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EFFECT OF SPRAYING WITH EXTRACTS OF PLANTS AND AMINO ACIDS ON GROWTH AND PRODUCTIVITY ON *CORIANDRUM SATIVUM* L PLANTS UNDER SHALATEEN CONDITION

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ABSTRACT

This experiment was carried out at the Shalateen station, Desert Research Center, Shalatin city - Red Sea Governorate, Egypt during the two successive seasons (2016/2017and 2017/2018) to study the effect of plants extracts (Garlic and Aloe vera) and amino acids on the vegetative growth, seed yield, oil yield and chemical constituents of Coriander plant. Results show that amino acids and/or extracts (garlic and/or aloe) stimulate and encourage of growth and yield characters of coriander plants. Also these treatments had a pronounced effect on essential oil (percentage and yield), as well as P and K%. The main constituents of essential oil under this study were linalool, p-cymene and limonene.

Introduction

Coriandrum sativum (Coriander)belongs to family Apiaceae, it is a herbaceous plant around 100 cm in height, the leaves are a feathered flower, a small white and a violet, the fruits are yellowish-green in color and, it is one of the largest medicinal plants cultivated in the area for use in traditional Egyptian food. It is used medically as anti nausea and vomiting, soothing for the stomach and intestines, an analgesic for stomach ache, stomach upset, neurotoxic and anti-insomnia-used as fresh or dry leaves, dry fruits or aromatic oil. The active substance is an essential oil with a ratio of 0.4-1.2% of the fruits.

The use of plant extracts as stimulants and stimuli for growth is one of the modern areas to increase productivity and increase the resistance of plants to environmental stresses and to combat many pests Hanafy *et al*. (2012). These extracts are garlic extract due to the high content of phosphorous, iron, potassium, magnesium, vitamin B, ascorbic acid and aloe vera extract as it contains nutrients and vitamins (ABCE), and minerals such as sodium, magnesium, selenium, zinc, proteins, amino acids and sugars.

There are numerous studies that have shown the importance of using plant extracts, which opens a new future for expansion In the cultivation and use of medicinal and aromatic plants and increasing their added value. Youssef explained (1997) on Delphinium plant who found that, the use of aloe vera extract with a concentration of 50 and 100% worked on increasing the fresh and dry weight in the leaves as well as increasing the weight of the inflorescence and the number of flowers in the inflorescence. Also, Dong Zhi *et al*. (2004) confirmed that, the use of aloe vera extract as a natural plant growth regulator because it contains some of the auxins. Padmaja *et al*. (2007) on *Abelmoschus esculentus* indicated that, the addition of *aloe vera* powder at a rate of 140 g / pot resulted in a significant increase in the fresh and dry weights of the plant. Also El-Shayeb (2009) on *Oenthera biennis* plant confirmed that the use of spraying with *aloe vera* extract with a concentration of 75% resulted in significant increment in fresh and dry weight in the plants. *Aloe vera* possess allelopathic effect on mainly crops and some weeds (Youssef 1997; Lin *et al*., 2004; Hanafy *et al*., 2012.). The aim of the study was to evaluate the effect of different concentrations of water extracts from fresh leaves of *aloe vera* on germination and early growth of four weed species.

Garlic extract is rich in minerals, plant hormones, which induce cell enlargement and cell division, hence improve growth, fruit characters and essential oil productivity of some medicinal plants. In this respect, Many studies were carried out to explore the effectiveness of Garlic extract (Saadoun *et al*., 2004; Hanafy *et al*., 2012; Nour Eldeen, 2014 and Ziedan and Eisa, 2016). Garlic extracts possess allelopathic activity (Wei *et al*., 2008; Wang *et al*., 2009; Cheng *et al*., 2011; Cheng *et al*., 2016 and Ding *et al*., 2016). Garlic extract improves growthcharacters, flowering parameters, fruit yield and fruit quality (El-Shayeb, 2009; El-Said and Ali, 2013; Mohamed and AkJadious, 2014 and Al-Obady, 2015). Also Shadia, *et al*., 2014 on basil plant (*Ocimum basilicum*, L), they remarked that, the best treatment of garlic + yeast was garlic 50 % + 8 g. yeast / L, while it was the treatment of aloe 100 % for aloe treatments gives significantly increases in plant height, number of branches, dry weight of herb as well as oil yield compared with control.

Helmy (1992) applied fresh garlic clove extract solution (in ethyl alcohol or tap water) to summer squash cv. Eskandarani plants. He remarked that soil side dressing of garlic extract at 50 mg dw/plant gave the best results in increasing the number of flowers. Ahmed *et al*. (2005) confirmed that, greater increase in number of pods of pea (cv.meteor) was obtained with post inoculation treatment

with garlic extract at 10 g/8 liters. Sayeeda and Ahmed 2005 they stated that, garlic bulb extract showed superiority efficacy on promoting growth of two local varieties of groundnut.

The amino acids are the basic building blocks for proteins that are the main source of the formation of plant hormones and enzymes (Goss, 1973 and Hounsome, *et al*.2008). Amino acids is a well known has positive effects on plant growth, yield and significantly mitigatesthe injuries caused by abiotic stresses (Kowalczyk and Zielony 2008) Saeed *et al*. (2005) on soybean found that treatments of amino acids significantly improved growth parameters of shoots and fresh weight as well as pod yield. Liu *et al*. (2008) revealed that foliar application with the mixture of amino acids to radish plants increased N content of shoots whereas, NO_3 content reduced by 24-38%. El-Zohiri and As four (2009) on potato found that spraying of amino acids at 0.25 ml/L significantly increased in plant height and dry weight of plant. AboSedera *et al*. (2010) revealed that spraying strawberry plants with amino acids(peptone) at 0.5 and 1.0 g/L significantly increased total yield as well as total nitrogen, phosphorus and potassium, vitamin C and total sugars content of fruits compared to untreated plants. The results are in harmony with the findings of Abdel Aziz *et al*., (2010) on *Thuja orientalis* L. plant, Abdel-Mawgoud *et al*. (2011)on green bean and Abou-Hussein (2011) on green bean.

The aim of this experiment was to study the effect of spraying with extracts of plants (*aloe vera*, garlic and amino acids) on growth and productivity on *Coriandrum sativum* L plants under the condition of chalatin.

Materials and Methods

This experiment was carried out at the Shalateen station, Desert Research Center, Shalatin city-Red Sea Governorate, Egypt during the two successive seasons (2016/2017and 2017/2018) to study the effect of extracts plants and amino acids on the vegetative growth, seed yield, oil yield and chemical constituents of Coriander plant

Table 1 : Chemical analysis of irrigation water.

EC, dS/m	PH	Cations me/l				Anions me/l				SAR
		Ca^{++}	Mg^{++}	K^{+}	Na^{+}	CO_3^{-2}	HCO_3^{-}	Cl^{-1}	SO_4^{-2}	
2.23	7.65	11.70	8.19	4.05	18.34	0.0	6.00	35.67	0.61	5.56

The seeds of coriander plant were obtained from the Medicinal and Aromatic Plants Research Department, Horticulture Institute, Agricultural Research Center, Dokki, Egypt. The seeds were sown on October 14th during both seasons. The distance between rows was 60 cm and between plants within row was 25 cm. Seedlings were thinned to one plant per hill. The irrigation system of the experiment was drip irrigation with the rate of 4 l/h. The chemical analysis of irrigation water and physical and chemical properties of experimental farm soil of Shalateen Research Station are shown in tables 1, 2 and 3, respectively.

Table 2 : Soil physical properties of the studied area.

Depth, cm	Particle size distribution%				Textural Class	Bd ($Mg.m^{-3}$)	Moisture content, 102KPa	
	Coarse Sand	Fine =Sand	Silt	Clay			0.06	15
0-20	12.91	61.97	20.21	4.91	L.S	1.66	14.55	5.89
20-40	15.22	63.58	18.21	4.99	L.S	1.69	13.96	5.56
40-60	17.11	61.44	17.31	4.14	L.S	1.68	13.58	5.45

L.S = Loamy Sand

Table 3 : Soil chemical properties of the studied area.

Depth, Cm	$CaCO_3$%.	EC,dS/m	PH	% O.M	Cations me/l				Anions me/l			
					Na^{+}	K^{+}	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
0-20	17.25	0.76	7.9	0.32	0.72	0.31	2.81	3.76	0.0	0.30	3.22	4.08
20-40	14.52	0.67	7.9	0.34	0.73	0.30	2.82	2.85	0.0	0.32	\3.09	3.29
40-60	15.58	0.49	7.8	0.65	0.65	0.29	1.89	2.06	0.0	0.28	2.81	1.81

The chemical fertilizer recommended rates for coriander. plant are NPK(80:32:24) divided into three equal sections and added every two months from planting and calcium super phosphate per feddan was added during soil preparation. The normal agricultural practices were followed in this district.

Extracts Preparation

1-Garlic plant extract

According to El-Desouky *et al*. (1998) the fresh mature garlic were blended in the presence of distilled water 1 kg cloves/L, then frozen and thawed two times then filtered. The filter was used for preparation of different garlic extract concentration. The garlic plant extracts were used as a foliar spray at half strength by adding distilled water.

2- Aloe plant extract

It was prepared as described by Wilfred *et al*. (1990) where the plant tissues were crushed using a porcelain mortar and pestle, aloe extract presence of distilled. Water at equal rate (1/1by volume), then filtered.

The Foilar Spraying of Amino Acids

Amino acids were sprayed with a concentration of 15% from the commercial procession king mail extra from the shura company starting from the arrival of the plant from 10 to 15 cm and then spraying every 15 days until flowering .it contains glatomic acid (8.02%); glysine. 1 (3.20%); serine (5.8%); aspartic acids (2.7%); arginine (5.08%); treonine (3.78%) leucine (3.16 %) .plants were sprayed with plant extracts one month after planting, then sprayed every 45 days after planting, then sprayed two months after planting.

This experiment included 7 treatments, as the following:

1-Without spraying control

2. Amino acid at 15% concentration

3. Garlic extract at a concentration of 1: 1v

4. *Aloe vera* extract 10 cm^3, dilute with water for 1 liter

5. Amino acids 15% + garlic extract

6. Amino acids 15% + *aloe vera* extract

7. Garlic extract + *aloe vera* extract

The treatments were arranged in Randomized Block Design with three replicates every replicate contained ten plants.

Data recorded

1-Vegetative growth

1.1. Plant height (cm)

1.2. Number of umbel per plant

1.3. Fresh and dry weights per plant (g)

2- Seed yield characters

2.1. Seed index (g) (weight of 1000 fruits)

2.2. Weight of fruits per plant (g) and per feddan (Kg)

3- Essential oil percentage and yield

3.1. Oil percentage of fruits according to British Pharmacopoeia (1936)

3.2. Oil content per feddan (L)

3.3. Chemical composition of oil by GC/MS system according to Adams, (2007)

4- Chemical constituents

4.1. Total nitrogen percentages according to Koch and Mc-Meekin, (1924)

4.2. Total phosphorus percentages according to Troug and Mayer (1939)

4.3. Total potassium percentages according to Brown and Lilleland (1946)

4.4. Total carbohydrate percentage according to Dubios *et al*., (1956)

All the obtained data during the two seasons of study were subjected to analysis of variance method according to Snedecor and Cochran (1980). Meanwhile, differences among means were compared using Duncan's multiple range tested at probability of 5 % level (Duncan, 1955).

Results & Discussion

Vegetative growth

It is clear from data tabulated in table (4) that all treatments enhanced vegetative growth characters comparing with untreated during both seasons. It can be noticed that amino acid at 15%+garlic extract treatment was the superior for plant height and fresh weights both seasons. On the other hand, the maximum mean values of dry weights were obtained as a result of garlic extract + aloe extract and amino acid at 15% + aloe extract at 10% during 1st and 2nd seasons, respectively.

Table 4 : Effect of spraying with plants extracts and amino acids on growth characters of *Coriandrum sativum*, L. plants, during both seasons.

characters Treatments	Plant height (cm)	Fresh weight/ Plant (g)	Dry weight/ plant (g)	Plant height (cm)	Fresh weight/ Plant (g)	Dry weight/plant (g)
	First season			Second season		
control	76.26g	220.29g	73.85g	77.65g	215.36g	71.89g
Amino acids at 15%	92.66d	288.42e	96.63d	93.40c	339.25d	113.55d
Garlic extract	88.28e	325.65d	70.56g	87.74e	300.54e	100.45e
Aloe extract	84.64f	233.00f	77.90e	84.54f	284.2f	94.42f
Amino acid at 15%+ garlic extract	98.51a	415.25a	108.30c	99.15a	453.1a	117.38c
Amino acid at 15%+Aloe extract	93.59c	385.77b	119.67b	95.56b	394.3b	131.85a
Garlic extract + Aloe extract	94.84b	357.84c	128.50a	92.41d	352.88c	123.81b

2- Seed yield characters

Data dealing with the effect of plant extracts and amino acids on the seed yield characters (no. of umbels per plant, fruits yield per plant (g), weight of 1000 seeds (g) and fruits yield per fed (kg) of coriander plants) in the both growing seasons were presented in table (5). Spraying coriander plants with amino acid at 15%+garlic extract produced the highest values of yield parameters when compared with all treatments while untreated plants gave the lowest values of these characters in both seasons.

Table 5 : Effect of spraying with plants extracts and amino acids on some seed yield characters of (*Coriandrum sativum*, L.) plants, during both seasons.

Characters Treatments	No. of umbels/ plant	Fruits yield / plant (g)	Weight of 1000 seeds (g)	Fruits yield / fed (kg)	No. of umbels / plant	Fruits yield / plant (g)	Weight of 1000 seeds (g)	Fruits yield / fed (kg)
	First season				Second season			
Control	43.56g	73.26g	10.88g	1277.65g	49.88f	80.12g	11.58g	1387.65g
Amino acids at 15%	62.14g	91.66d	13.30e	1793.4d	71.56c	99.26d	14.30e	1905.40d
Garlic extract	57.45e	87.28e	13.80d	1587.74e	66.45d	94.22e	14.80d	1698.74e
Aloe extract	53.76f	83.65f	12.00f	1384.54f	61.70e	91.45f	13.54f	1495.54f
Amino acid at 15%+ garlic extract	69.55a	98.70a	16.17a	1997.15a	78.23a	106.83a	18.27a	2105.15a
Amino acid at 15%+Aloe extract	64.50c	94.59c	14.07c	1855.87c	71.54c	101.59c	15.67c	1964.87b
Garlic extract + Aloe extract	66.98b	96.84b	14.43b	1892.41b	76.04b	103.41b	15.93b	1909.41c

3. Essential oil percentage and yield

Data illustrated the effect of plant extracts and amino acids on the essential oil percentage and yield (ml / hill and l/Fed.) in Table (6). It revealed that during first season, application of amino acid at 15%+garlic extract caused an increment in the essential oil percentage and yield compared with other treatments. Generally all treatments enhanced the essential oil percentage compared with untreated plants.

Table 6 : Effect of spraying with extracts plants and amino acids essential oil content of coriander fruits (*Coriandrum sativum* L) plants, during both seasons.

Treatments	First season			Second season		
	Volatile oil (%)	Oil yield (mL/plant)	Oil yield (L/fed.)	Volatile oil (%)	Oil yield (mL/plant)	Oil yield (L/fed.)
control	1.22f	0.45 e	12.85g	1.12e	0.38f	10.89g
Amino acids at 15%	2.71b	0.71c	18.78d	2.63ab	0.61c	17.56d
Garlic extract	1.90d	0.54d	17.54e	2.00c	0.44e	15.26e
Aloe extract	1.52e	0.60d	13.58f	1.48d	0.52d	14.07f
Amino acid at 15%+garlic extract	2.93a	0.87a	24.88a	2.72a	0.86a	25.15a
Amino acid at 15%+Aloe extract	2.50c	0.79b	23.69b	2.55b	0.74b	21.87c
Garlic extract + Aloe extract	2.00d	0.74bc	22.49c	2.14c	0.65c	23.45b

According the data tabulated in Table (6) plant extracts and / or amino acids had a positive significant effect on essential oil yield. Values of essential oil yield reached to its maximum mean values as a result of amino acid at 15%+garlic extract. The increment of essential oil yield may be due to the increase of essential oil percentage or/and yield of fruits / plant.

Essential oil constituents:

Data in Table (7) recorded about 6 main components of coriander essential oil for the 2nd season. The first main component was linalool which ranged from 35.66 to 38.77% followed by p-cymene (26.22 – 26.85%). Limonene was the 3rd one ranged from 19.11 to 19.82% while the 4th main components was nerol (7.41–7.99%). The maximum mean value of linalool (38.77%) was obtained from plants treated with Garlic extract + Aloe extract. P-Cymene reached to its highest value (26.85%) under Garlic extract only. Amino acid at 15% + Aloe extract at 10% treatment produced the highest mean value of limonene (19.82%).

Table 7: Effect of spraying with extracts plants and amino acids on the main components (%) of fruit volatile oil of coriander (*Coriandrum sativum* L) plants, during the 2nd season.

Treatments	Main components component			Nerol	Borneol	Geraniol
	Limonene	p-Cymene	Linalool			
control	19.76ab	26.8a	37.54d	7.94a	2.23c	2.02d
Amino acids at 15%	19.64c	26.46b	36.23e	7.85ab	2.55b	2.21c
Garlic extract	19.71bc	26.85a	38.35b	7.74b	2.54b	1.84e
Aloe extract	19.55d	26.22c	35.66f	7.54c	1.89d	1.97e
Amino acid at 15%+garlic extract	19.74b	26.26c	38.42b	7.99a	2.84a	2.4b
Amino acid at 15%+Aloe extract	19.82a	26.56b	38.1c	7.56c	2.6b	1.84e
Garlic extract + Aloe extract	19.11e	26.54b	38.77a	7.41c	2.42b	2.86a

4- Nutrients Content (%)

Data tabulated in Table (8) clear that (Garlic extract + Aloe extract treatment) had a positive effect on nitrogen percentage which gave 2.73 and 2.90 during 1st and 2nd seasons, respectively.

where untreated plants produced the minimum value of nitrogen percentage (1.53 and 1.61 % during 1st and 2nd

seasons, respectively). On the other hand, amino acids and extracts treatments had a positive significant effect on both P and K percentage during both seasons. The highest mean values of P % were obtained as a result of Amino acid at 15%+Aloe extract and Amino acid at 15%+garlic extract which recorded 0.72 and 0.75% during 1st and 2nd seasons, respectively.

Also, Amino acid at 15%+garlic extract and Amino acid at 15%+Aloe extract treatments gave the best values of K% (1.96 and 2.55%) during 1st and2nd seasons, respectively.

Concerning total carbohydrate content (%) as shown in table (8). It is clear that Amino acid at 15%+Aloe extract gave the highest mean values of carbohydrate content (24.87 and 23.00%) and Amino acid at 15%+garlic extract which reached (21.16 and 22.45%) during both seasons, respectively.On the contrary, the least mean values obtained from untreated plants during1st season and Aloe extract treatment only during 2nd season, respectively.

Table 8 : Effect of spraying with extracts plants and amino acids on chemical composition of coriander herb (*Coriandrum sativum* L) plants, during both seasons.

Treatments	First season				Second season			
	N (%)	P (%)	K (%)	Carbohydrates (%)	N (%)	P (%)	K (%)	Carbohydrates (%)
control	1.53	0.26	0.98	15.65	1.61	0.29	1.02	16.37
Amino acids at 15%	2.14	0.66	1.30	18.34	2.32	0.68	1.40	19.82
Garlic extract	1.66	0.61	1.80	19.67	1.74	0.63	1.82	17.56
Aloe extract	1.76	0.55	1.00	17.34	1.82	0.57	0.89	15.87
Amino acid at 15%+garlic extract	2.55	0.70	1.96	21.16	2.75	0.75	2.12	22.45
Amino acid at 15%+Aloe extract	2.50	0.72	1.76	24.87	2.66	0.73	2.55	23.00
Garlic extract + Aloe extract	2.73	0.68	1.43	16.41	2.90	0.67	1.54	16.43
mean	2.12	0.60	1.46	19.06	2.37	0.62	1.62	18.79

Discussion

The above results show that amino acids and /or extracts (garlic and / or aloe) stimulate and encourage of growth and yield characters of coriander plants. Also these treatments accelerate and accumulate essential oil of fruits. The positive effect of garlic extract growth and yield characters may be attributed to the fact that garlic extract contains considerable amounts of plant nutrients, especially sulfur, in addition to the protective effect of garlic extract against most plant pathogen infections, (Lampkin, 1994),

Containing natural sources of many growth promoting substances such as macro and micronutrients and gibberellic acid. Helmy (1992) found that soil side dressing of garlic extract at 250 mg DW /plant gave the best results in increasing the number of flowers. Ahmed *et al*. (2005) confirmed that greater increase in number of pods of pea (cv. Meteor) was obtained with post inoculation treatment with garlic extract at 10 g/8 liters.

In this connection Josias (2008) reported that, the *Aloe vera* juice contain, anthraquinone, enzymes, vitamins, inorganic compounds and essential amino acid. Moreover many authors (Shyamal *et al*., 1990; Rajeswari *et al*., 2012; Hamouda *et al*., 2012; Sahu *et al*., 2013 and Raman *et al*., 2013) reported that *Aloe vera* contains all the essential amino acids, i.e. isoleucine, leucine, lysine, methionine, phenylalanine, threonine, valine and tryptophan. It also contains few other non-essential amino acids, which are alanine, arginine, asparagin, cystenien, glutamic acid, glycine, histidine, proline, serine, tyrosine, glutamine and aspartic acid. Also, it contains mono polysaccharide (cellulose, glucose, mannose, aldopentose), lignin, macro nutrients (N, P, K), secondary nutrients (Mg, Ca), micro nutrients/trace elements (Zn, Fe, Mn, Cu), vitamins (B1, B2, B6, C, niacin, collin, enzyme, innositol, aloin, isobarbaloin, aloe emodin, natural hormones 0.63mg/100g F.W., gibberellins 16.00 mg/100g F.w. and salicylic acid.

In this respect, Dong Zhi *et al*. (2004) concluded that the aqueous leaf extract of Aloe vera could be useful as a natural plant growth regulator. Padmaja *et al*. (2007) stated that *Aloe vera* peelings powder at 140 g/pot significantly increased fresh and dry weights of Lady's Finger (*Abelmoschus esculentus*) plants. El-Shayeb (2009) declared that all concentration of *Aloe vera* extract increased fresh and dry weights of flowers of *Oenthera biennis*, the best response resulted from the highest concentration of Aloe.

The results of extracts effect on essential oil content are in agreement with different researches such as Mady (2009) on Major anahortensis and *Salvia officinalis* plants, Hamouda *et al*. (2012) on and Ahmed *et al*. (2014) on basil as well as AbdelKader *et al*. (2014). Amino acids are important for growth regulation and as modulators of growth and cell differentiation, which may be affecting general metabolism and consequently morphogenesis (Basu *et al*., 1989). Amino acids are of special interest to plant producer due to their wide range of roles in plant metabolism. Amino acids are not only building blocks of proteins but also precursors for a myriad of other molecules that serve important functions in plants. Amino acids are involved in the synthesis of other organic compounds, such as protein, amines, alkaloids, vitamins, enzymes, terpenoids and plant hormones that control various plant processes (Glawischnig *et al*., 2000; Ibrahim *et al*., 2010). Amino acids are crucial to stimulating cell growth, act as buffers, provide a source of carbon and energy and protect the cells from ammonia toxicity, with amid formation (Abdel Aziz *et al*., 2010). The effect of amino acids on the chemical contents could be through plant protection from ammonia

toxicity as they remove amide formation, serving as a source of carbon and energy as well as protection of plants against pathogens, functioning as buffers and biosynthesis of other organic compounds such as protein, amines, purines, pyrimidines, vitamins, enzyme, terpenoids (Goss, 1973). Amino acids are the fundamental ingredients of the process

of protein synthesis because of their nitrogen content. The importance of nitrogen or amino acids came from their increased application for the biosynthesis of a large variety of non-nitrogenous materials i.e. pigments, vitamins, coenzymes, purine and pyrimidine bases (Kamar and Omar, 1987). Many studies have reported that foliar application of amino acids caused an increase in the growth and development of plants. Omer *et al*. (2013) on chamomile and El-Tarawy *et al*., (2017) on caraway reported that foliar spray with amino acids improved the growth and chemical composition of plants.

The above results indicated that the main constituents of coriander fruits under different treatments are linalool, p-cymene and limonene. Variation in essential oil compositions can occurs as a result of differing soil conditions, altitude, climatic conditions, seasonal factors and other environmental features, leading in some cases to the evolution of different chemical variants or chemotypes (Heywood, 2002).

It has been shown that essential oil content and composition of *C. sativum* can be influenced by cultivation practices, ontogenetic and genetic factors (Hornok, 1976; Msaada *et al*., 2007; Telci *et al.*, 2006). The essential oil content of coriander fruits varies from very low (0.03%) to a maximum report of 2.7% (Bandara *et al.*, 2000; Purseglove *et al.*, 1981). Dobos and Novak (2005) reported a range of variation of oil content between 0.2 and 1.3% among 36 different Coriander accessions from Austria.

Msaada *et al*. (2007) reported that essential oil yield and compositions of Coriander fruit increase during maturation process. Geranyl acetate (46.27%) and linalool (10.96%) were the main compounds of immature fruits while essential oils of mature fruits consist mainly on linalool (87.54%) and cis-dihydrocarvone (2.36%) (Msaada *et al*., 2007). The ecological variation of significant effect on seed yields, oil content and composition of different Coriander varieties were reported. Linalool content was 63.5–71.0% and 42.1–52.7% in var. *microcarpum* and var. *vulgar*, respectively (Telci, *et al*., 2006). Raal *et al.* (2004) analyzed the oil of Coriander seeds from different geographical origins of Europe. The major constituent of the oils were linalool (58.0–80.3%), γ-terpinene (0.3–11.2%), α-pinene (0.2–10.9%), *p*-cymene (0.1–8.1%), camphor (3.0–5.1%) and geranyl acetate (0.2–5.4%) (Raal *et al*. 2004). The main constituents of the essential oil of Coriander growing in 6 different zones of Argentina were linalool (68.9–83.7%), γ-terpinene (2.2–5.1%), camphor (3.2–4.8%), α-pinene (1–6.5%), geraniol (1.4–3.2%) and geranyl acetate (0.8–3.8%). The contents of cis- and trans-linalool oxide (0.1–0.4%) were low (Bandoni *et al*., 1998).

Linalool (77.48 %), γ-terpinene (4.64 %), α-pinene (3.97 %), limonene (1.28 %), geraniol (0.64 %) and 2-decenal (0.16 %) have been reported as main oil components of *C. sativum* from Brazil (De Figueiredo *et al*., 2004). The composition of the essential oils of *C. sativum* from Bulgaria was analyzed (Stoyanova *et al*., 2002). The main components of the essential oil were linalool (63.3%), α-pinene (6.1%) and p-cymene (5.0%) (Dimri *et al*., 1976). Variation in seed oil content and composition of Coriander due to genetic or environmental factors has been reported in Several other studies (Kalra *et al*., 1999; Singh *et al*., 2002).

Linalool is the main volatile compound in seeds, typically constituting more than 50% of the total essential oil (Ramadan and Mörsel, 2003).

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