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Influence of Organic and Inorganic Fertilizers on Coriander (*Coriandrum sativum* L.) Agronomic Traits, Essential Oil and Components under Semi-Arid Climate

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Abstract: Environmental contamination and the excessive use of inorganic fertilizers resulting in stagnant yields of field crops which necessitate the utilization of combined fertilization approach under changing climatic conditions. Current study was aimed to clarify the influence of several fertilizer sources (chemical, organic, organomineral fertilizers) on yield and quality of coriander (*Coriandrum sativum* L.). The results revealed that the fertilizer sources significantly affected the yield of coriander cultivars. The absence of "Year × Variety × Fertilizer Type" interactions for any of the noted parameters signaled that the detected "Variety × Fertilizer Type" interactions were constant regardless of the year factor. The recorded values of traits according to fertilizer sources different for the plant height from 61.85 to 69.67 cm, number of branches from 5.98 to 7.71 (piece/plant), number of umbels per the main umbel from 5.62 to 7.18 pieces, seed yield from 1.06 to 1.66 t/ha^{-1}, the biological yield from 4.29 to 5.70 t ha^{-1}, harvest index from 25.29 to 29.41%, essential oil ratio from 0.29 to 0.33%, and essential oil yield from 3.1 to 5.6 L ha^{-1}. Erbaa variety was observed to be superior over the rest of the varieties producing the maximum values of 6.5 L ha^{-1} of essential oil, 0.36% essential oil content, 30.9% harvest index, 1.81 t/ha seed yield, and 5.9 t ha^{-1} biological yield with the treatment of chemical fertilizers.

Keywords: *Coriandrum sativum*; chemical fertilizer; organic fertilizer; yield; yield components; seed oil quality

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1. Introduction

Coriander (*Coriandrum sativum* L.) also called Cilantro, Arab parsley, Chinese parsley, or Kasbour [1], belongs to the family of Apiaceae (Umbelliferae) [2]. It is an annual herbaceous plant that initiated from the Mediterranean and Middle Eastern regions [3,4]. Plant grown widely all over the world [5]. It has been cultivated for many years in several regions of Iran [6] and Turkey [7]. Coriander or cilantro are the fruit and herb of *Coriandrum sativum* [8] known for their special fragrance. Coriander oil is a major essential oil in the global market [9]. Global coriander productivity has the largest volume as essential oil seed crops. The leafy vegetable form is becoming progressively popular in the world. Advanced breeding targets are focused on the industrial extraction of their essential oil from fruits but dual-purpose (for fruit and leaf) and sole leaf use also exist [10]. The extractable essential oil content of fruits ranges between 0.5 to 2.5% to be used as flavors to manufacture perfumes and soaps [5]. The essential oil and its main constituent, linalool is an very significant raw material in the perfume and cosmetic products, in addition, the essential oil percent of dried fruits varies from the minimum value (0.03%) to a maximum value of 2.7% [3]. Plant contains monoterpenes, limpnene, α-pinene, γ-terpinene, p-cymene, citronellol, borneol, camphor, coriandrin, geraniol, dihydrocoriandrin, coriandrons A–E, flavonoids and essential oils. Terpenoids are a large and diverse class of specialized metabolites essential for the growth and development of plants. The mericarps of coriander produce an essential oil-rich in monoterpenes (volatile C10 terpenoids) which have numerous industrial applications [11].

Fresh edible herbs represent a faster-growing market for gourmet production globally [12]. Coriander foliage is a daily spice in curry in Indian conventional foods [13]. It is a flavoring agent in food products for flavoring sweets, beverages, tobacco, bakery and curry powder [5]. Essential oils and extracts of *C. sativum* are non-toxic to humans but have various degrees of antibacterial, antifungal, antioxidative and preservative activities, which progress the shelf-life of foods [14]. Essential oils are natural and safe antioxidants and substitutes for synthetic antioxidants in food processing [15]. Plants foliage is rich in natural folates, which turns it into a natural vitamin B9 source [16]. Its seeds, leaves, and roots are edible. The herb has a light and fresh flavor. But leaves have a various taste than seeds. The source of the flavor of coriander is the significantly superior content of linoleic and furanocoumarins (coriandrin and dihydrocoriandrin) in its essential oil [17].

The popularity of conventional herbal medicines is increasing each year [18]. Coriander has antioxidant, anticancer, hypolipidemic, neuroprotective, anticonvulsant, analgesic, migraine-relieving, hypoglycemic, hypotensive, anxiolytic, antimicrobial, and antiinflammatory activities. The main compound linalool is abundant in seeds, and it's has shown a wide variety of biological activities and health benefits. It is also protective against neurodegenerative diseases, cancer, and metabolic syndrome [19]. Its ethnopharmacological use is to heal inflammatory disorders, altered blood lipid levels, respiratory and digestive problems [20]. All parts of the plant have medicinal substance, but seed oil is special in folk medicine to treat anxiety and depression [21]. The whole plant is mainly used for renal ailments diseases worldwide [22]. It has analgesic, carminative, digestive, anti-rheumatic, and antispasmodic charecters, [5]. Its nervous system activities find a place in Iranian conventional medicine [23].

C. sativum is a summer annual plant [24]. It is cultivated worldwide, and cultivar, soil nutrients, or agronomical training affect this crop significantly [25]. Its yields and chemical structures of the main bioactive constituents get influenced by genotype, variety, season, ecotype, climate, growth stage, plant part, harvesting time, and extracting process [26]. The study of Beyzi et al. [27] investigated the biochemical and bioactive properties of four different varieties from Turkey (Arslan, Gamze, Gürbüz, and Erbaa). The greatest crude oil content was extracted from the Gamze cultivar. Petroselinic acid was noted as a major fatty acid for all cultivars. The highest amount of total phenolic compounds was extracted from Arslan cultivar.

The role of N fertilization on coriander seed yield is important, but research on this topic is lacking [28]. Knowledge of organic and organomineral fertilizer studies in coriander is very limited. In a study, the application of vermicompost (7.5 t ha^{-1}) + 25% recommended NPK (25:12.5:12.5 kg ha^{-1}) produced the maximum biomass, seed yield, and oil yield of coriander [29]. Darzi [30] realized that the highest umbel number per plant, biomass yield, and essential oil yield were obtained with consumption of 15 t ha^{-1} cattle manure. Effect of nutrient application through organic sources on the growth, yield, and quality of coriander was studied resulting that the highest plant height, number of primary and secondary branches, number of umbels/plant, number of umbelets/umbel, number of seeds/umbel, the weight of 1000 seeds and seed yield were documented with the combination of organic sources of FYM 25% (5 t ha^{-1}) + Vermicompost 75% (3.75 t ha^{-1}) [31].

This study aimed to assess the effects of various fertilizer sources (chemical, organic, organomineral) on the yield and quality of coriander cultivars under semi-arid conditions of the Southeastern Anatolia Region of Turkey.

2. Materials and Methods

The experiment was conducted in 2017–2019, growing seasons at the province of the Southeastern Anatolia Region, which is located in the semi-arid climate zone of Turkey. After analyzing the climatic data of the trial location, it was measured that by average temperature for the vegetation period (November-June) was slightly higher but total precipitation was lower in the first year compared to the second year. The total amount of precipitation in the first year of the research was below the long-term average and much higher in the second year (Table 1).

Table 1. Main climate data of the research site for the long term (1981–2019) and for the trial years [32].

	Average Temperature (°C)			Relative Humidity (%)			Total Precipitation (mm)		
	Long Term	2017–2018	2018–2019	Long Term	2017–2018	2018–2019	Long Term	2017–2018	2018–2019
November	10.6	11.2	11.0	72.3	64.4	76.2	74.3	85.2	93.6
December	5.1	8.0	6.6	67.1	65.2	82.4	90.6	46.8	188.6
January	3.2	5.7	4.0	72.5	70.5	72.5	81.3	65.0	94.4
February	4.7	8.2	5.8	67.3	67.7	66.9	96.4	75.6	110.6
March	9.1	13.7	8.3	61.3	55.9	67.4	108.8	47.2	185.2
April	14.2	16.8	11.9	58.3	47.6	66.8	101.7	60.8	167.0
May	19.7	19.8	21.9	50.2	59.1	42.1	63.8	146.8	1.3
June	26.5	27.4	29.1	34.2	31.7	26.9	9.4	3.0	0.0
Total/Average	11.6	13.9	12.3	60.4	57.8	62.7	626.3	530.4	840.7

Some physical and chemical properties of the soil samples taken from fields at a depth of 0–20 cm before trials is given in Table 1. Study soils were in clay texture, slightly alkaline and non-saline with low organic matter content, medium lime content, very low available phosphorus content, and sufficient available potassium content (Table 2).

Table 2. Major physical and chemical properties of the trail field soils (0–20 cm).

Soil Properties	Values	
	2017–2018	2018–2019
Clay (%)	55.84	58.00
Sand (%)	7.90	14.00
Silt (%)	36.26	28.00
pH	7.98	7.95
Organic matter (%)	1.31	1.58
Lime ($CaCO_3$) (%)	13.0	10.5
Electrical conductivity (dS m^{-1})	0.363	0.575
Available Phosphorus (P) (kg P_2O_5 ha^{-1})	29	35
Available Potassium (K) (kg K_2O ha^{-1})	1350	1180

Analyzes were conducted in Siirt University Science and Technology Application and Research Center Laboratory.

In the experimental field, after wheat harvesting, the field was plowed and prepared for planting. Coriander varieties "Arslan" and "Erbaa" were used in the research as planting material. The experiments were established in a split-plot design with four replications. Four rows were planted in each plot with a 30 cm inter-row distance. The plot length was 4 m, and the parcel area was 1.2 m × 4 = 4.8 m^2. Distance between the parcels and blocks was 1 m. Two varieties were placed in the main plots, and four types of fertilizers management viz., control (zero fertilizer), chemical fertilizer, organomineral fertilizer, and vermicompost were placed in the sub-plots.

Pre-sowing soil analysis was performed for the determination of the chemical and organomineral fertilizers amount to be applied. We applied P_2O_5 at 60 kg ha^{-1} as a form of triple superphosphate (42% P_2O_5) and mixed it into the soil in planting time for the chemical fertilizer. Half of the nitrogen (N) fertilizer was given in planting, while the second half was applied during the stem elongation period, with an account of 80 kg N ha^{-1} in the form of urea (46% N). Potassium fertilizer was not applied because the soil of the study area contains sufficient potassium. Organomineral fertilizer application parcels received 20-15-0% solid organomineral fertilizer during planting and then solid organomineral fertilizer containing 30% N at the stem elongation period. Vermicompost (solid worm manure) was used as an organic fertilizer and applied to the soil 15 days before planting at a 3 t ha^{-1} rate. Specifications of the vermicompost used in the study were as follows: EC value = 3.2 dS m^{-1}, pH value = 6.8, organic matter content = 57%, total nitrogen (N) content = 3.1%, C/N ratio = 9.2, total P (P_2O_5) content = 1.2%, water-soluble K_2O = 0.89%.

The coriander seed was sown manually to the lines at 20 kg ha^{-1}. Sowing was done on 09th November, 2017 and 07th November, 2018. Hand weeding was done several times to control weeds in both years. No irrigation was applied as spring rains were sufficient. The harvesting was performed at the yellowish-brown seed stage. The middle two rows in each parcel were harvested and used for yield data collection.

Plant height (cm), number of branches (pieces/plant), number of umbelets per the main umbel (pieces), thousand seed weight (g), seed yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index (%), essential oil ratio (%), and essential oil yield (L ha^{-1}) properties were investigated in the study. The essential oil ratio was determined by the water-steam distillation method in the Neo-Clevenger appliance. The essential oil ratio was determined by adding 500 mL of distilled water to the grounded 50 g seed sample and boiling at 130 °C for 4 h. Components of the essential oil were determined by using gas chromatography. Operating conditions of the device were: System: Thermo Fisher Scientific, Austin, TX; Colon: Thermo TG-WAXMS GC colon (60 m × 0.25 mm ID × 0.25 um); Temperature Program: 10 min at 60 °C//4 °C/min increments until 230 °C//10 min at 230 °C//1 °C/min increments until 250 °C; Injector: 250 °C; Carrier Gas: Helium (1.2 mL/min); Mass spectral scanning range: 55–550 (amu); Peak identification was performed by comparison of stored known components in NIST Demo, Wiley7, Wiley9, redlip, mainlip, WinRI (NIST, Gaithersburg, MD, USA).

The data obtained from the study were subjected to the homogeneity test, and the analysis of variance, which was combined with the data found homogeneous according to the random blocks trial design was performed using the JMP 5.0 statistical program. Differences between groups was tested via F test and means were determined by Tukey's multiple comparison test at 0.05 significance level [33].

3. Results and Discussion

Fertilizer sources and the variety significantly influenced the plant height of the coriander. However, their interactions were not significant (Table 3). Considering the fertilizer sources, the lowest (61.85 cm) and the highest (69.67 cm) plant height was obtained from control and chemical fertilizers, respectively. Considering the variety, the Erbaa produced a taller plant (76.50 cm) than the Arslan variety (35.03 cm). It is thought that the differences between the cultivars in terms of plant height are due to the diverse genotypic structures of the cultivars. These variations can be attributed to differnt factor like climatic conditions, species and growing conditions [34].

Number of branches was different for cultivars. The two-year average number of branches of the Erbaa variety (7.2 pieces) was higher than the value of the Arslan variety (6.6 pieces) (Table 4). Application of various types of fertilizer influenced the number of branches per plant. Plants under control conditions produced the lowest number of branches (5.98 pieces), while the highest number of branches (7.71 pieces) were achieved from the plants treated with chemical fertilizers (Table 4). Various types of fertilizer distinguished the number of umbelets per plant. The lowest number of umbelets per umbel (5.62 pieces) was achieved by control application. Other applications produced a group of higher similar values (Table 5). As it is known, the number of branches and umbelet are a feature depends on the genotype, but they are greatly affected by the ecological conditions and cultivation techniques in which the plant grows [35].

The year significantly influenced the biological yield of coriander. The average biological yield (5.42 t ha^{-1}) was higher in the second year than the first year (4.55 t ha^{-1}) (Table 6).

Table 3. Effect of fertilizer types on plant height of coriander varieties (cm) [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
Year 2017–2018					
Arslan	53.13	58.53	53.80	57.20	55.67
Erbaa	69.20	80.33	76.27	74.27	75.02
Averages	61.17	69.43	65.03	65.73	65.34
Year 2018–2019					
Arslan	51.42	56.67	55.39	54.13	54.40
Erbaa	73.63	83.13	77.87	77.30	77.98
Averages	62.52	69.90	66.63	65.72	66.19
Averages					
Arslan	52.28	57.60	54.59	55.67	55.03 b
Erbaa	71.42	81.73	77.07	75.78	76.50 a
Averages	61.85 C	69.67 A	65.83 B	65.73 B	
Level of Significance					
Year (Y): 0.4023, Variety (V): 0.0001 **, Fertilizer Types (FT): 0.0001 **, Y × V: 0.0806, Y × FT: 0.8387, V × FT: 0.0819, Y × V × FT: 0.3968					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant.
**: Significant at $p < 0.01$ level.

Table 4. The effect of fertilizer types on the number of branches in coriander varieties (pieces) [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
Year 2017–2018					
Arslan	6.20	7.07	6.72	5.97	6.49
Erbaa	6.56	8.04	7.54	7.72	7.47
Averages	6.38	7.56	7.13	6.84	6.98
Year 2018–2019					
Arslan	5.52	7.64	6.98	6.59	6.68
Erbaa	5.65	8.07	7.41	6.73	6.97
Averages	5.58	7.86	7.20	6.66	6.82
Averages					
Arslan	5.86	7.36	6.85	6.27	6.58 b
Erbaa	6.10	8.06	7.47	7.23	7.22 a
Averages	5.98 D	7.71 A	7.16 B	6.75 C	
Level of Significance					
Year (Y): 0.3460, Variety (V): 0.0117 *, Fertilizer Type (FT): 0.0001 **, Y × V: 0.0718, Y × FT: 0.0784, V × FT: 0.3200, Y × V × FT: 0.2642					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant.
*: Significant at $p < 0.05$ level, **: Significant at $p < 0.01$ level.

Table 5. The effect of fertilizer types on the number of umbelets per umbel in coriander varieties (pieces) [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
Year 2017–2018					
Arslan	5.63	5.89	6.44	6.65	6.15
Erbaa	5.72	8.28	7.44	6.71	7.04
Averages	5.68 bc	7.08 a	6.94 ab	6.68 abc	6.59
Year 2018–2019					
Arslan	5.40	5.90	6.27	6.16	5.93
Erbaa	5.76	8.67	8.30	7.39	7.53
Averages	5.58 c	7.28 a	7.28 a	6.78 abc	6.73
Averages					
Arslan	5.52 d	5.89 cd	6.35 cd	6.41 cd	6.04
Erbaa	5.73 d	8.47 a	7.87 ab	7.05 bc	7.28
Averages	5.62 B	7.18 A	7.11 A	6.73 A	
Level of Significance					
Year (Y): 0.8043, Variety (V): 0.0729, Fertilizer Type (FT): 0.0001 **, Y × V: 0.6593, Y × FT: 0.2049, V × FT: 0.0885, Y × V × FT: 0.3654					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant.
**: Significant at $p < 0.01$ level.

Table 6. Effect of fertilizer types on biological yield of coriander varieties (t ha^{-1}) [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
Year 2017–2018					
Arslan	3.41	4.75	4.20	3.94	4.07
Erbaa	4.52	5.56	5.03	5.01	5.03
Averages	3.96	5.15	4.62	4.47	4.55 b
Year 2018–2019					
Arslan	4.09	6.32	5.44	5.23	5.27
Erbaa	5.13	6.18	5.66	5.36	5.58
Averages	4.60	6.25	5.55	5.30	5.42 a
Averages					
Arslan	3.74 e	5.53 ab	4.82 cd	4.58 d	4.67
Erbaa	4.82 cd	5.87 a	5.35 abc	5.19 bc	5.30
Averages	4.29 C	5.70 A	5.08 B	4.88 B	
Level of Significance					
Year (Y): 0.0320 *, Variety (V): 0.0793, Fertilizer Type (FT): 0.0001 **, Y × V: 0.3018, Y × FT: 0.2656, V × FT: 0.0209 *, Y × V × FT: 0.1951					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant.
*: Significant at $p < 0.05$ level, **: Significant at $p < 0.01$ level.

Chemical fertilizers produced the highest biological yield (5.70 t ha^{-1}) and the lowest (4.29 t ha^{-1}) biological yield was achieved in by control condition where no treatment was applied (Table 6).

The interaction of variety × types of fertilizer significantly affected the biological yield. The highest biological yield (5.87 t ha^{-1}) was produced with chemical fertilizer in Erbaa variety, and the lowest (3.74 t ha^{-1}) was in the control condition in the Arslan variety. However, values achieved with the organomineral application to the Erbaa variety and chemical fertilizer to the Arslan variety was close to the highest value (Table 6).Application of vermicompost (7.5 t ha^{-1}) + 25% advised NPK (25:12.5:12.5 kg ha^{-1}) acjieved the greatest biomass, seed yield, and oil yield of coriander [29].

Climate had effectively influenced the seed yield. The average seed yield of the second year (1.47 t ha^{-1}) was higher than the value of the first year (1.33 t ha^{-1}) (Table 7). The climatic variances clarify the responses of all coriander cultivars were produced high fruit yield to the conditions [34].

Table 7. The effect of fertilizer types on seed yield of coriander varieties (t ha^{-1}) [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
Year 2017–2018					
Arslan	0.99	1.44	1.32	1.23	1.25
Erbaa	1.04	1.72	1.54	1.38	1.42
Averages	1.02	1.58	1.43	1.31	1.33 b
Year 2018–2019					
Arslan	1.05	1.60	1.47	1.40	1.38
Erbaa	1.17	1.89	1.68	1.51	1.56
Averages	1.11	1.74	1.57	1.46	1.47 a
Averages					
Arslan	1.02 f	1.52 c	1.39 de	1.32 e	1.31 b
Erbaa	1.11 f	1.81 a	1.61 b	1.45 cd	1.49 a
Averages	1.06 D	1.66 A	1.50 B	1.38 C	
Level of Significance					
Year (Y): 0.0233 *, Variety (V): 0.0093, Fertilizer Type (FT): 0.0001 **, Y × V: 0.9347, Y × FT: 0.3462, V × FT: 0.0001 **, Y × V × FT: 0.4961					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant.
*: Significant at $p < 0.05$ level, **: Significant at $p < 0.01$ level.

The two-year average seed yield of Erbaa variety (1.49 t ha^{-1}) was higher than the value of the Arslan variety (1.31 t ha^{-1}) (Table 7). The chemical fertilization significantly improved the seed yield. The lowest (1.06 t/ha) and the highest (1.66 t ha^{-1}) seed yields were observed with control application and chemical fertilizer application, respectively (Table 7). Variety × fertilizer type interaction was significant on the seed yield. The lowest seed yield values (1.02 and 1.11 t ha^{-1}) were obtained with the control applications in Arslan and Erbaa varieties, respectively.Instead, the highest seed yield value (1.81 t ha^{-1}) was obtained with chemical fertilizer to Erbaa variety (Table 7). An increase in seed yield occurred with increasing rainfall in the second year. Types of fertilizer had a significant effect on the harvest index. However, the lowest harvest index value (25.29%) was found with the control application. Other applications produced a group of higher similar values (Table 8). It was found that the maximum biomass yield, and essential oil yield were produced by using of 15 t ha^{-1} cattle manure [30].

"Variety × Fertilizer Type" interaction was significant on harvest index. The lowest (23.04%) and the highest (30.86%) harvest index values were produced by control application of Erbaa variety and chemical fertilizer application of Erbaa variety, respectively.Though, all applications treatments except the control application of both varieties produced values near to the highest value (Table 8). The essential oil ratio was different for the cultivars; the two-year average oil ratio of the Erbaa variety (0.34%) was higher than the value of the Arslan variety (0.29%) (Table 9). Nutrient supplementation through organic sources on the quality of coriander was studied resulting that the maximum oil ratio as recorded with the combination of organic sources of FYM 25% (5 t ha^{-1}) + Vermicompost 75% (3.75 t ha^{-1}) [31].

Table 8. The effect of fertilizer types on the harvest index of coriander varieties (%) [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
			Year 2017–2018		
Arslan	29.35	30.57	31.93	31.78	30.91
Erbaa	23.19	30.98	30.65	27.87	28.17
Averages	26.27	30.77	31.29	29.83	29.54
			Year 2018–2019		
Arslan	25.75	25.37	27.43	27.11	26.42
Erbaa	22.89	30.73	29.78	28.24	27.91
Averages	24.32	28.05	28.61	27.68	27.16
			Averages		
Arslan	27.55 c	27.97 bc	29.69 abc	29.45 abc	28.66
Erbaa	23.04 d	30.86 a	30.22 ab	28.06 bc	28.04
Averages	25.29 B	29.41 A	29.95 A	28.75 A	
			Level of Significance		
Year (Y): 0.1867, Variety (V): 0.6978, Fertilizer Type (FT): 0.0001 **, Y × V: 0.2297, Y × FT: 0.9545, V × FT: 0.0014 **, Y × V × FT: 0.9337					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant. **: Significant at $p < 0.01$ level.

Table 9. The effect of fertilizer types on the essential oil ratio of coriander varieties (%) [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
			Year 2017–2018		
Arslan	0.27	0.31	0.30	0.29	0.29
Erbaa	0.31	0.35	0.35	0.34	0.34
Averages	0.29	0.33	0.32	0.32	0.31
			Year 2018–2019		
Arslan	0.28	0.31	0.30	0.30	0.30
Erbaa	0.30	0.37	0.35	0.34	0.34
Averages	0.29	0.34	0.33	0.32	0.32
			Averages		
Arslan	0.27 d	0.31 c	0.30 c	0.30 c	0.29 b
Erbaa	0.31 c	0.36 a	0.35 ab	0.34 b	0.34 a
Averages	0.29 C	0.33 A	0.32 B	0.32 B	
			Level of Significance		
Year (Y): 0.1976, Variety (V): 0.0001 **, Fertilizer Type (FT): 0.0001 **, Y × V: 0.8722, Y × FT: 0.3438, V × FT: 0.0107 *, Y × V × FT: 0.2295					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant. *: Significant at $p < 0.05$ level, **: Significant at $p < 0.01$ level.

Fertilizer type was distinguished the essential oil ratio; the lowest (0.29%) and the highest value (0.33%) of oil ratio was obtained with the control and chemical fertilizer application, respectively (Table 9). "Variety × Fertilizer Type" interaction was significant on oil ratio. The lowest (0.27%) and highest (0.36%) oil content values were produced by control application of Arslan variety and by chemical fertilizer application of Erbaa variety, respectively. In addition, the organomineral fertilizer application of the Erbaa variety also produced a value near to the highest value (Table 9). Beyzi et al. [27] reported that, the oil contents of different coriander varieties can be affected by the fruit size. Small-fruit types contain higher oil compared with large-fruited types and the oil composition of seeds can be affected by several factors, such as genetic structure, climatic conditions, soil macro and micronutrient, and agricultural applications [34]. Climate was effective on seed yield; average oil yields in the second year (4.8 L ha^{-1}) were higher than the in first year (4.3 L ha^{-1}) (Table 10). Application organic sources on the oil yield and quality of crop was studied resulting that the highest plant oil yield was documented with the combination of organic sources of FYM 25% (5 t ha^{-1}) + Vermicompost 75% (3.75 t ha^{-1}) [31].

Table 10. Effect of fertilizer types on essential oil yield of coriander varieties (L ha^{-1}). [1].

Varieties	Fertilizer Types				Averages
	Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer	
Year 2017–2018					
Arslan	2.7	4.4	3.9	3.6	3.7
Erbaa	3.2	6.0	5.4	4.8	4.8
Averages	3.0	5.2	4.6	4.2	4.3 b
Year 2018–2019					
Arslan	2.9	5.0	4.4	4.2	4.1
Erbaa	3.5	6.9	5.9	5.2	5.4
Averages	3.2	6.0	5.2	4.7	4.8 a
Averages					
Arslan	2.8 f	4.7 c	4.1 d	3.9 d	3.9 b
Erbaa	3.4 e	6.5 a	5.7 b	5.0 c	5.1 a
Averages	3.1 D	5.6 A	5.0 B	4.5 C	
Level of Significance					
Year (Y): 0.0237 *, Variety (V): 0.0010 **, Fertilizer Type (FT): 0.0001 **, Y × V: 0.7442, Y × FT: 0.0567, V × FT: 0.0001 **, Y × V × FT: 0.4098					

[1] The difference between the averages represented with the same letter in the same column/same group is not statistically significant.
*: Significant at $p < 0.05$ level, **: Significant at $p < 0.01$ level.

Essential oil yield different across cultivars; the two-year average oil yield of the Erbaa variety (5.1 L ha^{-1}) was higher than the Arslan variety (3.9 L ha^{-1}) (Table 10). Fertilizer type was differentiated from the essential oil yield; lowest (3.1 L ha^{-1}) and highest (5.6 L ha^{-1}) oil yield values were achieved by control and chemical fertilizer application, respectively (Table 10). "Variety × Fertilizer Type" interaction was significant on essential oil yield. The lowest (2.8 L ha^{-1}) and the highest (6.5 L ha^{-1}) essential oil yield values were produced by control application of Arslan variety and chemical fertilizer application of Erbaa variety, respectively (Table 10). In essential oils, 12 components were determined in the Arslan variety in both years, whereas ten components in the first year and 8 components in the second year were determined in the Erbaa variety (Tables 11 and 12). It was reported that oil composition was sensitive to the year variation in climate conditions as well as in soil conditions [35].

Linalool was the dominant essential oil component for both coriander varieties. Linalool content of the Arslan variety was between 69.62–73.17% in the first year and 73.40–75.91% in the second year in relation to fertilizer type. In the Erbaa variety, the ratio of the linalool component was between 80.46–82.80% in the first year and 85.03–90.12% in the second year. Beyzi et al. [27] stated that linalool, the main essential oil component, was found in the highest cultivar Erbaa. As a result of organomineral and organic fertilizer applications, a slight increase in linalool content was found in both coriander varieties in the study compared to the control. The linalool ratios obtained from coriander plants may vary depending on the cultivars and environmental conditions. Moreover, the fertilizers mediated transcriptional regulatory molecular mechanism behind the overall improvement in agronomic and nutritional traits is also important from the sustainability perspective [36].

Table 11. Essential oil components of Arslan coriander variety (%).

R.T *	Component Names	Fertilizer Types			
		Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer
		2017–2018			
14.45	dl-limonene	1.25	1.07	0.79	1.47
16.21	Ç-terpinene	6.81	6.32	5.17	5.02
17.19	Benzene, 1-methyl-2-(1-methylethyl)	2.36	1.81	1.47	1.80
25.13	Decanal	1.92	2.01	0.9	2.15
25.99	Camphor	3.11	1.55	2.05	1.55
26.53	Linalool	69.62	71.34	73.17	72.40
26.78	1-octanol	2.17	3.01	2.96	0.79
29.76	2-Decenal	0.64	0.98	0.76	0.51
32.86	1-Decanal	8.98	6.08	7.88	8.72
34.42	Cyclodecanol	1.00	1.92	1.24	1.97
34.42	Trans-2-dodecenil-ol	1.00	1.94	1.81	1.81
35.25	Geraniol	2.14	1.97	1.80	1.81
	Total	100.00	100.00	100.00	100.00
		2018–2019			
13.07	α-pinene	0.49	0.77	—	0.81
14.45	dl-limonene	1.31	1.44	1.09	0.51
16.21	Ç-terpinene	5.91	7.23	7.28	7.33
17.19	Benzene, 1-methyl-2-(1-methylethyl)	1.88	2.14	2.16	2.32
25.13	Decanal	1.20	1.52	1.00	2.16
25.99	Camphor	3.61	2.63	2.70	3.37
26.53	Linalool	73.40	74.76	75.81	75.44
26.78	1-octanol	1.43	1.62	2.38	
28.44	3-cyclohexen-1-ol, 4 methyl	1.20	0.77	1.00	1.00
32.86	1-Decanal	6.44	5.63	4.96	5.28
34.41	Trans-2-dodecenil-ol	0.83	—	0.53	0.86
35.25	Geraniol	2.30	0.97	1.09	0.92
	Total	100.00	100.00	100.00	100.00

* Retention time.

Table 12. Essential oil components of Erbaa coriander variety (%).

R.T *	Component Names	Fertilizer Types			
		Control	Chemical Fertilizer	Organomineral Fertilizer	Organic Fertilizer
		2017–2018			
14.45	dl-limonene	1.07	1.13	1.02	0.98
16.21	Ç-terpinene	5.09	5.32	4.46	4.84
17.19	Benzene, 1-methyl-2-(1-methylethyl)	1.81	1.44	1.29	1.48
25.13	Decanal	1.37	0.86	0.81	0.48
25.98	Camphor	1.55	2.74	1.46	2.18
26.56	Linalool	80.46	80.46	82.80	81.58
26.79	1-octanol	0.74	0.95	1.52	0.91
31.22	α-terpeniol	0.28	0.46	0.48	0.52
32.84	Nerol	5.96	5.06	4.65	5.55
35.25	Geraniol	1.67	1.58	1.51	1.48
	Total	100.00	100.00	100.00	100.00
		2018–2019			
14.45	dl-limonene	0.97	0.92	0.83	0.72
16.21	Ç-terpinene	5.32	4.37	2.43	2.11
17.19	Benzene, 1-methyl-2-(1-methylethyl)	1.35	1.07	—	0.62
25.98	Camphor	2.49	2.35	1.82	2.24
26.54	Linalool	85.03	86.26	90.12	89.04
26.79	1-octanol	—	—	—	0.69
32.84	Nerol	3.11	3.42	2.85	2.55
35.25	Geraniol	1.73	1.61	1.96	2.03
	Total	100.00	100.00	100.00	100.00

* Retention time.

4. Conclusions

In current study, coriander genotypes were assessed under various fertilizer applications in semi-arid conditions. Results showed that the different fertilizers had significant influences in coriander genotypes for yield, yield components, and essential oil content. An increase in seed yield occurred with increasing rainfall. Results concluded that Erbaa cultivar in Siirt ecological conditions produced the maximum seed yield. Organic and organo-mineral fertilizers, which are very important for soil fertility, decompose slowly in the soil. For this reason, their influences on yield and yield components appear in the long term compared to chemical fertilizers. Although chemical fertilizers achieved the greatest results in term of the properties assessed in our study, when considering soil fertility and environment, organomineral fertilizers can be used partially or completely instead of chemical fertilizers.

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