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Research Article

Inhibitory Effect of Oregano and Laurel Essential Oils and Their Main Components on Seed Germination of Some Weed and Crop Species

Nihat TURSUN[1], Ali Arda IŞIKBER[2], Mehmet Hakkı ALMA[3], Ayşe USANMAZ BOZHÜYÜK[4*]

[1] Malatya Turgut Ozal University, Faculty of Agriculture, Department of Plant Protection, Malatya, Turkiye

[2] Kahramanmaraş Sütçü İmam University, Faculty of Agriculture, Department of Plant Protection, Kahramanmaraş, Türkiye

[3]Kahramanmaraş Sütçü İmam University, Forestry Faculty, Department of Engineering of Forestry, Kahramanmaraş, Türkiye

[4*]Igdir University, Faculty of Agriculture, Department of Plant Protection, Igdir, Türkiye

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ABSTRACT

The essential oils from oregano (*Origanum syriacum* L.) and laurel (*Laurus nobilis* L.), and their main components, namely**,** carvacrol, 1,8-cineole and α-pinene, were tested to determine their inhibitory effects on the seed germinations of three different weeds [redroot amaranth (*Amaranthus retroflexus* L.), wild licorice (*Glycyrrhiza glabra* L.), curled dock (*Rumex crispus* L.) and cutleaf ground-cherry (*Physalis angulata* L.)] and three crops [(wheat (*Triticum aestivum* L.), corn (*Zea mays* L.) and cotton (*Gossypium hirsitum* L.)]. Gas chromatography/mass spectroscopy (GC-MS) analysis showed that 1,8-cineole and carvacrol were the major components of laurel and oregano essential oils, respectively. An *in-vitro* bioassay seed germination test showed that oregano essential oil and carvacrol completely inhibited the germination of weeds at all the concentrations ranging from 1 to 5 µl/Petri dish, while seed germination of test weeds significantly decreased with increasing of the concentrations of laurel essential oil and its main components, 1,8-cineol and α-pinene ranging from 5 to 20 µl/Petri dish. Oregano essential oil and carvacrol were totally ineffective on cotton and corn germination (except for the concentration of 5 µl/Petri dish of cavracrol), whereas they had a strong inhibitory activity against wheat seeds. On the other hand, the laurel essential oil and its main component, 1,8-cineole, showed less selective action on test crop species. It could be concluded that volatile oil from *O. syriacum* and its main component, cavracrol, possessed a strong inhibitory effect on germination of the weeds and was totally selective action on some crops, and could be utilized as bioherbicide for future weed management programmes.

1. Introduction

Environmental constraints of crop production systems have stimulated interest in alternative weed management strategies. In fact, the continued use of synthetic herbicides may threaten sustainable agricultural production and has resulted in serious ecological and environmental problems, such as the increased incidence of resistance in weeds to important herbicides and increased environmental pollution and health hazards (Narwall 1999; Heap 1999). Therefore, there has, recently, been growing interest in research concerning the possible use of plant extracts as an alternative to synthetic herbicides (Dudai et al., 1993; 1999; Singh et al., 2005; Bozhuyuk, 2020; Karaman et al., 2021).

Allelopathy offers potential for selective biological weed management through the production and release of allelochemicals from the leaves, flowers, seeds, stems and roots of living or decomposing plant materials (Weston, 1996). Under appropriate conditions, allelochemicals may be released in quantities suppressive to developing weed seedlings (Wu et al., 2002). A variety of allelochemicals has been identified, including essential oils that inhibit seed germination and plant growth (Neori, 2000). Among natural plant products, volatile essential oils and their constituents have attracted much attention because of their phytotoxicity (also providing allelopathic property) and relatively quicker degradation in the environment (Muller, 1965; Dudai et al., 1999; Romagni et al., 2000; Tworkoski, 2002).

* Corresponding author email: *ayseusanmaz@hotmail.com*

Terpenoids, particularly monoterpenes and sesquiterpenes, are the main components of essential oils and are often responsible for their inhibitory activity. Among the many species of Lamiaceae family release phytotoxic monoterpenes that hinder the development of herbaceous species (Muller, 1966; Alsaadawi et al., 1985) among which the common ones are α- and β-pinene, camphene, limonene, α-phellandrene, ρ-cymene, 1,8-cineole, borneol, pulegone and camphor (Fisher, 1986). Allelopathic inhibition typically results from the combined action of a group of allelochemicals that interfere with several biochemical interactions among plants, including those mediated by soil microorganisms (Bozhuyuk, 2020; Yasar et al., 2021).

The flora of Turkey includes plant species that have been traditionally produced for centuries and used in folk medicine, some as spices and additives in perfumes. Many different species of local plants such as *Laurus nobilis* L. (Lauraceae), the laurel, and *Origanum syriacum* L. (Lamiaceae), rosemary, have a long history of use as medicinal plants and spices. The laurel is a perennial, flowering tree, which is commonly found in Mediterranean climate. *Origanum* (Lamiaceae) species are well known for their essential oils. Among them, thyme (*Thymus vulgaris* L.) is widely grown in different parts of the world for its essential oils that are used in perfumery and as flavouring agents besides possessing pesticidal properties (Langenheim, 1994; Isman, 2000). Morover, Angelini et al. (2003) reported that aqueous solution of essential oil from oregano and cavracrol had a strong inhibiting activity on the seeds of three different annual weeds (*Chenopodium album*, *Portulaca oleracea*, and *Echinochloa crus-galli*) and three crops (*Raphaus sativus*, *Capsicum annuum* and *Lactuca sativa*). Various studies have demonstrated inhibitory effect of various essential oils on seed germination of some weed species (Dudai et al., 1999; Onen et al., 2002; Angelini et al., 2003; Singh et al., 2003; Thompson et al., 2003). Various essential oils and their volatile constitutes as weed germination inhibitor against three different annual weeds (*Chenopodium album*, *Portulaca oleracea* and *Echinochloa crus-galli*) and three crops (*Raphanus sativus*, *Capsicum annuum* and *Lactuca sativa*) indicated that savory (*Satureja montana* L.) essential oil inhibited completely the germination of test weeds while concurrently displaying little effect on pepper (Angelini et al., 2003). However, very little has been done to explore the effect of essential oil from oregano and laurel, and their main components in vapor phase on the germination of the seeds of some weed species and crops studied here.

Objective of this study were: to identify chemical compositions of oregano and laurel essential oils, to evaluate *in vitro* the inhibitory activity of oregano and laurel essential oils and their main compounds (cavracrol, 1,8 cineole and α-pinene) in vapor phase on the seed germination of some weed and crop species, and to discuss their possible use as bio-herbicide for future weed management.

2. Materials and Methods

Weed and Crop seeds

Mature seeds of the weeds redroot amaranth (*Amaranthus retroflexus* L.), wild licorice (*Glycyrrhiza glabra* L.), curled dock (*Rumex crispus* L.) and cutleaf ground-cherry (*Physalis angulata* L.) were collected from parent plants in Karamanmaraş region in Turkey. Weed seeds were dried under the sun-light and then rubbed gently over a sieve to remove excess chaff, which, together with empty seeds, was removed with a seed blower. Dry seeds were stored at 10 ºC under relative humidty (RH) of 35% until germination testing began. Certified seeds with recommended germination and purity characteristics of cotton (*Gossypium hirsitum* L.), wheat (*Triticum aestivum* L.), and corn (*Zea mays* L.) were used kindly provided by Beyazaltın Seed Co.

Plant materials and distillation procedure

The plant materials of *O. syriacum* and *L. nobilis* were collected in highlands of Kahramanmaraş Province of Turkey during the spring of 2005. Raw materials for each sample were obtained from same area. The essential oil of oregano was obtained from their fresh leaves. The essential oils from the fresh leaves of *O. syriacum* and *L. nobilis* were extracted by steam distillation in stainless steel tank. After extraction, the essential oil was dried over anhydrous sodium sulphate, then were collected in sealed glass containers and were refrigerated in the dark at 4 ºC until their use. Cavracrol, 1,8-cineole and α-pinene were purchased from Aldrich.

Gas chromatography-mass spectrometry procedure

The percent content of components in the essential oils from oregano and laurel described above (11.5 mg) diluted in petroleum ether (Et_2O) (1 ml) was determined on a Finnigan-MAT 8200 Mass Spectrometer (low resolution) coupled with a Hewlett-Packard GC-5890II series GC and a SE-54 fused silica capillary column (30 m x 0.25 mm i.d.; 0.25 µm film thickness). One µl of the diluted oil was injected into the column. The GC oven temperature was kept at 60 ºC for 5 min and programmed to 260 ºC at a rate of 2 ºC min^{-1} and then kept at 260 ºC. The injector temperature was 250 ºC. The amount of injection was 1 µl. The carrier gas (He) with a flow rate of 1.15 ml min^{-1} was delivered at a constant pressure of 5 kg cm^{-2}. MS spectra were taken at EI ion source of 70 eV. Split ratio was 1:5. The components of the oil were identified by comparison of their mass spectra with that of internal (computer) library, NIST libraries, reference compounds and those described by Adams (1995). Identification of the essential oil was conducted by Gas Chromatography with flame ionization detector (GC-FID) on a Hewlett-Packard GC-5890II series GC. One µl oil sample was injected into the same column under the same GC conditions as described for Gas chromatography/mass spectroscopy (GC-MS) study. However, split ratio was 1:14.

Weed and crop germination bioassay procedure

Seeds of the weeds (*G. glabra*, *R. crispus* and *P. angulata)* and the crops (corn, wheat and cotton) were rinsed with distilled water and then shade-dried on the

filter paper in the laboratory at 25ºC for 7 days. These were then equidistantly placed in 9 cm diameter Petri dishes (10 seeds per Petri dish, six replicates per treatment) lined with two layers of moistened Whatman No. 1 filter paper wetted with 7 ml of distilled water. A piece of filter paper (3 cm diameter) stuck on the inner side of cover of Petri dishes was treated with 0, 1, 2, 3, 4 and 5 µl per Petri dishes of oregano essential oil and carvacrol, and 0, 5, 10, 15 and 20 µl per Petri dishes of laurel essential oil, 1,8-cineol and α-pinene. After closing the covers treated with oregano and laurel essential oils, carvacrol, 1,8-cineol and α-pinene, Petri dishes were sealed with paraffin film and placed in an illuminated growth chamber at 25±1ºC temperature and 65±5% R.H. in the darkness. After two weeks, the number of seeds that germinated (0.5 cm radicule length) was counted in each Petri dishes and then germination percentages of each treatment were calculated. Control treatments were kept without loading the essential oils, carvacrol, 1,8-cineole and α-pinene.

Experimental design and data analysis

A completly randomized design with six replicates adopted for the germination trials. Data were submitted to analysis of variance after arcsin transformation, and the means were separated using LSD test at $P \leq 0.05$ significant level (SAS, 1989).

3. Results and Discussion

Chemical composition of essential oils of Origanum syriacum and Laurus nobilis

Chemical compositions of essential oils from the leaves of oregano (*O. syriacum*) and laurel (*L. nobilis*) from Kahramanmaraş Province in Turkey are given in Table 1. The major components in the essential oil from the oregano were found to be carvacrol (73.47%), γ-Terpinene (2.50%), B-caryophyllene (2.29%), Borneol (1.75%) and E-Sabinene hydrate (0.80%). However, laurel essential oil essentially contained 1,8-cineole (54.71%), sabinene (9.19%), *α*-terpinyl acetate (6.95%), *α*-pinene (5.34%) and *B*-pinene (4.28%). Chemical analysis clearly indicated that carvacrol and 1,8-cineole were the main component of oregano and laurel essential oils respectively.

Table 1
Chemical composition of essential oils from oregano (*Origanum syriacum* L.) and laurel (*Laurus nobilis* L.)

Components of *O. syriacum*	Component in vol. -% of components ± SD	Components of *L. nobilis*	Component in vol.-% of components±SD
Carvacrol	73.47±0.15	1,8-cineole	54.71±0.13
γ-Terpinene	2.50±0.09	Sabinene	9.19±0.09
B-caryophyllene	2.29±0.07	*α*-terpinyl acetate	6.95±0.01
Borneol	1.75±0.04	*α*-pinene	5.34±0.12
E-sabinene hydrate	0.80±0.02	*B*-pinene	4.28±0.005
Terpinene-4-ol	0.77±0.01	*p*-cymene	3.04±0.02
Thymol	0.70±0.01	Terpinen-4-ol	2.60±0.02
1,8-Cineole	0.34±0.08	*α*-terpineol	1.90±0.03
		γ-terpinene	0.90±0.04

Germination Inhibition of Oregano Essential Oil and Carvacrol

Data from the germination trials in weed seeds treated with oregano essential oil and carvacrol at different concentrations are shown in Table 2. Oregano essential oil and carvacrol indicated strong toxicity to seeds of all the weed species tested. Thus, essential oil completely inhibited germination in three weed species (*G. glabra*, *R. crispus* and *P. angulata*) at all the concentrations. For species *A. retroflexus*, while very low germination was obtained at the lowest concentration (1 µl/Petri dish), rest of three concentration of oregano essential oil resulted in completely inhibited germination. On the other hand, carvacrol completely inhibited germination in all weed species at all the concentrations. Germination percentage for all treatments clearly differed from the controls.

Table 2
Effect of different concentrations of oregano essential oil and carvacrol on the seed germination of tested weeds

Treatments	Treatment rate (µl/Petri dish)	Germination rate (%) ± Standard Error*			
		Amaranthus retroflexus	*Glcycrrhiza glabra*	*Rumex crispus*	*Physalis angulata*
Oregano essential oil	1	3.3±1.7 B a	0±0 B a	0±0 B a	0±0 B a
	2	0±0 C a	0±0 B a	0±0 B a	0±0 B a
	3	0±0 C a	0±0 B a	0±0 B a	0±0 B a
	4	0±0 C a	0±0 B a	0±0 B a	0±0 B a
	5	0±0 C a	0±0B a	0±0 B a	0±0B a
Carvacrol	1	0±0 B a	0±0B a	0±0 B a	0±0 B a
	2	0±0 B a	0±0 B a	0±0 B a	0±0 B a
	3	0±0 B a	0±0 B a	0±0 B a	0±0 B a
	4	0±0 B a	0±0 B a	0±0 B a	0±0 B a
	5	0±0 B a	0±0 B a	0±0 B a	0±0 B a
Control	0	78.3 ±3.3 A a	73.3±6.7 A a	63.3 ±3.3 A b	80 ±5.8 A a

*Satistical analyses were carried out on arcsin-transformed data and results were extrapolated to original data. Two-way ANOVA was applied for data analysis. Means within a column with the same upper-case letter and a row with the same lower-case letter are not significantly different at 1% level by LSD test.

Data from the germination trials in seeds of crop species treated with oregano essential oil and cavracrol at two concentrations are shown in Table 3. Crop species responded differently to both oregano essential oil and carvacrol in terms of seed germination. Both oregano essential oil and carvacrol had no effect on the germination of cotton seeds, giving a hundred percent of germination at all concentration similar to control. Whereas, except for the lowest concentration (1µl/Petri dish), they completely inhibited germination in wheat seeds. In corn seeds, while a hundred percent of germination was obtained at the lowest concentration (1 µl/Petri dishes) of both oregano essential oil and carvacrol, the germination was significantly reduced in response to only carvacrol at the highest concentration (5 µl/Petri dish) compared to control.

Table 3
Effect of different concentrations of oregano essential oil and carvacrol on the seed germination of tested crop species

Treatments	Treatment rate (µl/Petri dish)	Germination rate (%)±Standard Error *		
		Wheat	Corn	Cotton
Oregano essential oil	1	100±0 A a	100±0 A a	100±0 A a
	5	0±0 B b	93.3±6.6 A a	100±0 A a
Carvacrol	1	0±0 B b	100±0 A a	100±0 A a
	5	0±0 B c	56.7±3.3 B b	100±0 A a
Control	0	100±0 A a	100±0 A a	100±0 A a

*Satistical analyses were carried out on arcsin-transformed data and results were extrapolated to original data. Two-way ANOVA was applied for data analysis. Means within a column with the same upper-case letter and a row with the same lower-case letter are not significantly different at 1% level by LSD test.

Germination Inhibition of Laurel Essential Oil, 1,8-Cineole and α-Pinene

The effect of different concentration of laurel essential oil and its main components, 1,8-cineole and α-pinene, on the seed germination of tested weeds is shown in Table 4. Laurel essential oil and its main components, 1,8-cineole and α-pinene had a significant effect on seed germination of test weed species (P<0.01). Seed germination of test weeds was significantly reduced by an increase in the concentrations of laurel essential oil and its main components, 1,8-cineole and α-pinene ranging from 5 to 20 µl/Petri dish. Laurel essential oil completely inhibited germination in the three weed species (*A. retroflexus*, *G. glabra* and *P. angulata*) at higher concentrations of 15 and 20 µl/Petri dish, while *R. crispus* had very low percentages of seed germination (10-13.3%). On the other hand, at low concentration of 5 µl/Petri dish it caused a significant decrease in germination percentage, but not completely inhibited seed germination in all the test weed species. 1,8-cineole at all the treatments rates completely inhibited germination in only one weed species, *G. glabra*. This component at the lowest concentration (5 µl/Petri dishes), however, led to a low inhibition of seed germination in *A. retroflexus*, *R. crispus* and *P. angulata*, while its higher concentrations (15 and 20 µl/Petri dish) produced either complete or very low inhibition in seed germination (except for *P. angulata* at 15 µl/Petri dish). The other main component of laurel essential oil, α-pinene, led to significant increase in inhibiting seed germination of test weed species with increased concentration of α-pinene from 5 to 20 µl/Petri dish. At low concentration of α-pinene, no difference in germination amongst the treated seeds was observed compared to control (except for *R. crispus*). However, at higher concentrations (15 and 20 µl/Petri), the seed germination of the weed species was significantly reduced in response to α-pinene compared to control. It appeared that 1,8-cineole and α-pinene were ineffective on inhibiting seed germination at low concentrations and require to have a higher concentration to cause complete inhibition in seed germination of test weed species.

Table 4.
Effect of different concentration of laurel essential oil and its main components, 1,8-cineole and α-pinene, on the seed germination of tested weeds

Treatments	Treatment rate (µl/Petri dish)	Germination rate (%) ± Standard Error*			
		Amaranthus retroflexus	*Glcycrrhiza glabra*	*Rumex crispus*	*Physalis angulata*
Laurel essential oil	5	16.7±6.0 B c	53.3±6.7 B a	31.7±1.7 B bc	36.7±3.3 B ab
	10	8.3±6.0 BC b	31.3±5.9 C a	13.3±3.3 C b	10.0±0 C b
	15	0±0 C b	0±0 D b	13.3 ±3.3 C a	0±0 D b
	20	0±0 C b	0±0 D b	10.0±0 C a	0±0 D b
1,8-cineole	5	73.3±3.3 A a	0±0 D d	33.3±3.3 B c	56.7±3.3 B b
	10	23.3±1.7 B b	0±0 D d	13.3±3.3 C c	53.3±3.3 B a
	15	10.0±5.0 C b	0±0 D c	13.3±3.3 C b	50.0±0 B a
	20	0±0 D b	0±0 D b	10±5.8 C a	13.3±3.3 C a
α-pinene	5	61.7±4.4 A a	60.0±0 AB a	26.7±6.7 B b	76.7±6.7 A a
	10	33.3±7.3 B bc	46.7±6.7 BC ab	26.7±3.3 B c	56.7±3.3 B a
	15	23.3±6.0 B ab	33.3±6.7 C a	16.7±3.3 BC b	10.0±0 C b
	20	21.7±4.4 B a	31.3±5.9 C a	6.7±3.3 C b	0±0 D b
Control	0	78.3 ±3.3 A ab	73.3±6.7 A ab	63.3 ±3.33A b	80 ±5.8 A a

*Satistical analyses were carried out on arcsin-transformed data and results were extrapolated to original data. Two-way ANOVA was applied for data analysis. Means within a column with the same upper-case letter and a row with the same lower-case letter are not significantly different at 1% level by LSD test.

The effect of different concentration of laurel essential oil and its main components, 1,8-cineol and α-pinene, on the seed germination of tested crop species is shown in Table 5. Laurel essential oil and its main

components, 1,8-cineole and α-pinene had a significant effect on seed germination of test crop species (P<0.01). Crop species responded differently to laurel essential oil, 1,8-cineole and α-pinene in the terms of seed germination. Laurel essential oil at low concentrations (5 and 10 µl/Petri dish) had no or very little effect on the germination of corn and wheat seeds, whereas its high concentrations (15 and 20 µl/Petri dish) completely inhibited germination in wheat and cotton seeds and significantly reduced in inhibiting seed germination of corn. Similarly 1,8-cineole at high concentrations completely inhibited seed germination of weed and cotton, while it caused significant decrease in inhibiting seed germination of corn. Contrary to the laurel essential oil and 1,8-cineole, α-pinene showed no inhibitory activity on seed germination of both wheat and corn with same germination percentage as compared to control. In case of cotton, germination significantly decreased with increasing in the concentration of α-pinene. It appeared that laurel essential oil and 1,8-cineole had a strong inhibitory activity on all test seeds (except lower concentrations of laurel essential oil and 1,8-cineole for corn), whereas α-pinene was totally ineffective on the seed germination of all the crop species except for the cotton seeds.

Table 5
Effect of different concentration of laurel essential oil and its main components, 1,8-cineol and α-pinene, on the seed germination of tested crop species

Treatments	Treatment rate (µl/Petri dish)	Germination rate (%)±Standard Error*		
		Wheat	Corn	Cotton
Laurel essential oil	5	90.0±0 B b	100±0 A a	26.6±0 B c
	10	60.0±10.0 C b	100±0 A a	26.6±0 B c
	15	0±0 D b	46.7±6.7 B a	0±0 C b
	20	0±0 D b	23.3±8.8 C a	0±0 C b
1,8-cineole	5	63.3±6.7 B b	100±0 A a	26.7±6.7 B c
	10	10±0 C b	80±11.5 B a	13.3±6.7 B b
	15	0±0 D b	46.7±6.7 C a	0±0 C b
	20	0±0 D b	23.3±8.8 C a	0±0 C b
α-pinene	5	100±0 A a	100±0 A a	66.7±6.7 B b
	10	100±0 A a	100±0 A a	40±11.5 BC b
	15	100±0 A a	100±0 A a	33.3±6.7 CD b
	20	80±20 A a	86.7±13.3 A a	13.3±6.7 D b
Control	0	100±0 A a	100±0 A a	100±0 A a

*Satistical analyses were carried out on arcsin-transformed data and results were extrapolated to original data. Two-way ANOVA was applied for data analysis. Means within a column with the same upper-case letter and a row with the same lower-case letter are not significantly different at 1% level by LSD test.

The chemical composition of a plant product depends on the plant species, the plant part, the season (temperature, photoperiod, and hygrometry), the method of harvesting, the geographical zone, pedological conditions, and the method used to isolate the plant product. Therefore, the extract of the same species from different geographical areas and from various plant parts can be different in chemical composition. Andronikashvilli and Reichmuth (2002) reported laurel essential oil extracted from its leaves collected from the samples of Georgia essentially contained 1,8-cineole (40.74%), *α*-terpinyl acetate (17.81%), sabinene (5.72%), *α*-pinene (4.86%) and *B*-pinene (3.17%). However, the chemical composition and content of the main compounds of essential oils extracted from the leaves of *L. nobilis* in this study is different from those reported by Andronikashvilli and Reichmuth (2002). It indicated that the chemical composition of essential oils from different geographical areas varied.

Under appropriate conditions, allelochemicals may be released in quantities suppressive to developing weed seedlings (Wu et al., 2002). Due to their high volatility, many plant extracts and essential oils have been tested for inhibitory activity on seed germination of many weed species (Dudai et al., 1999; Singh et al., 2003). A variety of allelochemicals have been identified, including essential oils that inhibit seed germination and plant growth (Neori et al., 2000). Likewise, our study indicated that vapor of oregano and laurel essential oils had also inhibitory effect on seed germination of test weed species. However, both oregano and laurel essential oils indicated a remarkable difference in response to the weed species. Since laurel essential oil required higher concentrations to obtain complete inhibition of seed germination of the weeds, oregano essential oil was more toxic in inhibiting seed germination of some weeds than that of laurel essential oil. The results presented here are similar to those on inhibitory activity of volatile essential oil from a number of aromatic plants on seed germination of various weed species (Dudai et al., 1999; Angelini et al., 2003; Singh et al., 2003).

The mechanisms by which oregano essential oil completely inhibit seed germination remain unkown. However, some studies have indicated that volatile oxygenated monoterpenes, such as cineole, are potent inhibitors of mitosis (Baum et al., 1998; Romagni et al., 2000). Vaughn (1991) reported that essential oils from cinnamon (*Cinamommum zeylanicum* Blume) and red

thyme (*Thymus vulgaris*) inhibit potato sprout growth by killing meristematic cells. Lorber and Muller (1976) reported that roots exposed to monoterpene vapours exhibited a variety of membrane fragments and absence of intact organelles, thereby indicating a structural breakdown in response to monoterpenes. All these reports indicated that probably loss or disruption of mitotic activity might also be responsible for the observed reduction or the inhibition of germination as observed in present study.

Terpenoids, particularly oxygenated monoterpenes and sesquiterpenes, are the main components of essential oils and are often responsible for their inhibitory activity. Since carvacrol completely inhibited seed germination in all species, showing a behavior similar to that of oregano essential oil, it would be the sole ingredient responsible for inhibitory activity shown to be exerted by oregano essential oil. Similar results were reported by Angelini et al. (2003), Dudai et al. (1999) and Singh et al. (2003). Comprasion between the activity of laurel essential oil and that of its pure constituents suggests that both laurel essential oil and its constituents, 1,8-cineole and α-pinene, indicated a remarkable difference in response to the weed species. While 1,8-cineole and α-pinene had same response to *R. crispus* with laurel essential oil, only in the case of *G. glabra* did 1,8-cineole completely inhibit seed germination. Therefore, they can not be the only components responsible for inhibiting activity on the weed species, particularly *A. retroflexus* and *P.angulata*. These compounds or the other constituent monoterpenes (*α*-terpinyl acetate, sabinene, *B*-pinene) may be acting synergistically like other allelochemicals (Einhellig, 1996).

Selectivity is one of the main properties in developing novel herbicide for weed management system. In this study, the germination trials for crop species showed that oregano and carvacrol were totally ineffective on cotton and corn germination, whereas they had a strong inhibitory activity on wheat seeds. On the other hand, laurel essential oil and 1,8-cineole had a strong inhibitory activity on all the test seeds (except for their lower concentrations for corn), whereas α-pinene was totally not effective on seed germination of all crop species except the cotton seeds. Therefore, it appeared that both oregano essential oil and carvacrol were more selective than both laurel essential oil and its main components, 1,8-cineole and α-pinene. As similar to our results, Angelini et al. (2003) reported that carvacrol was more selective as it did not inhibit radish germination. Dudai et al. (1999) reported that oregano (*O. syriacum* L.) essential oil was very effective on the inhibiting of seed germination of the wheat as similarly determined in our study.

4. Conclusions

From present study, it could be concluded that volatile oil from *O. syriacum* and carvacrol showed a strong inhibitory activity against the seed germination of the weed species and had selective action on various crop species. These data, therefore, suggested that oregano essentials oil could be used as bio-herbicide to inhibit emergence of weeds in agro-agriculture system. Future experiments on the possible effects of the periods of time during which such compounds are present in soil, possible structural modifications with consequent loss or acquisition of activity, allelopathic action on weed seeds in field conditions and formulation of essential oil for application are still needed to be studied in agriculture area.

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