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The effect of changes of N, P, and Ca on *Coriandrum sativum L.*'s essence and its components

Mojgan Shoghi Jamil[1], Mahdis Ebrahimzade[2*], Mohammad Reza Hassandokht[3]

[1]*Department of Horticulture, Science and Researches Branch, Islamic Azad University, Tehran, Iran*

[2]*Department of Microbiology, Karaj Branch, Islamic Azad University, Karaj, Iran*

[3]*Department of Horticulture University of Tehran, Karaj, Iran*

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Abstract

Coriandrum sativum L. is classified as Apiaceae type plants. The plants of this family are famous because of having different active components such as extract oils. Regarding important role of macro nutrition in production of active components, present study considered essence content of *Coriandrum sativum L.* under 4 treatments (complete Hoagland, low Nitrate (N) Hoagland, low Phosphate (P) Hoagland, and full Calcium (Ca) Hoagland) after cultivating them in pots including perlite. This consideration was done after field cultivation of these plants, to compare their oil types and amounts. To do so, GC-MS was used after extraction from shoots, roots and seeds by Clevenger, and its components were identified. Linalool was determined as a main component which existed in shoots of cultivated samples in pots, cultivated plants if full Ca environment had the highest percentage of Linalool, similar results achieved about cultivated plants in filed format. In addition other components were identified such as Geraniol acetate, α-Pinene, and β-Bisabolol.

* **Corresponding Author:** Mahdis Ebrahimzade ✉ m_ebr1974@yahoo.com

Introduction

Coriandrum sativum L. is classified in Cariandrum genus and apiaceae family. Traditional use of this plant is two times more than its medical use. Its main oils are used in industry separately or in compound. One of the other benefits of this plant is the biological use of it. *Coriandrum sativum L.* has significant amount of sweat nectar, which absorbs insects and leads to pollination. Therefore, it has ecological and economic value. This plant is also melliferous.

Regarding Luk'janov and Reznikov and (1976) 500 kg honey can be achieved from one hector of *Coriandrum sativum L.* field. The use of *Coriandrum sativum L.*'s seed is referred to its chemical components. Its main component is volatile oils. The use of this plant as spice has been common since antiquity. In baking famous Russian bread "Borodinsky chelb" *Coriandrum sativum L.* is used. India is one of the biggest costumers of this plant. Today this plant is used as a curry powder which forms 20-40% of this powder (Pasey love, 1981). In India *Coriandrum sativum L.*'s fruits are used as a flavor in preparation of sausages, pickles, cookies and tobacco (Zargari, 1988).

Coriandrum sativum L. is also used in herbal medication as a carminative, anticonvulsant and antimicrobial drug. In addition this plant can be used for reducing blood sugar and changing carbohydrate metabolisms inside the body (Wichh, 1994; Anonymous, 1950; Asolkal, 1992; Chorpra, 1956; Chain, 2003; Gray and Flatt, 1992; Chithra and Lee Lamma, 2000; Yusef, 1994).

Volatile components in the oil are reported both in leaves can seeds which act as an obstacle for growth of micro organisms and fat peroxidation (Bhuigyan *et al.*, 2009; Girard and Mazza, 2002; Nayaraj and Santhanam, 2001; Yoshida and Tomita, 2002). *Coriandrum sativum L.*'s essence has antimicrobial and anti bacterial affects on Basilios bacteria with MIC equal to 1250 PPM (Ghaderi *et al.*, 2013).

Haj Hashemi *et al.* (2004) showed that this plant has anti-inflammatory effect. In a research different extracts with different polarity of leaves and seeds were considered to study antioxidant activities.

It was determined that *Coriandrum sativum L.*'s leaves have more strong pad oxidant activity than its seeds. In addition it was shown that seeds and leaves of this plant can trap radicals. The results showed that entrance of its leaves and seeds in our feed can present activity indirectly (Wanesteen *et al.*, 2004).

Chani (2003) asserted the presence of Bornyl, Geranyl, Phellandrene, Cymene, Pinen and Linalool compounds in *Coriandrum sativum L.* In other reports Linalol is identified as a main component (Tashinen and Leungan Faster, 1996; Colem and Lawrence, 1992; Pino, 1996; Nykahen, 1975).

The essence of mints' leaves has significant pad oxidant activity more than *Coriandrum sativum L.*
In addition the oils that extracted from leaves of these herbal plants have more Fenels and antioxidant activity than roots' essences (Juhoumi and Ghafoor, 2011).

In Telci (2006) report in ripe fruits the percentage of essence was relatively low (lower than 1%) and the oil mostly contains 50-60% Linalool and 20% Terpenes (Cymene, Limonene, α- Terpinene, γ- Terpinene, Phellandrene, Camphor, Mycin and Pinene).

The oil of *Coriandrum sativum L.*'s leaves included 44 compounds that mostly contains aromatic acids, 2-Decanoic acid (30.8%), Ell – tetra Decanoic acid 134%, Capric acid (12.7%) and Undeci alcohol 6.4%, 3-decanoic acid 5.5%, and Undecanoic acid 7.1% as main components. Seeds' essence contains 53 components which its main compounds included 37.7% of Linalool and 17.6% of Geraniol acetate and 4.14% γ-Tripinene (Bhuiggan *et al.*, 2009).

The aim of this study is cultivation of *Coriandrum sativum L.* in pot condition and 3 nutritional environments: low Nitrate, low phosphate, and full Ca consider essence content of plant and determine the

best environment for producing the essence.

Method and materials

Geographic coordinates

Present study was carried out as a greenhouse study in 2013 in Damavand. The geographical coordinate of study location were 35° latitude, 52.59// (longitude).

Cultivation

Integrated seeds of *Coriandrum sativum L.* were provided from "green plants of life" company with S121/12 code. Cultivation was done in both field and pot format. In field planting after drainage and land clearing, seeds were separated accidentally indifferent parts of field, then they were covered by soil.

Irrigation was done in daily base after sun set. Pot planting was done in a greenhouse with 27±1°C in pots that contained perlite. To do this consideration 4 series of cultivation environment was selected. Basic solvent for irrigation was Hoagland cultivation environment and for first series of samples (control) Hoagland solvent was used without any change. For second series of plants Hoagland solvent was used with lower amount of phosphate (the amount of phosphate was half of the amount of Hoagland).

For third series Hoagland solvent was used with low amount of Nitrate (Nitrate's amount was half of the Hoagland) and for the fourth series Hoagland solvent was used with high amount of Calcium (Ca amount was two times more than Hoagland) (Table 1).

For each series at least 6 pots were used and each pot contained 10-15 seed.

After cultivation, pots were put in basins that contained water. For 1 week or ten days (till germination happened and their height reached to 3 cm) basins were full of pure waster. After this time treatment solvents were prepared and for each 2 pots 250 m lit treatment solvent was added to basins. These solvents were added each 3 days and in the interval time irrigation was done by pure water as it was said before. Weed control was done daily and manually.

At the last stage, a lot of samples were prepared for extracting. To do so, samples became dry on a clean paper out of sun light and in room temperature. For this purpose, oven isn't recommended because it damages some parts of essences.

Essence extraction

To extract essence from this plant, distillation method with water vapor by the means of Clevenger was used. First, dried samples were mixed, and then they weighted and poured into the balloon. According to the weight of sample, proper volume of distilled water was added to it (for each 1 gr of dried plant, 12 m lit distilled water). Balloon was put on a heating source which was adjustable and Clevenger system was set on it. Before starting this stage, some amounts of distilled water plus hexane were solute (to solve extracted oil in hexane). Temperature should be set properly and made the liquid boiling. Cold water flew in Clevenger simultaneously with the start of heater. After 4 hours, extraction reached to its end. Water phase of pipe was thrown away; hexane phase plus extract were transferred to a clean vial and were dehydrated by sodium sulphate. Essences were kept in refrigerator till evaluation time.

Evaluation of effective component of oil was done by GC-MC

To do so, a GC-Mass (Hewlett-packard 6890) with splitless injector and a column with 30 m height and 0.25 mm inside diameter and film thickness of 25mm DB WAX (Agilent/j and W Scientific, Folsom, CA, USA) was used.

The ray of detector ionization had 210°C temperature in which H gas and air were passed with 40 m lit/min, primary temperature was kept in 80°C for 2min and then by changing to 10°C per min it reached to 140°C and after one minute by changing temperature 4°C per minute it reached to 190°C and was maintained for 2 min and then by changing 2°C per min, the temperature reached to 210°C. Supper pure He was passed with 1 m lit/min as a carrier gas.

Exit picks were compared with standard samples and their concentrations were determined according the area bellow the curve.

Results

Essence considerations

After preparation of harvested plants and extraction phase, separation and identification of extract's compounds in different treatment were done by GC-MC. After injection of each plant's oil, data were compared with standard (Adams, 2004), and qualitative and quantitative consideration of oil's compounds were done according to library information that are existed in GC-MC. Extracted sections were shoots, seeds and roots. The results of this consideration are shown in table 2.

Table 1. Different cultivation environment with different concentration of macro nutrition.

Culture medium components	Name of Culture medium
Hoagland solution without changing	Control
The phosphate-half Hoagland	Low phosphate
The Nitrate-half Hoagland	Low Nitrate
Calcium twice Hoagland	Full Calcium

Studying compounds of *Coriandrum sativum L.*'s seed essence showed the presence of 20 main compounds (Linalool (67.12%), Geranyl acetate (10.52%), γ-Terpinene (6.52%), α-Pinene (6.52%) and 2-decenal (3.31%)). Studying shoots and roots essence of pot samples which were cultivated in different concentration of P, N and Ca, showed that differences in concentration of these macro nutrition had effect on the amount of existed compounds of produced essence.

Table 2. Existed compounds in seeds' essence.

Compound	RT (min)	Area (%)
Alpha-Pinene	6.656	6.52
Sabinene	8.083	0.15
2-Beta-Pinene	8.202	0.5
Beta-Myrcene	8.787	0.27
Benzene, 1-methyl-2-(1-methylethyl)	10.168	1.62
dl-Limonene	10.333	0.11
γ-Terpinene	11.668	6.63
Linalool	13.809	66.12
Camphor	15.458	0.07
Citronella	15.951	0.23
Dodecane	18.164	0.13
Decanal	18.452	0.58
Undecanal	23.551	0.17
Myrtenyl acetate	24.27	0.15
α-Terpinolene	25.302	0.51
Neryl acetate	25.954	0.23
Geranyl acetate	26.766	10.52
Tridecanal	27.69	0.55
2-Dodecenal	29.76	3.31
Hexadecanal	34.448	0.14
		15.26

In shoots of pots' samples the most identified compound was β-linalool which mostly was seen in full Ca environment (38.1%). After that it mostly was seen in control environment (27.2%), low P (20.9%) and low N (16.1%). The second rate compound was Geraniol acetate (15.6%) that mostly was seen in control environment. The third rate compound was α-Pinene (10.5%) in low N environment; the fourth rate compound was Limonene (6.7%) in low P environment, and finally β-Bisabolol (4.6%) in low N environment. To study on the existed essence of roots, roots of control plants were extracted and considered.

Table 3. Existed compounds in different parts of *Coriandrum* sativum (both pot and field samples).

No.	Compounds in essence	Inhibition time	Farm	Pot culture				
			aerial parts	aerial parts				Root
			Culture Medium					
			Damavand Arial	$Po_{3}\downarrow$	$No_{3}\downarrow$	Ca↑	Con	Con
1	Pyridin	775	2.0	1.6	1.5	1.3	1.1	1.3
2	2-Pentyl furan	840	-	2.0	3.1	0.9	1.4	5.7
3	α-Thujene	920	0.8	1.9	1.4	1.5	0.8	-
4	α-Pinene	941	5.1	1.4	10.5	7.8	4.0	1.8
5	Camphene	950	1.1	1.1	1.7	2.1	1.8	7.7
6	Benzaldehyde	961	2.0	1.3	-	1.1	0.9	2.0
7	Sabinene	969	1.4	1.0	2.2	1.4	1.5	3.5
8	β-Pinene	980	8.6	3.1	4.1	2.7	7.9	1.3
9	α-Phellandrene	989	1.1	1.2	2.0	1.6	1.1	7.7
10	1,8-Cineole	1019	2.2	2.2	1.7	1.0	-	2.8
11	Limonene	1030	0.8	6.7	2.6	1.9	3.0	1.0
12	γ-Terpinene	1068	1.7	2.8	3.1	0.8	1.4	2.5
13	1,4-Menthadiene	1089	3.3	0.9	1.5	0.9	1.9	8.3
14	1-Octanol	1112	1.5	1.1	3.0	0.7	2.2	1.7
15	β-Linalool	1169	33.2	20.9	16.1	38.1	27.2	2.2
16	Camphor	1180	1.8	8.3	2.2	5.9	3.3	11.3
17	Borneol	1212	4.0	0.8	3.7	1.5	1.4	-
18	Carvacrol methyl ether	1241	1.4	1.3	2.1	2.7	1.8	5.1
19	Thymoquinon	1265	1.9	5.5	7.2	1.3	1.0	-
20	Decanal	1340	0.9	2.8	1.6	1.1	1.7	1.3
21	Geraniol	1365	6.4	1.4	5.3	1.8	2.1	1.2
22	o-Cymen	1405	-	1.7	0.9	2.2	0.9	6.6
23	Geraniol acetate	1475	7.0	9.3	1.4	11.1	15.6	2.7
24	2-Dodecenal	1494	1.3	2.3	1.6	1.4	1.1	3.0
25	Caryophyllen oxide	1550	-	9.6	3.2	1.9	3.2	1.9
26	β-Bisabolol	1585	1.4	0.9	4.6	1.5	1.8	6.3
27	Z-E- Feranesol	1619	3.0	0.8	1.7	1.1	1.3	1.7
28	Tetradecanal	1669	0.8	1.9	1.2	1.2	2.1	5.6
29	Camazulene	1702	0.9	1.3	1.6	1.4	1.9	0.7
30	α-Bisabolol oxide	1730	1.0	0.9	2.3	1.0	1.4	1.1

Except α-Thujene, Borneol, and Thymoquinon all other compounds that were identified in shoot, were identified in roots' essence. In addition, it was shown that some separated compounds from root were even more than shoots. These materials were Camphor (11.3%), 1,4-Menthadiene (8.3%), α- Phellandrene (7.7%), O- Cymene (6.6%), β-Bisabolol (6.3%) and Tetra decanal (5.6%).

Moreover, the highest amount of Geraniol acetate was

seen in control sample (15.6%) and the lowest percentage was related to low N treatment, which had significant difference with low P, full Ca and control treatments. In the root's essence of control plant Camphor had the highest percentage (11.3%) and Camazulene had the lowest percentage (0.7%). Consideration of shoots' essence of field samples showed that the highest percentage was related to β-Linalool 33.2%, the second rate compound was β-Pinene 8.6%, the third rate compound was Geraniol acetate (7%), and finally α-Pinene (5.1%).

Some materials that were seen in pot samples were not identified in field samples. These materials were 2-pentil foran, O- Cymene and Caryophyllen oxide (Table 3).

Table 4. Selected compounds for comparing their percentages in different treatments.

Material	Damavand Arial	Arial P	Arial N	Arial Ca	Arial Con	Root Con
B linalol	32.200000	20.9000	16.1000	38.1000	27.2000	2.2000
Thymoquinon	1.900000	5.5000	7.2000	1.3000	1.0000	0.0000
geraniol acetat	7.000000	9.3000	1.4000	11.1000	15.6000	2.7000
a-pinen	5.100000	1.4000	10.5000	7.8000	4.0000	1.8000
limonen	0.800000	6.7000	2.6000	1.9000	3.0000	1.0000
β bisabolol	1.400000	0.9000	4.6000	1.5000	1.8000	6.3000
2pentylfuran	0.00000	2.0000	3.1000	0.9000	1.4000	5.7000
a phellandrene	1.100000	1.1000	1.7000	2.1000	1.8000	7.7000
1- 4 menthdien	3.300000	0.9000	1.5000	0.9000	1.9000	8.3000
o cymen	0.000000	1.7000	0.9000	2.2000	0.9000	6.6000
tetradecanal	0.800000	1.9000	1.2000	1.2000	2.1000	5.6000
Total	4.963636	4.7545	4.6182	6.2727	5.5182	4.3545

Discussion and conclusion

Researchers are shown that proper use of nutrition leads to enhancement of yield. According this, consideration of the effect or interaction effect of nutritional treatments is important for reaching to the best product from essence aspect. The results of this study showed that changes concentration of macro nutrition had effect on percentage and yield of produced essence; this changed the Linalool and Geraniol acetate percentage.

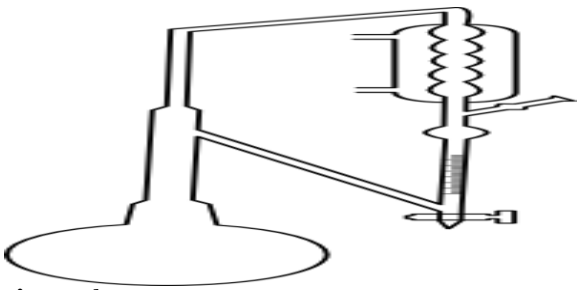

Fig. 1. Clevenger.

The highest amount of Linalool (38.1%) was related to full Ca treatment and the lowest amount of it (16.5%) was referred to low Nitrate. The results showed that low Nitrate had reduced effect on Linalool of essence which was correspondent with Akbari Nia (2004) and Bist (2000).

In a study Nitrate fertilizer increased *Coriandrum sativum L.*'s essence yield, and the highest amount of essence reached with application of 90 kg/ha^{-1} of N. the studies about the effect of N on *Coriandrum sativum L.*'s seeds showed that by increasing N level, seeds essence increases (Gulen 1995; Yalcinta, 1995; Bhal, 1996). In addition the highest yield of *Coriandrum sativum L.* and *Foeniculum vulgare*'s fruits were referred to application of 90kg/ha^{-1} N, and the highest seed's yield is related to 60 kg/ha^{-1} N (Akbari Nia, 2004; Yalcintas, 1995).

In a research N fertilizer increased yield of *Coriandrum sativum L.*'s essence percentage, and by

applying more N, essence yield trend was ascending (Malakoti *et al.*, 2005).

Studies on the effect of some elements such as Nitrogen, phosphate and K showed the key role of these materials on different stages of metabolic activities and development in herbal plants. Among this, enhancement of *M. piperita*'s essence with citlate *M. spicata* variety in development stage can be mentioned. It should be paid attention that application of Nitrogen, Phosphorus and K fertilizers with different ratio in *M. piperita L.* led to enhancement of branches and leaves' number and essence amount. Researches which were done by Sahher *et al.* and Ruminska (1984) confirmed findings of aforementioned researches.

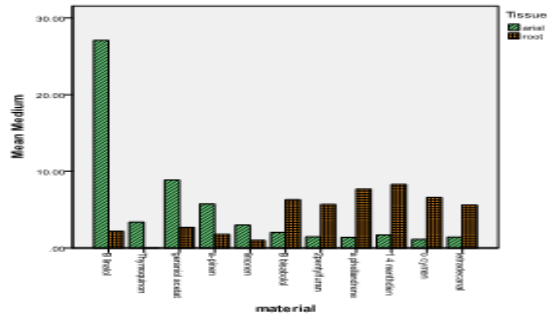

Fig. 2.

Essence analysis of field samples showed that the highest percentage of essence is related to Linalool which was correspondent with previous researches' results (Tashien, 1996; Nykalen, 1975; Pino, 1996). In present study ascending trend of Linalool compound in leaves is because of its affected role from nutritional treatment (full Ca). The causes of this fact can be attributed to wide surface of leaves and long period of growth.

Correspondent with achieved information, seed compound in Pakistan showed that from total 48 chemical compound, which formed more than 90% of essence, Linalool (69.6%) was the main structure and then Gernyl acetate (4.99%) and γ-Tripinene (4.17%) and α-Pinene (1.63%) were stood in the next rates (Farooq Anvar, 2011). In addition seed's essence compound in Pakistan involved 52 compounds from 98.45% of essence, which the most important elements were 73.3% of Linalool, and 4.09% of α-Pinene (Singh *et al.*, 2006; Zoubri and Baolieua Keel, 2010).

In the other study 17 compounds were identified in *Coriandrum sativum L.*'s seed essence. Linalool (73.1%) was determined as main compound, and other compound were 1-Menta, 0-7-Uodian, α-Pinene. According to Bhugan *et al.* (2009) findings in the essence of fruit 53 compounds were found, which Linalol (37.7%), Gerniol acetate (17.6%) and γ-Tripinen (14.4%) were the main compounds, these compounds weren't correspondent with seed's essence.

Seed's essence had different compounds such as 2-E-Decanal (15.9%), Decanal (14.3%) and N-Decanal (13.6%), 2-E-3 Dicen, 2-Dodecenal. These qualitative and quantitative changes in seed's essence can be attributed to seed's sources, different way of harvest, different diets, and climate changes. These issues were correspondent with Telci *et al*'s views (2006), but were not correspondent with Nazral Islam Bhuiyan's views (2009) who knows ecological and geographical issues as the man sources of changes in selected plants. Storing condition and extraction method can also affect these features. For instance, raw fruit can affect stem or leaves capacity and reduce the amount of Linalool (Parthasarathy *et al.*, 2008).

Totally essence of European *Coriandrum sativum L.*'s seed had high amount of Linalol in comparison with Asian type. European essence had 30-60% of monoterpene and 60-75% of Linalool.

The main compounds of Monopropen *in this essence are listed as follow:*

γ- Terpinene till 10% and Limonene, P- Cymene and α-Pinene each 7%. The main monoterpene, non Linalool that were reported are Gerniol acetate 5%, Boranyl 7% and Camphor and Geranyl 4% and Geranyl 2%.

Russian essence had 69-75% Linalool while Indian essence were different from European and Russian

type and had lower amount of Linalool and more amount of Easter (Weiss, 2002; Parthasarathy *et al.*, 2008).

Telci *et al.* (2006), studied on the chemical compounds of 2 seed's types (Var *Vulgar Alefand* and Var *Mierocarpum*) which were cultivated in different parts of Turkey. They found that extracted essence had monoterpene (Microcarpum) 73-82% and vulgare had 50-65% of these chemical components. Achieved essence from *Coriandrum sativum L.* in Iran has rich source of monoterpene in which Linalool is the main structure. This study showed that this plant had potential ability of consuming nutrition (it has a biotical feature); it also can be used as pesticide, and in making shampoos and soups; in addition this plant has herbal application.

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