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Evaluation of some agronomical characteristics and essential oil ratio of coriander (Coriandrum sativum L.) cultivars cultivated by applying different humic acid doses

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ABSTRACT

Coriander (*Coriandrum sativum* L.) is grown as a spice crop all over the World. Its essential oil is used as a flavor ingredient, but it also has a long history as a traditional medicine. Coriander essential oil and extracts possess promising antibacterial, antifungal and anti-oxidative activities as various chemical components in different parts of the plant, which thus play a great role in maintaining the shelf-life of foods by preventing their spoilage. This study was conducted to investigate the effects of different humic acid doses on some agronomical characteristics and essential oil ratio of coriander in Yozgat ecological condition at Research and Application Area of Gedikhasanlı, Faculty of Agriculture, Yozgat Bozok University during 2015-2016. Two coriander cultivars (Arslan and Gurbuz) and different humic acid doses (Dose-1: Control, Dose-2:100 L ha^{-1}, Dose-3:200 L ha^{-1}, and Dose-4: 300 L ha^{-1}) were used in the study. Spring and winter sowings were made on April 17, 2015 and on October 29, 2015, respectively. According the results of this study; the main values in plant height, number of branches per plant, number of umbel per plant, number of seed per umbel, first branch height, a thousand seed weight, biological yield, seed yield, stalk yield, harvest index, essential oil ratio, and yield were recorded as 39-77 cm, 3-5 number, 5-17 number, 21-52 number, 15-23 cm, 8-16 g, 1000-5900 kg ha^{-1}, 300-2300 kg ha^{-1}, 600-3700 kg ha^{-1}, 30-75%, 0.2-0.5%, and 60-800 L ha^{-1}, respectively. While values obtained from winter sowing are higher than sipring sowing. The best results were obtained from cv. Arslan and 100-200 L ha^{-1} humic acid doses.

1. Introduction

Coriander (*Coriandrum sativum* L.) is an essential oil and spice plant cultivated throughout the world [1]. Coriander is belonging to the genus *Coriandrum* of the Apiaceae family. The native land of cultivated coriander plant is not fully known. However, it is cultivated in the Mediterranean countries, Southwest Asia and North Africa [2]. *Coriandrum* L. genus is represented by two species of flora in Turkey. These are *Coriandrum sativum* L. and *Coriandrum tordylium* (Fenzl) Bornm. When cultivating Coriander, 2 varieties of *Coriandrum sativum* L. are used: These are *Coriandrum sativum* L. *vulgare* Alef. (large seeded varieties) and *Coriandrum sativum* L. var. *microcarpum* D.C. (small seeded varieties) is known as coriander [3].

Commercially used parts of the plant are fresh green leaves, ripe dried fruits (or seeds) and essential oil from these seeds. The use of coriander seeds relates to the chemical composition. The most important components of the seed are essential oil and fatty oil. The essential oil ratio of mature and dried seed varies between 0.03% and 2.6%, while the fatty oil varies between 9.9% and 27.7% [4]. Linalool (68%), α-pinene (11%), γ-terpinene (9%), geranylacetate (4%), camphor (3%), and geraniol (2%) are main components of the essential oil from coriander seeds [5]. Linalool is used as a raw material in the advanced technical processing stages while the commercial used oil is widely used by mixing sweet

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orange oil, cedar wood oil, terementi and anethol or anise oil [6].

Humic substances are natural organic materials which have colloidal properties in soils, lakes, rivers and waters and are the most common distribution in nature [7]. Soil humic substances play an important role directly and indirectly in the development of plants [8]. Studies have shown that humic acid has positive effects on plant growth [9], it was observed that plant growth was positive effect in low amount humic acid application (0.6-60 pmm) and negative effect in high amount one [10], also, humic acid increased plant dry weight, plant phosphorus concentration and useful phosphorus concentration in the soil [11].

The aim of this study was investigate the effects of spring and winter sowing times and the humic acid applied at different times and doses on some agricultural characteristics and essential oil content of coriander (*Coriandrum sativum* L.), a medicinal and aromatic plant.

2. Material and Method

2.1 Material

In this study, Arslan (large seeded) and Gurbuz (small seeded) coriander cultivars registered by the Ankara University, Faculty of Agriculture, Field Crops Department and humic acid with a commercial name of Phila-22 (Table 1) was used.

2.2 Method

The study was carried out in Application Area of Gedikhasanlı, Faculty of Agriculture, Yozgat Bozok University during 2015-2016. In the experimental area, total rainfall, mean relative humidity and temperature in 2015 and 2016 were recorded to be 554.2 mm and 421.5 mm, 64.45% and 63.16%, and 11.7 ºC and 10.04 ºC, respectively. According to the results of soil taken from 0-20 cm depth from the experiment area; the soil was loamy (46.31%), poor in organic matter (1.47%), lime content was low (4.04%), slightly alkaline (pH:7.67), phosphorus (P_2O_5) content (58.3 kg ha^{-1}) is low, but is rich in potassium (K_2O) (794.8 kg ha^{-1}).

The cultivars used in this study were sown in 40 cm row spacing and 3 m row length on April 17, 2015, in spring, and October 29, 2015, in winter. Experiment was established randomized complete design in split plot arrangements with three replications by using two cultivars as main plots and humic acid treatments (Dose-1: control, Dose-2: 100 L ha^{-1}, Dose-3: 200 L ha^{-1}, Dose-4: 300 L ha^{-1}) as split plots (Figure 1). After germination of the sown seeds, weed control and humic acid application were performed as needed during the growing season. Humic acid was diluted with water at a rate of 1/10 and the plants which are about 10-15 cm high were given in the designed doses and after each application, the soil was mixed by hoeing. Harvest was made by hand on August 15, 2015 in spring sowing and on July 27, 2016 in winter sowing. In harvested plants, plant height (cm), first branch height (cm), number of branches per plant, number of umbrellas per plant, number of seeds per umbrella , a thousand seed weight (g), seed yield (kg ha^{-1}), stem yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%), essential oil ratio (%) and essential oil yield (L ha^{-1}) were determined.

100 g of seed was ground from each parcel and 500 mL of water was added. The distillation was carried out using a Clevenger apparatus for 3h to determine the essential oil content (w/w).

The differences between the averages of the characters examined in the statistical evaluation of the results were grouped according to the Duncan test. SPSS 23 package program was used for statistical analysis.

Table 1. Commercial humic acid content used in the experiment

Content	W/W
Total Organic Matter (%)	36
Total Nitrogen (N) (%)	1.5
Organic Nitrogen (%)	1
Total Humic + Fulvic Acid (%)	22
Water Soluble Potassium Oxide (K_2O) (%)	4
pH	4-6

3. Results and Discussion

According to research findings (Table 2); plant height was found to be between 39.40 cm (cv. Arslan, Dose-3, spring sowing) and 77.00 cm (cv. Gurbuz, Dose-2, winter sowing) and the plants grown in winter sowing were longer than those grown in spring sowing. When previous studies were examined, plant height ranged from 37.75 cm to 120 cm [12-14]. In our study, the number of branches per plant was higher in winter sowing than spring sowing. The average number of branches per plant varied from 3 to 5. It has been stated that cultural factors such as sowing time, fertilization, irrigation and climatic factors and genetic characteristics have been effective on the number of branches per plant [13-15].

The number of umbrella per plant was between 5.13 (cv. Gurbuz, Dose-2, in spring sowing) - 16.33 (cv. Arslan, Dose-3, winter sowing) and the number of umbrella in winter sowing was higher than that of spring sowing. The number of seeds in the umbrella was 21.33 (cv. Arslan, Dose-3, spring sowing) and 51.33 (cv. Arslan, Dose-3, winter sowing). In the studies carried out, the number of umbrella per plant was found between 5 and100, and it was changed according to ecological factors and cultural processes applied [13-18]. The number of seeds in the umbrella was determined between 15 and 22.85 seeds in previous studies. In our study, the value from the winter sowing was higher than ones from the other studies, but it has values close to the average in spring sowing [15, 17, 19].

Table 2. Performance of coriander cultivars (Arslan and Gurbuz)

Humic Acid Doses (L ha^{-1})	Plant height (cm)						Number of branches per plant (number)					
	Winter Sowing			Spring Sowing			Winter Sowing			Spring Sowing		
	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean
Control	64.33	76.33	70.33	43.33	45.80	44.55	4.33	3.67	4.00	3.20	3.60	3.40
100	68.33	77.00	72.66	41.87	42.07	41.97	3.50	5.00	4.25	3.53	3.33	3.43
200	73.00	63.67	68.30	39.40	48.67	44.05	4.67	4.00	4.33	3.40	3.73	3.56
300	71.67	66.00	68.83	43.87	43.13	43.50	5.00	4.67	4.83	3.60	3.83	3.75
Mean	69.33	70.75	70.03	42.15	44.95	43.51	4.29	4.33	4.35	3.45	3.65	3.55

Humic Acid Doses (L ha^{-1})	Number of seeds per umbrella (number)						Biological yield (kg ha^{-1})					
	Winter Sowing			Spring Sowing			Winter Sowing			Spring Sowing		
	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean
Control	51.33	41.33	46.33	22.00	26.33	24.15	3979.7	477.0.3	437.5.0	1126.7	1526.2	1326.5
100	45.66	46.00	45.83	23.33	24.67	24.00	4133.0	508.0.2	460.6.6	1069.3	1183.8	1126.5
200	51.33	45.66	50.00	21.33	23.67	22.50	4312.0	417.5.7	424.3.8	1002.9	1484.3	1246.8
300	44.33	41.33	42.83	23.67	23.33	23.50	5872.0	326.5.3	456.8.6	1263.6	1205.3	1234.4
Mean	48.16	43.58	46.24	22.55	24.50	23.55	4574.1	432.2.8	444.8.5	1115.5	1349.9	1233.5

Humic Acid Doses (L ha^{-1})	Stem yield (kg ha^{-1})						First branch height (cm)					
	Winter Sowing			Spring Sowing			Winter Sowing			Spring Sowing		
	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean
Control	2340.3	3226.3	2783.3	696.7	1154.3	925.5	22.33	16.00	19.16^{a*}	17.00	15.00	16.00
100	2408.9	3496.5	2952.7	678.7	843.6	761.5	15.67	20.00	17.83^{a}	14.13	19.00	16.55
200	2728.9	2896.3	2812.6	690.3	1107.7	899.0	12.33	13.67	13.00^{b}	13.00	18.07	15.55
300	3628.3	2172.3	2900.3	864.3	896.3	880.3	16.00	15.00	15.50^{ab}	16.73	17.67	17.20
Mean	2776.6	2947.8	2862.2	732.5	1000.5	866.5	16.58	16.16	16.37	15.25	17.45	16.35

Humic Acid Doses (L ha^{-1})	Number of umbrellas per plant (numbers)						Seed yield (kg ha^{-1})					
	Winter Sowing			Spring Sowing			Winter Sowing			Spring Sowing		
	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean
Control	16.00	8.67	12.33	5.93	6.13	6.03	1639.7	1543.6	1591.6	430.5	381.9	406.2
100	15.00	13.67	14.33	5.93	5.13	5.53	1739.0	1595.3	1667.1	391.3	340.7	366.0
200	16.33	11.00	13.66	6.93	6.53	6.73	1583.0	1279.0	1431.0	312.7	378.3	345.5
300	15.67	13.66	14.66	6.60	6.13	6.35	2243.3	1093.0	1668.1	399.7	309.0	354.5
Mean	15.75	11.75	13.74	6.35	5.98	6.16	1801.2	1377.7	1589.4	383.5	352.5	368.5

Humic Acid Doses (L ha^{-1})	Harvest index (%)						A thousand seed weight (g)					
	Winter Sowing			Spring Sowing			Winter Sowing			Spring Sowing		
	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean
Control	41.68	32.77	37.22	74.03	62.07	68.05	14.45	9.02	11.73	14.57	9.07	11.82
100	41.94	31.13	36.53	70.57	65.43	68.00	12.93	8.90	10.91	14.93	10.13	12.53
200	38.29	30.03	34.16	68.95	61.97	65.46	13.17	9.03	11.10	14.37	9.87	12.12
300	38.50	32.57	35.53	67.07	64.72	65.85	13.89	8.94	11.40	15.04	10.17	12.65
Mean	40.10^{a}	31.62^{b}	35.86	70.15	63.55	66.84	13.61^{a}	8.97^{b}	11.28	14.75^{a}	9.81^{b}	12.28

Humic Acid Doses (L ha^{-1})	Essential oil ratio (%)						Essential oil yield (L ha^{-1})					
	Winter Sowing			Spring Sowing			Winter Sowing			Spring Sowing		
	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean	Arslan	Gurbuz	Mean
Control	0.40	0.33	0.36	0.24	0.18	0.21^{b}	647.3	511.3	579.3	98.7	69.7	84.2
100	0.43	0.38	0.41	0.26	0.20	0.23^{ab}	720.3	593.4	659.8	96.7	62.7	79.7
200	0.43	0.33	0.38	0.28	0.23	0.25^{a}	650.7	468.3	559.5	78.3	79.8	79.5
300	0.36	0.44	0.40	0.30	0.23	0.26^{a}	778.8	500.7	639.7	106.7	63.8	85.5
Mean	0.40	0.37	0.38	0.25	0.21	0.25	69.9.2	518.4	609.5	95.1	69.0	82.1

* The difference between the meanings indicated in different letters in the same column is statistically significant.

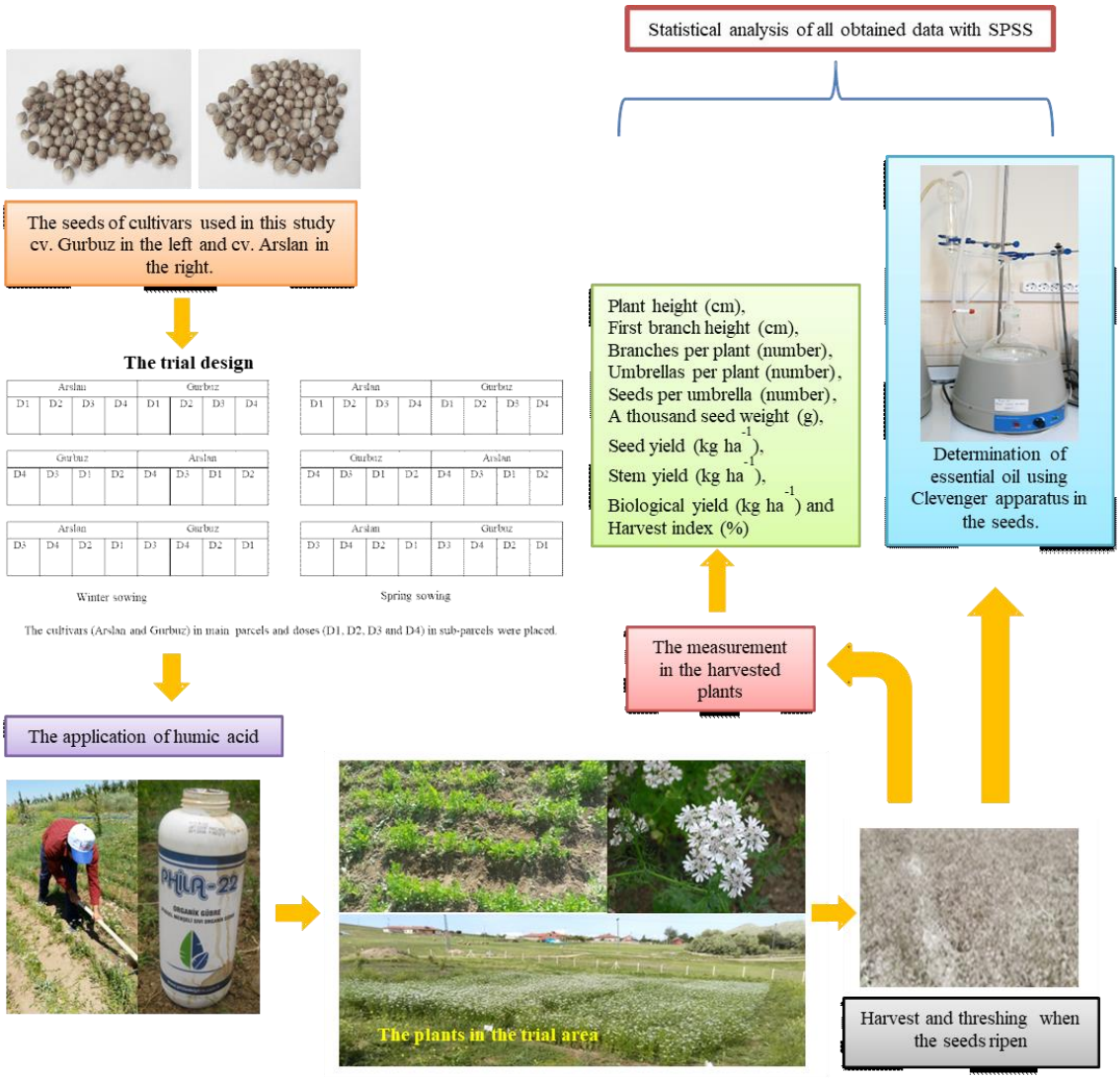

Figure 1. Schematic presentation of the all applications in this study.

The biological yield values obtained from two different cultivars were between 1002.9 kg ha^{-1} (cv. Arslan, Dose-3, spring sowing) – 5872.0 kg ha^{-1} (cv. Arslan, Dose-4, winter sowing) and the biological yield of winter sowing was higher than that of spring sowing. Our findings obtained from this study are similar to those reported by [5, 13, 15-17, 20]. Seed yield was recorded between 309.0 kg ha^{-1} (cv. Gurbuz, Dose-4, spring sowing) and 2243.3 kg ha^{-1} (cv. Arslan, Dose-4, winter sowing). The values obtained from our study were in agreement with those obtained from other studies (450.8-3591.3 kg ha^{-1}) [5, 12-14, 2, 22]. The stalk yield values obtained from coriander varieties were found at 678.7 kg ha^{-1} (cv. Arslan, Dose-2, spring sowing) – 3628.3 kg ha^{-1} (cv. Arslan, Dose-4, winter sowing). The first branch height was between 13.00 cm (cv. Arslan, Dose-3, spring sowing) - 22.33 cm (cv. Arslan, Dose-1, winter sowing). In our study, the first branch height was found higher in winter and spring sowings than the other studies [23]. In our study, the harvest index was between 30.03% (cv. Gurbuz, Dose-3, winter sowing) and 74.03% (cv. Gurbuz, Dose-1, spring sowing), many researchers found similar findings with the harvest index (8.6%-117.54%) of coriander [13, 15, 17, 23]. A thousand seed weight were obtained between 8.90 g (cv. Gurbuz, Dose-2, winter sowing) - 15.04 g (cv. Arslan, Dose-4, spring sowing). In the previous studies conducted, the lowest one thousand seed weight was determined as 5.03 g and the maximum value was determined as 19.88 g [12-20, 22, 24, 25].

In our study, essential oil ratio obtained from mature seed and essential oil yield were respectively; 0.18% (cv. Gurbuz, Dose-1, spring sowing) - 0.43% (cv. Arslan, Dose-2 and Dose-3, winter sowing); 62.7 L ha^{-1} (cv. Gurbuz, Dose-2, spring sowing) – 778.8 L ha^{-1} (cv. Arslan, Dose-4, winter sowing). In different studies, the essential oil ratio of coriander seeds were reported as 0.27-0.60% by Gök [19], 0.26-0.36% by Tunçtürk [25], 0.35% by Bahadırlı et al. [26], 0.32-0.71% by Yalçın [27], and 0.23-0.39% by Beyzi and Güneş [28]. Generally, findings related essential oil ratio were found within these limits with many studies (0.18%-0.77%) [5, 12-16, 18, 22, 24, 25, 29, 30]. According to other studies,

essential oil yield was recorded as 0.61 L ha^{-1} and the highest was 16.5 L ha^{-1}. In our study, the essential oil yield of the mature seed was higher in winter and summer sowings than in other studies [12, 15, 18, 19, 21, 24, 31]. According to our study, four humic acid doses applied showed statistically significant effects on the first branch height and the essential oil ratio. Dose-2 and Dose-3 for the essential oil ratio and Dose-1 and Dose-2 for the first branch height showed the highest effect. Soil humic substances play an important direct and indirect role in the development of plants. Indirect effects are the uptake of water-soluble forms by water retention, drainage, aeration, and formation of chelating compounds or metallic-hydroxides with metallic ions. Direct effects in plants are promoting root development of the plant and the metabolism of nutrient elements absorbed by plants [32]. For the positive effects of humic acid to occur, it has to be applied to the same field for several years [33]. Due to the fact that the study was carried out for a single year, no significant effect of humic acid on the investigated properties was observed. According to our findings, the yield of winter sowing was higher than that of spring sowing. The reason for this is that the vegetation during in winter sowing is longer, the root structure of the plant is better developed and there are more favorable environmental conditions for plant growth. At the same time it is known that the genotype has a great effect on the yield and yield components obtained from the plants.

3. Conclusion

Soil humic substances play an important role (water retention, drainage, solubility of some nutrients, encouraging plant root growth etc.) in the development of plants. It must be applied to the same soil for several years in order to reveal these effects of humic acids. Due to the fact that our study was only single year, humic acid had no significant effect on the properties examined. According to the findings of this study, it was observed that winter sowing has more yield than spring sowing. This is due to the fact that winter sowing has a longer vegetation period, better development of the plant root structure and more favorable environmental conditions for plant growth. It is also known that genotype has a great effect on yield and yield components obtained from plants. Arslan and Gurbuz cultivars were sown in spring and winter in Yozgat ecological conditions, and the highest seed yield, essential oil ratio and essential oil yield were obtained from the winter sowing of the cv. Arslan. For Yozgat and similar ecologies, we can recommended the winter sowing of cv. Arslan and doses of 100-200 L ha-1 of humic acid containing 36% of total organic matter, 1.5% of total nitrogen (N), 1% of organic nitrogen, 22% of total humic and fulvic acid, water soluble Potassium Oxide (K2O) value with 4% and pH 4-6.

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References

1. Başer, K.H.C., *Tıbbi aromatik bitkilerin endüstriyel kullanımı*. Anadolu Üniversitesi Tıbbi ve Aromatik Bitki ve İlaç Araştırma Merkezi, TAB Bülteni, 1998. **13-14**: p. 19-43.
2. Baytop, T., *Türkçe bitki adları sözlüğü.* Türk Dil Kurumu Yayınları, Ankara, Türkiye, 1994, 578: p. 508.
3. Zeybek, N. and Zeybek, U., *Farmasötik Botanik.* Ege Üniversitesi Eczacılık Fakültesi, İzmir, Türkiye, 1994, 2-436.
4. Diederichsen, A., *Promoting the conservation and use of underutilized and neglected crops 3 coriander*, 1996. Instutute of Plant Genetics and Crop Plant Research. Gatersleben/ International Plant Genetic Resources Institute, ISBN. 92-9043-284-5.
5. Yamanol, A., *Kişniş (Coriandrum sativum* L.*)'nin farklı ekim zamanı ve tohumluk miktarının agronomik ve teknolojik özellikleri üzerine olan etkisi*. Yüksek Lisans Tezi, Ege Üniversitesi, Fen Bilimleri Enstitüsü, 1996.
6. Bhatnagar, S.S., *Coriandrum* Linn. *(Umbelliferae).* A Dictionary of Indian Raw Materials and Industrial Research, New Delhi, 1950. p. 455-461.
7. Andriesse, J.P., *Nature and Management of Tropical Peats. FAO Soils Bulletin 59*. 1998. FAO, Rome. ISBN:92-5-102657-2: p.165.
8. Lobartini, J.C., Orioli, G.A. and Tan, K.H., *Characteristics of soil humic acid fractions separated by ultrafiltration*. Communication in Soil Science and Plant Analyses, 1997. **28**:p.787-796.
9. Siviero, P., Sandei, L., and Colombi, A., *Results of applying leonardite and humic asids to processing tomatoes.* Informarore Agrario,1996. **52**: p. 57-60.
10. Kononova, M.M., *Soil organic matter, its nature, its role in soil formation and soil fertility.* 1961. Pergamon Press Ltd. Lib. Oxford.
11. Sözüdoğru, S., Kütük, A.C., Yalçın, R. and Usta, S., *Humik asidin fasulye bitkisinin gelişimi ve besin maddeleri alımı üzerine etkisi.* Ankara Üniversitesi, Ziraat Fakültesi, Ankara, Türkiye, 1996, 1452.
12. Karaca, A., *Kişniş ve rezene bitkilerinde fenolojik, morfolojik ve bazı teknik özellikler üzerinde çalışmalar.* Yüksek Lisans Tezi, Odokuz Mayıs Üniversitesi, Fen Bilimleri Enstitüsü,1998.
13. Kaya, N., Yılmaz, G. and Telci, İ. *Farklı Zamanlarda Ekilen Kişniş (Coriandrum sativum* L.*) Populasyonlarının Agronomik ve Teknolojik Özellikleri.* Turkish Journal of Agriculture, 2000. **24**: p. 355-364.
14. Özcan, R., *Seçilmiş kişniş (Coriandrum sativum* L.*) hatlarının verim ve verim öğeleri üzerine bir araştırma.* Yüksek Lisans Tezi, Ankara Üniversitesi, Fen Bilimleri Enstitüsü, 2001.
15. Kandemir, K., *Farklı azot dozu ve sıraaralığının kişnişin verim ve verim unsurları üzerine etkisi.* Yüksek Lisans Tezi, Ordu Üniversitesi, Fen Bilimleri Enstitüsü, 2010.
16. Kızıl, S. and İpek, A., *Bazı Kişniş (Coriandrum sativum*

L.*) hatlarında farklı sıra arası mesafelerinin verim, verim özellikleri ve uçucu yağ oranı üzerine etkileri.* Tarım Bilimleri Dergisi, 2004.**10**: p. 237-244.

17. Okut, N. and Yıldırım, B., *Effecet of different row spacing and nitrogen doses on certain agronomik characteristic of coriander (Coriandrum sativum* L.*).* Pakistan Journal of Biological Sciences, 2005. **8**(6): p. 901-904.
18. Özel, A., Güler, İ. and Erden, K. *Harran Ovası koşullarında farklı ekim zamanlarının kişniş (Coriandrum sativum* L.*)'in verim ve bitkisel özelliklerine etkisi*. HR.Ü. Ziraat Fakültesi Dergisi, 2009. **13**(4): p. 41-48.
19. Gök, N., *Farklı zamanlarda ekilen kişniş (Coriandrum sativum* L.*) çeşitlerinin verim ve kalite özelliklerinin belirlenmesi.* Yüksek Lisans Tezi, Yüzüncü Yıl Üniversitesi, Fen Bilimleri Enstitüsü, 2011.
20. Uzun, A., Özçelik, H.and Özden, Y.G., *Orta Karadeniz Bölgesi için geliştirilen kişniş (Coriandrium sativum* L.*) çeşitlerinin bazı tarımsal özelliklerinin belirlenmesi, verim ve uçucu yağ oranının stabilite analizi.* GOÜ, Ziraat Fakültesi Dergisi, 2010. **27**: p. 1-8.
21. Gül, Ö., *Kişniş (Cariandrum sativum L.)'de farklı ekim sıklığının verim ve uçucu yağ oranı üzerine etkisi*. Yüksek Lisans Tezi, Çukurova Üniversitesi, Fen Bilimleri Enstitüsü,1995.
22. Kan, Y. and İpek A., *Kişniş (Coriandrum sativum* L.*) verim ve bazı özellikleri.* 2002. 14. Bitkisel İlaç Hammaeddeleri Toplantısı,Eskişehir, ISBN: 975-94077-2-8.
23. Karaca, A. and Kevseroğlu, K.., *Kişniş (Coriandrum sativum* L.*) ve Rezene (Foeniculum vulgare* Mill.*) Bitkilerinde Bazı Önemli Fenolojik, Morfolojik Özellikler Üzerine Bir Araştırma.* Türkiye 4. Tarla Bitkileri Kongresi, Tekirdağ, 2001, 243-248.
24. Gergerli, B., *Harran Ovası koşullarında kişniş (Coriandrum sativum* L.*)'de uygun ekim zamanının belirlenmesi.* Yüksek Lisans Tezi, Harran Üniversitesi, Fen Bilimleri Enstitüsü, 2002.
25. Tunçtürk, R., *Kişniş (Coriandrium sativum* L.*) çeşitlerinde değişik ekim mesafelerinin verim ve kalite üzerine etkisi.* Yüzüncü Yıl Üniversitesi, Tarla Bitkileri Dergisi, 2011. **21**(2): p. 89-97.
26. Bahadırlı , N.P., Türkmen, M. and Mert, A., *Hatay koşullarında yetiştirilen aşotu* (*Coriandrum sativum* L.) *bitkisinin uçucu yağ oranlarının ve içeriklerinin belirlenmesi.* Biyoloji Bilimleri Araştırma Dergisi, 2016. **9** (2): p.20-22.
27. Yalçın, Z., *Bazı kişniş genotiplerinin (Coriandrum sativum* L.*) Erzurum ekolojik koşullarında verim ve başlıca tarımsal özellikleri*. Yüksek Lisans Tezi, Atatürk Üniversitesi, Fen Bilimleri Enstitüsü, 2016.
28. Beyzi, E. and Gunes, A., *Kişniş* (*Coriandrum sativum* L.) *Bitkisinin Uçucu Yağ Bileşenleri Üzerine Bor Uygulamasının* Etkileri. Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi, 2017. **34**(1):p.146-152.
29. Demircan, F., *Kişniş (Coriandrum sativum* L.*) de sıra arası mesafesinin verim ve kaliteye olan etkisi.* Yüksek Lisans Tezi, Ege Üniversitesi, Fen Bilimleri Enstitüsü, 1997.
30. Ravi, R., Prakash, M. and Keshava Bhat, K., *Aroma characterizasyon of coriander (Coriandrum sativum* L.*) oil sampels.* European Food Research and Technology, 2007. **225**: p. 367-374.
31. Kırıcı, S., Mert, A. and Ayanoğlu, F., *Hatay ekolojisinde azot ve fosforun kişniş (Cariandrum sativum* L.*) verim değerleri ile uçucu yağ oranlarının etkisi.* II. Tarla Bitkileri Sempozyumu. Samsun, 1997, 347-351.
32. Lobartini, J.c., Orioli, G.A. and Tan, K.H., *Characteristic of soil humic asid fractions sparated by ultrafiltration.* Communications in Soil Science and Plant Analysis, 1997. **28**(9-10): p. 787-796.
33. Ergönül, U., *Ayçiçeği (Helianthus annuus* L.*) çeşitlerine uygulanan humik asit ve leonardit'in verim, verim öğeleri üzerine etkileri.* 2011. Yüksek Lisans Tezi, Ankara Üniversitesi, Fen Bilimleri Enstitüsü, 2011.