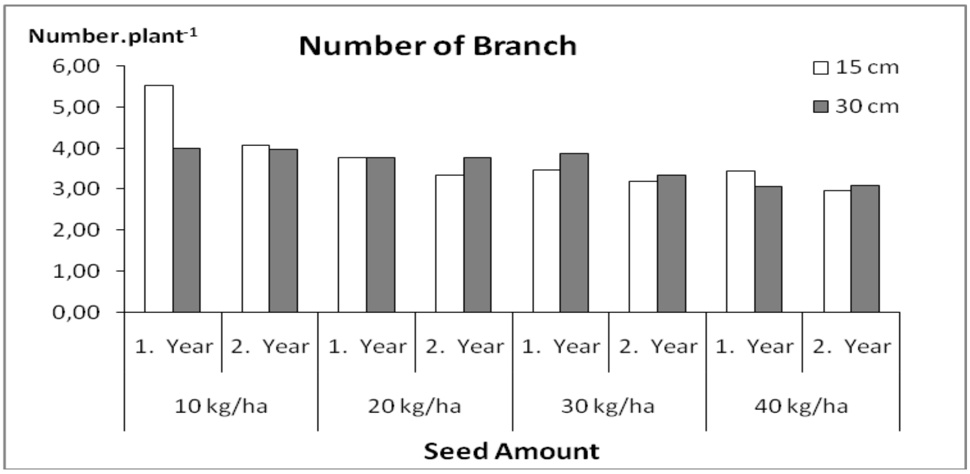

Figure 4. The branch number of coriander under different row spacing and seed amount on during the 2005 and 2006 growing periods

As seen in Table 1 in both years, the seed yields reached the highest level at the 15 cm row spacing and 20 kg ha^{-1} seed amount. In addition, the 15 cm and 30 cm row spacing showed differences. In both years, depend on up and down amount of this seed level, the seed yield declined considerably. This may be caused by the plants can be found a better competitive environment. The seed yield, in appropriate circumstances such as suitable number of umbels per plant and seed number per umbel, is high. Our results are contradictory to that is notified as it is obtained higher seed yield from sowing of narrow row spacing and small amount of seed [15, 23, 24]. However, it is contradictory to that is reported [18] as it is obtained higher seed yield from sparsely sowing. Furthermore, our values according to coriander seed yield are higher than values notified by some researches [12, 13, 15, 16, 23].

The trend of variation in essential oil yields showed similarities to the changes in seed yields. The essential oil yield means were ranged between 4.68 and 9.31 l ha^{-1} in first year and 5.20 and 13.13 l ha^{-1} in second year. It was obtained significantly high essential oil yield from 15 cm treatment comparing to 30 cm treatment. Essential oil yield was not changed regularly (Table 1). This resulted from the seed yield, as essential oil yield is calculated from the following formula;

Essential oil yield= seed yield x essential oil ratio.

Essential oil ratio values varied between 0.26-0.31% in the first year and 0.33-0.43% in the second year. Essential oil ratio was not changed regularly. The highest value of essential oil was obtained from 30 cm row spacing in first year and 15 cm row spacing and 20 kg ha^{-1} treatments in the second year (Figure 1). This may have resulted from that essential oil ratio is an easily changeable character by ecological conditions and agricultural practices [12, 13, 16, 23].

1000-seed weight of coriander varied between 10.24 and 10.76 g in the first year, and 9.00 and 9.56 g in the second year. In general, the second year, 1000-seed weight values were not affected significantly by the treatments and in the first year, only seed amount main effect were affected significantly. Additionally, the second year 1000-seed values determined lower than the first year (Table 2). This may have resulted from the changeable ecological conditions.

As seen in Table 2, the average seed number values varied between 23.57 and 59.67 number umbel^{-1} in the first year and 21.13-27. 42.07 and 57.57 number umbel^{-1} in the second year. In general, the highest values were recorded at the 10 kg ha^{-1} treatment in the both years. The umbel numbers decreased considerably to the increasing seed amount treatment. This may have resulted from less competing conditions for plant growth at treatment of high seed amount.

The number of umbels with seed varied between 2.87 and 10.30 number plant^{-1} in the first year and 4.17 and 9.13 number plant^{-1} in the second year. The highest values were recorded at the 15 cm x 10 kg ha^{-1} treatment in the both years. In general, the umbel numbers decreased considerably to the increasing seed amount treatment (Figure 2). This may have resulted from less competing conditions for plant growth at treatment of narrow row spacing (15 cm) according to treatment of 30 cm row spacing.

In Figure 3, it is seen that branch number means obtained from various row spacing and seed amounts were ranged between 3.07 and 5.53 number plant^{-1} in the first year and 2.97 and 4.07 number plant^{-1} in the second year. Generally, branch number was decreased at high seed amount, and the highest value was obtained from treatment of 15 cm x 10 kg ha^{-1}. Our results are contradictory to that is notified as it is not significantly affected by seed amount [15]. This case may be due to the coriander were sowed much wider range by the researchers. Branch number obtained from the experiment was found similar means reported by some researches [12, 13, 16, 23].

Distribution of essential oil components, bigger than 1% values (two years mean) and occurring groups were given on Table 3.

Total values of determined 7 components (1. *α-Pinene*, 2. *p-Cymene*, 3. *γ-Tterpinene*, 4. *Linalool*, 5. *Camphor*, 6. *Geraniol* and 7. *Geranyl acetate*) were ranged between 84.00 and 92.83 % of total essential oil. The main components of essential oil of *C. sativum* was *Linalool* (65.96%), it was followed by *α-Pinene* (13.64%). In result of previous researches, *Linalool* [1, 16, 25, 26, 27, 28] were reported as the main component of coriander. When it was examined effect of treatments on essential oil components, it was determined that seed amount treatment significantly affected the essential oil components. However, row spacing treatment was not affected components of *α-Pinene*. Generally, distribution of essential oil components showed variation according to treatments. This result was supported by inventions of researchers [1, 16, 25, 26, 27] reported that distribution of coriander essential oil components could change related to environmental factors and cultivation techniques. *β-pinene* values were ranged between 12.95 and 14.06. The highest values for *β-pinene* were obtained from 30 kg ha^{-1} seed amount. *p-Cymene* values were ranged between 1.64% and 2.12% and it was reached the highest values through 30 kg ha^{-1} and 15 cm row spacing. *γ-Terpinene* values were ranged between 1.60% and 2.01%. It was determined the highest values from seed amounts of 30 kg ha^{-1}. *Linalool* values were ranged between 61.59% and 70.14%. The highest value was determined from treatment of row spacing of 15 cm, and treatments of seed amounts of 20 kg ha^{-1}. *Camphor* values were ranged between 2.13% and 2.40%. The highest value was determined from treatment of row spacing of 15 cm, and 20 kg ha^{-1} seed amount. *Geraniol* and *Geranyl acetate* values were ranged between 0.96-1.81% and 1.37-4.43%, respectively. The highest values were determined from treatment of row spacing of 30 cm, and treatments of seed amounts of 40 kg ha^{-1}.

CONCLUSIONS

Result of this study showed that 15 cm row spacing and 20 kg ha^{-1} seed amount were found preferable for the Southeast Anatolia of Turkey. Because of the highest seed and essential oil yields, they are considered more promising than other treatments. Also, *Linalool* was determined the main component of coriander essential oils under all treatments and it was determined the highest values from the 15 cm row spacing and 20 kg ha^{-1} seed amount treatments.

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REFERENCES

[1] Msaada K, Hosni K, Ben Taarit M, Ouchikh O, Marzouk B, Journal of Food Biochemistry, 2009; 33: 603-612.
[2] Bandoni AL, Mizrahi I, Juarez MA, Journal of Essential Oil Research, 1998; 10: 581-584.
[3] Anitescu G, Doneanu C, Radulescu V, Flavour Frag. J. 1997;12: 73-176.
[4] Telci I, Bayram E, Avcı B, European Journal of Horticultural Science, 2006; 71 (6): 267-271.
[5] Machado ASR, De Azevedo EG, Da Ponte MN, Sardinha RMA, Journal of Essential Oil Research, 1993; 5: 645-649.
[6] Jeliazkova EA, Craker LE, Zheljazkov VD, J. Herbs Spices Med. Plants, 1997; 5: 73-79.
[7] Gil A, De-La-Fuente EB, Lenardis AE, Pereira ML, Suarez SA, Arnaldo B, Van Baren C, Di Leo LP, Ghersa CM, Journal of Agricultural and Food Chemistry, 2002; 50: 2870-2877.
[8] Msaada K, Hosni K, Ben Taarit M, Chahed T, Marzouk B, Italian Journal of Biochemistry, 2007; 56: 47-52.
[9] Elgayyar M, Draughon FA, Golden DA, Mount JA, J. Food Protect. 2001; 64: 1019-1024.
[10] Peana AT, D'aquila PS, Chessa ML, Moretti MD, Serra G, Pippia P, European Journal of Pharmacology, 2003; 460: 37-41.
[11] Begnami AF, Duarte MCT, Furletti V, Rehder VLG, Food Chemistry, 2010; 118: 74-77 .
[12] Özel A, Demirbilek T, HR.Ü Ziraat Fakültesi Dergisi, 2000; 4(3-4): 21-32.
[13] Özel A, Demirbilek T, Çopur O, Workshop on Agricultural and Quality Aspects of Medicinal and Aromatic Plants, May 29-June 01, 2001, 151-158, Adana/Türkiye.
[14] Fuente EB, Gil A, Lenardis AE, Pereira ML, Suarez SA, Ghersa CM, Grass MY, Agriculture, Ecosystems and Environment, 2003; 99: 159-169.
[15] Baswana KS, Pandita ML, Sharma SS, Indian Journal of Agronomy, 1989; 34(3): 355-357.
[16] Kaya N, Yılmaz G, Telci İ, Turkish Journal of Agriculture and Forestry, 2000; 24: 355-364.
[17] Ayanoglu F, Mert A, Aslan N, Gurbuz B, Journal of Herbs, Spices & Medicinal Plants, 2002; 9: 71-76.
[18] Malav NB, Yadav SN, Indian Cocoa, Arecanut and Spices Journal, 1997; 21(2): 37-41.
[19] Rangappa M, Bhardwaj HL, Showhda M, Hamama AA, J. Herbs Spices Med. Plants 1997; 5: 63–68.
[20] Lenardis AD, De-la-Fuente E, Gil A, Tubia A, Journal of Herbs, Spices and Medicinal Plants, 2000; 7: 47-58.
[21] Jat SC, Jat NL, Singh Ud, Singh U, Annals of Agri Bio Research, 1996; 1(1-2): 105-106.
[22] Gil A, de la Fuente E, Lenardis A, Lorenzo S, Marengo J, Journal of Herbs, Spices & Medicinal Plants, 1999; 6(3): 63-73.
[23] Karadoğan T, Oral E, At.Ü. Ziraat Fakültesi Dergisi, 1994; 25: 311-3183.
[24] Reddy K, Rolston MP, Journal of Applied Seed Production, 1999; 17: 49-53.
[25] Loaiza J, Cantwell M, HortScience, 1997; 32 (1): 104-407.
[26] Kürkcüoğlu M, Sargin N, Başer KHC, Chemistry of Natural Compounds, 2003; 39 (4): 355-357.
[27] Ravi R, Prakash M, Bha, KK, European Food Research and Technology, 2007; 225: 367-374.
[28] Telci I, Toncer OG, Sahbaz N, Yield, Journal of Essential Oil Research, 2011; 18(2): 189-193.