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Bioactivity of Essential Oil Isolated from *Coriandrum sativum* Plant Against the Weed *Avena fatua* Associated Wheat Plants

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Abstract

Essential oils are an important source of natural plant products that can be used widely in plant pest control and weed control. Therefore, dried coriander seeds and dry waste were collected for the purpose of recycling and production of volatile oil, in addition to reducing environmental pollution resulting from the methods used to dispose of agricultural waste.The chemical compositions of coriander oils were analyzed by GC/MS methods. The main constituent was linalool in dry seeds oils, while trans-anethole and linalool were found as the main oil constituents of waste oil. The results recorded that, the waste oil is very similar to that of dry seed. Experiment was conducted in the greenhouse of National Research Centre, Egypt for two winter seasons 2018/2019 and 2019/2020 aimed to evaluate herbicidal activity of essential oils extracted from *Coriandrum sativum* seeds and west on the control of *Avena fatua* weed and the net return on the growth and yield of wheat plants cv. Giza168. This experiment was preceded by a laboratory test to select the appropriate concentrations of both oils on *Avena fatua*. The results revealed that the difference between the effect of seed oil and waste of *C. sativum* on germination and seedling length of *A. fatua* was nonsignificant in most corresponding concentrations. So, essential oil of *C. sativum* waste was selected and sprayed at concentrations (1.5-4% v/v). The results in the pot experiment elucidated significant inhibition in *A. fatua* fresh and dry weight exceeding 78% inhibition of the control at harvest. Suppression of the weed was concomitant with increase in growth and yield of wheat. The result suggested using essential olis of seed waste of *C. sativum* as natural herbicide.

1. Introduction

To maximize the benefit from agricultural residues, this study focused on making use of the remnants of the coriander plant as a new source for producing coriander essential oil in order to preserve the environment and use it as a natural source for weed control. Coriander (*C. sativum* L.) plants an annual in the Umbelliferae family. It is an important medicinal and flavour plant. Coriander comes from the Mediterranean region and is grown all over the world [1-3]. A distillation of the aerial parts of coriander gave volatile oils in plants, full flowering fruit, and green, unripe and dry fruit.

Volatile oils can differ among different parts of the same coriander plant, [4]. Linalool compound is the main constituents of the seeds [5]. Many authors reported that, the volatile oil constituents of the coriander, herbs and fruit are completely different [4,6, 7,8].

Weeds compete with crops for light, moisture and nutrient elements so, reducing taking up of these elements by the main crops [9]. So, Weeds considered serious problems that compete with the main

crops causing great reduction in the yield [10-11]. Using chemical herbicides for long term produced resistant weeds [12-13]. In addition to producing contaminant environment, soil and foods due to the herbicidal residual effect [14].

Consequently, it is a strategy to search for alternative and safe methods for producing pure environment and for overcoming the resistance of weeds to continuous use of herbicides [15-16].

Allelopathy is one of these alternative methods at which secondary metabolites (allelochemicals) are released from allelopathic plants to the other neighbouring plants [17]. These allelochemicals are stimulators or inhibitors depending on their concentrations [18]. The allelopathic materials are found in plant residue as leaves, stems or roots or essential oils [19-23].

Essential oils are a natural source of active compounds with antimicrobial and herbicidal potential, and have been successfully used in organic agriculture, instead of synthetic compounds, due to their high bioactivity and the absence of toxicity [24]. Essential oils consisted of a mixture of volatile compounds in aromatic plants are well used in pharmaceutical, agronomic, food and flavour industries, cosmetics and perfume industries [25]. Essential oils are documented as one of the allelopathic materials that reduced germination and seedling growth of some plants [26-31].

In general, many workers documented allelopathic properties for some Apiaceae (Umbelliferae) seeds such as fennel, cumin, caraway, celery, dill, anise and coriander are reported [32-33]. Different concentrations of coriander essential oils ((3, 6, 10 and 20 µl) were found to reduce common weed species (*Alcea pallida* Waldst. & Kit., *Amaranthus retroflexus* L., *Centaurea salsotitialis* L., *Raphanus raphanistrum* L., *Rumex nepalensis* Spreng., *Sinapis arvensis* L. And *Sonchus oleraceus* L.) in the field and inhibited their germinations in laboratories [28]. In field experiment, Dhima *et al*. [34] recorded reduction in the fresh weight of purslane, common lambsquarters, black nightshade, and barnyardgrass growing with coriander. In addition, the authors reported reduction in barnyardgrass by the essential oil of coriander in Petri dish bioassay. Coriander seed essential oil at 200-800 ppm ethanol reduced germination of two weeds (*Lathyrus annuus* and *Vicia villosa*) in addition to complete inhibition in radicle growth after seven days [35]. Moreover, even the seed extract of coriander as well as leaves were reported to have allelopathic effect; Baeshen [36] reported that coriander leaf extract at different concentrations inhibited the seed germination and reduce radicle length of *Phaseolous vulgaris*. Işik *et al*. [37] recorded inhibition in the seed germination and seedling growth of *Chenopodium album* with a water extract of coriander and added that the growth was completely inhibited at 20% concentration.

This work aims to study the essential oils of coriander seeds and waste and their use in assaying their effect on seedling growth of the tested weed *Avena fatua* and application of suitable concentrations for controlling the tested weed in the greenhouse associated wheat.

2. Materials and methods

2.1 Plant material and isolation of essential oils*:*

Essential oils were extracted from dry plant materials by hydro-distillation for 3 hr. (Clevenger, 1928) [38]. The samples of volatile oils were subjected to GC/MS analysis.

2.2 Gas chromatography

GC analysis was performed by a Shimadzu GC- 9A gas chromatograph equipped with a fused silica column DB5 (30 m x 0.25 mm i.d., film thickness 0.25 µm). The oven temperature was held at 40°C for 5 min and then programmed until 250°C at a rate of 4°C/min. Injector and detector (FID) temperature were 260°C; helium was used as a carrier gas with a linear velocity of 32 cm/s.

2.3. Gas chromatography- mass spectrometry

GC-MS analyses were carried out on a Varian 3400 system equipped with a DB-5 fused silica column (30 m x0.25 mm i.d.); Oven temperature was 40 to 240°C at a rate of 4°C/min, transfer line temperature 260°C, injector temperature 250°C, carrier gas, helium with a linear velocity of 31.5 cm/s, split ratio 1/60, flow rate 1.1 ml/ min, Ionization energy 70 eV; scan time 1 s ; mass range 40-350 amu.

2-5.Qualitative and quantitative analysis of essential oil

Identifications were made by library searches (Adams, 1995) [39] combining MS and retention data of authentic compounds by comparison of their GC retention indices (RI) with those of the literature or with those of standards available in our laboratories. The retention indices were determined in relation to a homologous series of n-alkanes (C8–C22) under the same operating conditions. Further identification was made by comparison of their mass spectra with those stored in NIST 98 and Wiley5 Libraries or with mass spectra from literature. Component relative concentrations were calculated based on GC peak areas without using correction factors.

3.1. Bioassay test

Before assaying the oils of seeds and waste of *Coriandrum sativum* on the growth inhibition of *Avena fatua* in the pot experiment, simple test was done to detect the more active concentrations. Series of concentrations of seeds and waste essential oils of *Coriandrum sativum* starting from 0.25 to 4% (v/v) was tested against *Avena fatua* in Petri dishes [40]. The essential oils isolated from *Coriandrum sativum* seeds and waste were dissolved in distilled water with the help of ethanol. The concentrations of the essential oils isolated from *Coriandrum sativum* seeds and waste were prepared at 0.25, 0.5, 1, 1.5, 2, 2.5, 3, 3.5 and 4% (v/v) for both seeds and waste. Seeds of *Avena fatua* were germinated in sterilized Petri dishes (9 cm diameter) containing 1-layer filter paper Whatman No. 3. Ten millilitres of the prepared concentrations of isolated essential oils, seeds and waste [0.25-4% (v/v)] were added to each Petri dish. Distilled water was added to five Petri dishes serving as control. The germination of seeds was carried out in the laboratory in November with average maximum and minimum temperatures of **2**2±1°C and **1**4 ±1°C. Each treatment was represented by five replicates (5 Petri dishes); each Petri dish contained 20 seeds. Five days later 5 ml of the tested extracts was added. The percentage of germination were calculated by counting the germinating seeds. Shoot and root lengths were also determined 10 days after germination. The experiment was repeated twice, and the presented results are the mean of the two experiments. The treatments were arranged at complete randomized design.

3.2.Pot experiment:

On the bases of the bioassay test, the essential oil isolated from the waste of *Coriandrum sativum* was used in the pot experiment and dissolved in distilled water with the help of ethanol at concentrations at 1.5, 2, 2.5, 3, 3.5 and 4 % (v/v).

Pot experiments were conducted in the greenhouse of the National Research Centre, Egypt for two winter seasons 2018/2019 and 2019/2020. Wheat cv. Giza168 was obtained from the Agricultural Research Centre, Egypt. The pots, 30 cm in diameter and 30 cm in height, contained equal amounts of sieved soil (2: 1 v/v clay and sand). Wheat grains were selected for uniformity by choosing those of equal size and with the same colour. Grains were sown 2 cm deep (8 grains in each pot) and allowed to germinate. All pots (except weed free treatment) were infested with the same number of weeds (10 seeds) of *Avena fatua* and mixed thoroughly at a depth of 2 cm in the soil. Wheat grains and weed seeds were sown at the same time. The cultivated wheat grains were thinned two weeks after sowing so that three

homogeneous seedlings were left per pot. Irrigation and routine fertilizers were carried out. The experiment consisted of eight treatments including: two untreated controls, wheat only, wheat with *Avena fatua* (unweeded treatment). The other six treatments were *Coriandrum sativum* waste oil at concentrations 1.5, 2, 2.5, 3, 3.5 and 4 % (v/v). Each treatment was represented by 6 pots. The pots were distributed in a complete randomized design. The above concentrations of waste oil were sprayed on the pots contained wheat plants and *Avena fatua* weed at the rate of 60 ml /pot. The treatments were applied three times during three weeks starting from two weeks old plants. The data were taken at 40 days after sowing and at harvest.

3.3. Weed data:

In each season, weed samples were taken from each of the three pots 40 days after sowing and at harvest (all weed samples in each pot were pulled up). The fresh weights of *Avena fatua* was recorded and oven dried at 60°C for determination of dry weight (g/pot).

3.4. Wheat data:

Three plants in each pot were taken for recording, plant height, number of leaves, as well as fresh and dry weight (g/plant) were recorded 40 days after sowing. At harvest, spike length, number of spikes/ plants, number of spikelets/spike, grain yield (g/plant) and 1000- grain weight
(g) were determined.

3.5. Statistical analysis:

The data were subjected to analysis of variance (ANOVA) by using completely randomized design and the Least Significant Difference (LSD) at the 5% probability level were calculated [41].

4. Results and discussion

4.1 Essential oil content

The dry waste materials gave the highest percentage of coriander essential oil (0.81%), while, the dry seeds recorded (0.44 %) only .In Table 1, linalool was found as the main constituents of coriander dry seed oil, follow by, ethyl hexanoic acid <2> , sabinene hydrate trans and α–thujene . (OM) was recorded as the main group in the dry coriander seed oil which recorded (66.77%) .Similar results were reported by several investigators . α-Pinene and β-caryophyllene were foundIt in significant amounts. Some compounds have been identified with a concentration less than 1%.Anethole <trans-> was found as the main constituents of coriander waste oil (28.11%) followed by, linalool compound, butanoic acid, 2-methyl-, 2-methoxy-4-(2-propenyl)phenyl ester , estragole longifolen, and carvacrol.coriander waste oil consists of five chemical groups [(MHC), (OMC), (SHC) (OSC) and (VC)]. Result in Table 1 revealed the presence of five components of (OMC) group which recorded 70.41 % .

Comparing the oil constituents of the dry seeds and dry waste, it was found that, the major constituent was linalool in dry seeds oils, while trans-anethole was found as the main oil constituents of waste oil followed by linalool. The highest percentage of linalool was found in the seed oil followed by the waste respectively. There is an obvious variation in the oil components of the two oils due to the type of plant material, some compounds were found in the two oil samples with only differences in the concentrations of them. Such as α–pinene. Camphene, β–pinene, p- cymene and limonene. Also, some compounds were found in one sample and absent in the others. Cis-beta-ocimene, terpinene gamma, camphor, α–terpineol, β–caryophyllene and decanal were found in the dry seeds oils. While estragole and trans

anethole were found only in the waste oil. The constituents of the waste oil was close to that of the dry seed oils.

Table 1 The main constituents of coriander oils isolated from dry seeds and waist

Peak	KI	Constituents	Seeds %	Waste %
Monoterpene hydrocarbons (MHC)				
1	939	α-pinene	2.26	0.51
2	953	Camphene	1.10	0.29
3	980	β-pinene	0.10	0.15
4	995	α-thujene	3.33	0.00
5	1011	3-carene	0.56	0.00
6	1026	P-cymene	0.16	0.88
7	1031	Limonene	0.10	0.75
8	1041	(Z)-β-ocimene	0.65	0.00
9	1061	γ-terpinene	0.15	0.00
		Total	8.41	2.85
Oxygenated monoterpenes compounds (OMC)				
1	1097	Sabinene hydrate trans	4.35	0.00
2	1098	Tetrahydrolinalool	0.25	0.00
3	1098	Linalool	59.6	21.30
4	1151	Camphor	0.27	0.00
5	1161	Dihydro terpineol (trans-Alpha)	0.04	0.00
6	1168	Borneol	0.31	0.00
7	1189	-terpineol	0.02	0.00
8	1195	Estragol	0.00	9.85
9	1228	Nerol	0.9	0.00
10	1275	Citral A	0.25	0.00
11	1283	Trans anethol	0.00	28.11
12	1290	Thymol	0.57	0.00
13	1301	Carvacrol	0.21	4.65
14	1402	Longifolene	0.00	6.50
		Total	66.77	70.41
Sesquterpenes hydrocarbons compounds (SHC)				
1	1337	Elemene <Delta->	0.07	0.00
2	1418	Caryophyllene < beta>	2.48	0.00
3	1480	Germacrene D	0.00	2.21
4	1495	Zingiberene	0.00	0.91
5	1509	B-bisabolene	0.00	0.55
6	1556	Germacrene B	0.40	0.00
		Total	2.95	3.67

Oxygenated *sesquterpenes compounds (OSC)*				
1	1574	Dendrolasin	0.20	0.00
2	1576	Spathulenol	0.00	0.98
3	1589	Caryophyllene-oxide	0.09	0.00
4	1591	Elemenone <cic-beta->	0.41	0.00
		Total	0.70	0.98
Various compounds (VC)				
1	1129	Ethyl hexanoic acid <2->	4.91	0.00
2	1199	Dodecane	0.95	0.00
3	1204	Decanal	0.00	0.59
4	1383	Geranyl acetate	0.00	0.78
5	2149	Butanoic acid, 2-methyl,2-methoxy-4-(2-propenyl) phenyl ester	0.00	13.91
Total			5.86	15.28

4.2 Bioassay test

Seed and waste of *Coriandrum sativum* essential oils at concentrations from 1-4% significantly inhibited germination percentage, seedling root, and shoot length of *Avena fatua* as compared to the untreated control (Table 2). The inhibition was concentration dependent; the reduction in germination percentage as well as root and shoot length of *A. fatua* weed recorded maximum reduction under the untreated control by using the highest concentration of seed and waste oils (4%). It is worthy to mention that the difference between the effect of seed oil and waste of *C. sativum* on germination and seedling root and shoot length of *A. fatua* was nonsignificant in most concentrations used. Rahimi *et al*., [35] obtained similar results by Coriander seed essential oil the two weeds (*Lathyrus annuus* and *Vicia villosa*). Baeshen [36] and Işik *et al*. [37] confirmed these results on *Phaseolous vulgaris* and *Chenopodium album* by using coriander extract.

4.2. Pot experiment

4.2.1. Weed growth

The laboratory test (Table 2) indicated that the significant effect of seed and waste oils of *C. sativum* on *A. fatua* started from 1.5% and it is worthy to mention that both seed and waste oil was revealed non-significant results between corresponding concentrations. Consequently, it is advisable commercially to use waste oil of *C. sativum* at 1.5 -4% in the pot experiment. The results in Table 3. Show that both *A. fatua* fresh and dry weight were reduced significantly under the untreated control by all concentrations of *C. sativum* waste (1.5-4%) with noticeable inhibition at 4%. *A. fatua* dry weight at the end of the season follow similar trend reaching 78.8% as maximum reduction in comparison to the control.

Rahimi *et al*. [**35**] obtained similar results by Coriander seed essential oil on the two weeds (*Lathyrus annuus* and *Vicia villosa*). Baeshen **[36]** and Işik *et al*. [**37**] confirmed these results on *Phaseolous vulgaris* and *Chenopodium album* by using coriander extract. It has been shown that chemicals found in essential oils of plants that have the allelopathic effects on seed germination. Interaction between Medicinal, aromatic plants and the surrounding organisms occurred through transmitting volatile allelochemicals [42-44].

Table (2) Effect of *Coriandrum sativum* seed and waste oil on germination and seedling root and shoot length of the grassy weed *Avena fatua*

Source of oil	Essential oil concentration %	Germination %	Roo length (cm)	Shoot length(cm)
Seed oil	**0.25**	**100.00**	**14.00**	**13.01**
	0.50	**94.36**	**13.06**	**12.05**
	1.00	**92.40**	**11.57**	**9.89**
	1.50	**90.23**	**9.94**	**8.20**
	2.00	**88.00**	**7.96**	**5.42**
	2.50	**80.36**	**5.39**	**3.77**
	3.00	**74.86**	**3.27**	**3.34**
	3.50	**47.56**	**3.03**	**2.95**
	4.00	**16.33**	**1.99**	**1.78**
Waste oil	**0.25**	**100.00**	**14.56**	**12.91**
	0.50	**97.56**	**13.66**	**12.54**
	1.00	**96.93**	**12.16**	**10.33**
	1.50	**91.70**	**10.56**	**8.85**
	2.00	**89.16**	**9.60**	**6.09**
	2.50	**78.20**	**6.63**	**4.30**
	3.00	**69.73**	**4.35**	**4.24**
	3.50	**49.73**	**3.78**	**3.50**
	4.00	**20.06**	**2.72**	**2.09**
	0.00	**100.00**	**15.71**	**13.42**
LSD at 5%		**3.41**	**1.45**	**1.34**

Table 1 show that trans-anethole and linalool were found as the main oil constituents of waste oil. These two constituents related to the oxygenated monotupenes. Suppression of weed growth (Table 2) may be attributed to these two constituents. This suggestion was coincided with documents on monoterpenes phytotoxic effect that was mentioned by several workers [45-48]. Elsawi *et al*. [43]and El-Rokiek *et al*. (49) also confirmed this suggestion; they discussed the inhibition in weed growth on the bases of the presence of oxygenated monoterpenes especially trans-anethole and linalool.

Vasilakoglou *et al*. [50] tested the phytotoxicity of nineteen major components of essential oils against rigid ryegrass (Lolium rigidum Gaudin). The authors detected that trans-anethole and linalool were the most phytotoxic components that completely inhibiting rigid ryegrass germination and root growth. Furthermore, trans-anethole and linalool not only have allelopathic suppressing effect on higher plants but also on different microorganisms. These two compounds exhibited anti-fungal as well as anti-bacterial activity and others [51-55].

3.2.2. Wheat growth

Table 4 reveals significant increase in plant height, number of leaves / plant as well as fresh and dry weight of wheat when sprayed with *C. sativum* waste oil mostly by all concentrations 40 days after sowing in comparison to the untreated control.

Table (3) Effect of *Coriandrum sativum* waste oil on the growth of grassy weed *Avena fatua* (Average of the two seasons)

Treatments	Concentration (percentage)	40 DAS Fresh weight (gt)	Dry weight (g)	Weight at the end of the season (g)
Weed-free	0.0	0.00	0.00	0.00
Unweeded	0.0	9.33	2.311	32.04
	1.5	6.27	1.402	21.76
	2.0	5.25	1.292	17.63
Wheat + *A. fatua*+ *C. sativum*	2.5	5.087	1.188	12.60
	3.0	4.69	1.113	16.14
waste seed oil	3.5	3.99	1.014	9.88
	4.0	3.78	1.020	6.79
LSD t 5%		0.172	0.062	0.81

Application of 4% of *C. sativum* waste oil resulted in maximum significant increase in all growth parameters recorded in Table 3 as compared to the unweeded control. Growth inhibition of *A. fatua* caused by *C. sativum* oil waste (Table 3) had the payback on wheat growth as the competition of *A. fatu*a weed decreased with wheat leading to more nutrients absorbed by the target plant (wheat), consequently, increasing in wheat growth represented by plant height, number of leaves, fresh and dry weight / plant were increased as compared to unweeded control.

Table (4) Effect of *Coriandrum sativum* waste oil on different growth parameters of wheat(Average of the two seasons)

Treatments	Concentration (percentage)	Plant height (cm)	No. Leaves /plant	Fresh weigh (g/plant)	Dry weight (g/plant)
Weed-free wheat	0.0	35.20	12.00	1.699	0.335
Unweeded wheat	0.0	23.00	10.00	0.618	0.120
	1.5	24.00	10.86	0.890	0.156
Wheat + *A.* fatua+	2.0	26.83	11.83	1.074	0.213
C. sativum	2.5	30.66	13.33	1.186	0.253
waste seed oil	3.0	35.66	11.43	1.294	0.276
	3.5	38.00	12.76	1.341	0.281
	4.0	40.00	15.66	1.808	0.361
LSD at 5%		2.32	0.72	0.193	0.011

4.2.3. Wheat yield

The results in Table5 reveal significant increase in in spike length, number of spikes/ plant and number of spikelets/spike due to *C. sativum* waste oil spray at concentrations (2-4%) over that of unaided control. Maximum significant results were obtained with 4%. Both grain yield/plant (g) and weight of 1000grain (g) exhibited similar results. Grain yield in pots sprayed with 4% *C. sativum* waste oil exceeded 79% over that in unweeded pots. In addition, weight of 1000 grains exceeded 41% as remarkable results obtained by 4%. The increase in wheat yield resulted from increasing in growth. Several workers reported controlling weeds increased crop growth and production [49, 56-57].

Table (5). Effect of *Coriandrum sativum* waste oil on yield and yield components of wheat (Average of the two seasons)

Treatments	Concentration (percentage)	Spike length (cm)	No. spikes/plant	No. Spiklets/spike	Weight of grains/plant (g)	Weight of 1000 grains (g)
Weed-free wheat	0.0	10.75	6.33	23.00	10.73	36.88
Unweeded wheat	0.0	7.83	3.33	18.33	5.40	28.96
	1.5	8.35	3.72	19.33	5.89	29.41
	2.0	8.64	4.66	20.66	6.35	31.98
Wheat + *A. fatua* + *C. sativum* waste seed oil	2.5	9.00	4.83	22.00	7.21	32.91
	3.0	9.50	5.00	23.5	8.25	33.64
	3.5	9.66	5.66	24.00	8.93	39.28
	4.0	11.33	6.66	24.53	9.68	40.87
LSD at 5%		0.82	0.55	1.32	0.68	1.67

Conclusion

To maximize the benefit from coriander plant samples. The results suggested using coriander waste oil as a bioherbicide alternative to unsafe chemical recycling agricultural waste and preserve the environment, this research focuses on recycling agricultural waste from coriander plants as a new source for the production of aromatic oils. The dry coriander plant, where the difference was only in the percentage of the constituents with some additional new compounds. The results confirmed the presence of linalool as main ingredients in most herbicides.

References

1. S. Duarte, F. Ferreira, F. C. Silva, Synergistic activity of coriander oil and conventional antibiotics against Acinetobacter baumannii, *Phytomedicine*, 19 (2012) 236-238. https://doi.org/10.1016/j.phymed.2011.11.010
2. P.Mahendra, S. Bisht, *Pharma- cognosy J.* 3 (2011) 84. https://doi.org/10.5530/pj.2011.21.16
3. J. Sriti, W. A.Wannes, T. Talou, G .Vilarem , B. Marzouk., *J. Essent. Oil Res.* 23 (2011) 7. https://doi.org/1026872/jme.2018.1.1.9
4. N. I. Bhuiyan, J. Begum, M.Sultana, *Bangladesh J. Pharmacol*. 4 (2009) 150. DOI: https://doi.org/10.3329/bjp.v4i2.2800
5. M. A. Mohamed, M. E. Ibrahim, H. E.Wahba, Flavoring Compounds of Essential Oil Isolated from Agriculture Waste of Coriander (Coriandrum sativum) Plant, *J. Mater. Environ. Sci.,* 9(1) (2018) 77-82 https://doi.org/10.26872jmes 2018.9.1.9
6. T. L. Potter, Essential Oil Composition of Cilantro, *J. Agric. Food Chem.* 44 (1996) 1824. https://doi.org/10.1021/jf950814c
7. Z. Rakic, C h. B. Johnson, Influence of Environmental Factors (Including UV-B Radiation) on the Composition of the Essential Oil of Ocimum basilicum–Sweet Basil, *J. Herbs Spice. Med. Plants,* 9 (2002) 157. https://doi.org/10.1300/J044v09n02_22

8. I.S.N. Ebrahim, J. Hadian, H. Ranjar, Essential oil compositions of different accessions of Coriandrum sativum L. from Iran, *Nat. Prod. Res*. 24 (2010) 1287. https://doi.org/10.1080/14786410903132316
9. E. Lehoczky, and P. Reisinger, Study on the weed-crop competition for nutrients in maize. *Communications in agricultural and applied biological sciences*, 68(2003) 373-380.
10. K. M. Murphy, J.C. Dawson, S. S. Jones, Relationship among phenotypic growth traits, yield and Weed suppression in spring wheat landraces and modern cultivars. Field Crops Res. 105 (2008) 107–115. https://doi.org/10.1016/j.fcr.2007.08.004
11. K. G. El-Rokiek and S. A. Saad El-Din, Allelopathic Activity of Eucalyptus Globulus Leaf Water Extract on Pisum Sativum Growth, Yield and Associated Weeds, *Middle East Journal of Applied Sci.* 7 (4) (2017) 907-913.
12. J. K. Norsworthy, S. M. Ward, D. R. Shaw, R. Llewellyn, R. L. Nichols, T. M. Webster, K. W. Bradley, G. Frisvold, S. B. Powles, N. R. Burgos, W. W. Witt, M.l Barrett, Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations, *Weed Science* 60, (2012) 31-62. https://doi.org/10.1614/WS-D-11-00155.1
13. B.D. Tidemann, K.N. Harker, E.N. Johnson, C. J. Willenborg and S. J. Shirtliffe , Time of Wild Oat (Avena fatua) Panicle Clipping Influences Seed Viability. *Weed Science*, 68 (2020) 1-26. https://doi.org/10.1017/wsc.2020.19
14. M. Jamil, Z. A. Cheema, M. N. Mushtaq, M. Farooq and M. A. Cheema, Alternative control of wild oat and canary grass in wheat fields by allelopathic plant water extracts, *Agronomy for Sustainable Development* 29 (2009) 475-482. DOI:10.1051/agro/2009007
15. V. Kumar, D. C. Brainard, R. R. Bellinder, Suppression of Powell Amaranth (Amaranthus powellii) by Buckwheat Residues: Role of Allelopathy *Weed Science* 57 (2009) 66-73. DOI:10.1614/WS-08-028.1
16. S. O. Duke, Proving Allelopathy in Crop–Weed Interactions, *Weed Science*, 63 (2015) 121-132. DOI:10.1614/WS-D-13-00130.1
17. E. L. Rice, In Allelopathy, 2nd edn. Academic Press, Orlando (1984), p 422.
18. H. P. Singh, S. N. Batish and R. K. Kohli, Herbicidal activity of volatile oils from *Eucalyptus citriodora* against Parthenium hysterophorus. *Ann Appl Biol* 146 (2005)89–94. https://doi.org/10.1111/j.1744-7348.2005.04018.x
19. K. G. El-Rokiek and R. A. Eid, Allelopathic effects of Eucalyptus citriodora on amaryllis and associated grassy weed. *Planta daninha*, 27(2009) 887- 899. https://doi.org/10.1590/S0100-83582009000500002
20. K. Jabran, M. Farooq, M.,Hussain, R. Hafeez-ur and M. A. Ali, Wild oat (Avena fatua L.) and Canary Grass (Phalaris Minor Ritz.) Management through Allelopathy, *J. Plant Protection Res.*, 50 (2010) 41-44. DOI: 10.2478/v10045-010-0007-3
21. E. A. Khan, A. Khakwani, M. Munir and G. Farullah, Effects of allelopathic chemicals extracted from various plant leaves on weed control and wheat crop productivity. Pakistan Journal of Botany, 47 (2015) 735-740.
22. S. Kaur, H. P. Singh, D. R. Batish and Kohli, Chemical characterization and allelopathic potential of volatile oil of *Eucalyptus tereticornis* against *Amaranthus viridis*. *J. Plant Interactions* 6 (2011), 297–302. https://doi.org/10.1080/17429145.2010.539709
23. A. Mehmet, K. Mavi and I. Uremis, Bio-herbicidal eff ects of oregano and rosemary essential oils on germination and seedling growth of bread wheat cultivars and weed. *Romanian Biotechn Letters*, 21(2016) 11149–11159.

24. R. M. Sumalan, E. Alexa, I. Popescu, M. Negrea, I. Radulov, D. Obistioiu, I. Cocan Exploring Ecological Alternatives for Crop Protection Using Coriandrum sativum Essential Oil, *Molecules*, 24 (2019) 2040-
25. M. E. Ibrahim, M. A. Mohamed, H. E. Wahba and S. A. El-Sawi, Unconventional Source of Anise Volatile Oil. *J. Mater. Environ. Sci*., 8 (2017) 3968-3972 https://www.jmaterenvironsci.com/Document/vol8/vol8_N11/417-JMES-3158-Ibrahim.pdf
26. L. G. Angelini, G. Carpanese, P. L. Cioni, I. Morelli, M. Macchia and G. Flami, Essential oil from Mediterranean Lamiaceae as weed germination inhibitors. *J Agric Food Chem*. 51(2003) 6158-6164. https://doi.org/10.1021/jf0210728
27. D. R. Batish, H. P. Singh, R. K. Kohli and S. Kaur 2008. Eucalyptus essential oil as natural pesticide. *Forest Ecol. Manage.,* 256 (2008) 2166-2174. doi.org/10.1016/j.foreco.2008.08.008
28. S. Azirak and S. Karaman, 2008. Allelopathic effect of some essential oils and components on germination of weed species. *Acta Agriculturae Scandinavica, Section B — Soil & Plant Science*, 58 (2008) 88-92. https://doi.org/10.1080/09064710701228353
29. G. P. Young and J. K. Bush, Assessment of the allelopathic potential of Juniperus ashei on germination and growth of Bouteloua curtipendula. *J. Chem Ecol*. 35 (2009) 7480.
30. M. Rassaeifar, N. Hosseini, As. N. Haji Hasani and P. Zandiand, A. M. Aghdam, Allelopathic effect of *Eucalyptus globulus* essential oil on seed germination and seeding establishment of *Amaranthus blitoides* and *Cynodon dactylon, Trakia Journal of Sciences* 1 (2013) 73–81. DOI: 10.15547/tjs.2017.03.017
31. M. Ibáñez and Blázquez, Phytotoxicity of Essential Oils on Selected Weeds: Potential Hazard on *Food Crops*. *Plants* 7 (2018) 79.
32. M. Azizi and Y. Fuji, 2006. Allelopathic effect of some medicinal plant substances on seed germination of *Amaranthus retroflexus* and *Portulaca oleraceae*. *Acta Horticulturae,* 699 (2006) 61-67. DOI: 10.17660/ActaHortic.2006.699.5
33. M. Ravlić, R. Baličević, M. Nikolić and A. Sarajlić, Assessment of Allelopathic Potential of Fennel, Rue and Sage on Weed Species Hoary Cress (Lepidium draba), *Notulae Botanicae Horti Agrobotanici* Cluj-Napoca 44(2015) 48-52. DOI:10.15835/nbha44110097
34. K. Dhima, I. Vasilakoglou, V. Garane, Ch. Ritzoulis, V Lianopoulou and E. Panou-Philotheou, Competitiveness and Essential Oil Phytotoxicity of Seven Annual Aromatic Plants, *Weed Science,* 58 (2010) 457-465. DOI: https://doi.org/10.1614/WS-D-10-00031.1
35. R. Rahimi, S. J. Mousavizadeh, H. Mohammadi, A. Rokhzadi, M. Majidim and Sh. Amini, Allelopathic effect of some essential oils on seed germination of Lathyrus annuus and Vicia villosa. Journal of Biodiversity and Environmental Sciences 3(2013) 67-73.
36. A. A. Baeshen, Morphological and elements constituent effects of allelopathic Activity of some medicinal plants extracts on Zea mays, *Int. J. curr. Res. Aca. Rev.,* 2 (2014) 135-143.37.
37. D. Isik, H. Mennan, M. Cam, N. Tursun and M. Arslan, Allelopathic Potential of Some Essential Oil Bearing Plant Extracts on Common Lambsquarters (Chenopodium album L.), Revista de Chimie -Bucharest, 67(2016) 455-459.
38. J. F. Clevenger, Apparatus for the determination of volatile oil, *J Am Pharm Assoc* 17(4) (1928) 345-349. https://doi.org/10.1002/jps.3080170407
39. R.P. Adams, Identification of essential oil components by gas chromatography/mass spectrometry. ISBN : 9781932633214; *4th Ed. Allured Publisher. Corp., Carol Stream,* IL. (2007)

40. . K. G. El-Rokiek and W. M. El-Nagdi, Dual effects of leaf extracts of *eucalyptus citriodora* on controlling purslane and root-knot nematode in sunflower. *J. Plant Protection Res*. 51(2011) 121-129. DOI:10.2478/v10045-011-0021-0
41. . Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th ed. The Iowa State UniversityPress, Ames, Iowa, IA, USA, 507 pp.
42. H. Abo El Makarem, S. E. El Kholy, A. Abdel-Latif and A. Seif, . Effect of some botanical oilson the granary weevil, *Sitophilus granarius* (L.) (*Coleoptera*: *Curculionidae*). *Egypt. J. Exp. Biol.(Zool.)*, 13 (2017) 273 – 282. 10.5455/egysebz.20171025013938
43. S. A. El Sawi, M. E. Ibrahim, K.G. El-Rokiek and S. A.Saad El-Din , Allelopathic potential of essential oils isolated from peels of three citrus species. *Annals of Agricultural Science,* 64(2019)89-94. https://doi.org/10.1016/j.aoas.2019.04
44. S. Mirmostafaee, M. Azizi and Y. Fujii, Study of Allelopathic Interaction of Essential Oils from Medicinal and Aromatic Plants on Seed Germination and Seedling Growth of Lettuce. *Agronomy,* 10 (2020) 163. doi:10.3390/agronomy10020163
45. R. Kotan, R, A. Cakir, F. Dadasoglu, T. Aydin, R. Cakmakci, H. Ozer, S. Kordali, E. Mete and N.Dikbas, Antibacterial activities of essential oils and extracts of Turkish Achillea, Satureja andThymus species against plant pathogenic bacteria. *J Sci Food Agric*, 90 (2010) 145-160. DOI: 10.1002/jsfa.3799
46. B.Teixeira, A. Marques, C. Ramos, C. Serrano, O. Matos, N. R. Neng, J. M. F. Nogueira, J. A. Saraiva and M. L. Nunes, Chemical composition and bioactivity of different oregano (*Origanumvulgare*) extracts and essential oil. *J Sci Food Agric,* 93 (2013) 2707–2714. DOI: 10.1002/jsfa.6089
47. B. L. Yan, P. Gauthier, K.K. Keefover-Ring and J. D. Thompson, Variable Phytotoxic Effects of *Thymus vulgaris* (Lamiaceae) Terpenes on Associated Species. *Int. J. Plant Sci,* 176 (2015) 20-30. https://doi.org/10.1086/678772
48. 48. A. R. Ersilia, A., Sumalan, C. Danciu, D. Obistioiu, M. Negrea, M. Poiana, C. Rus, I. Radulov, G.Pop and C. Dehelean, Synergistic antifungal, allelopathic and antiproliferative potential of Salvia officinalis L., Thymus vulgaris L. essential oils. *Molocules*, 23 (2018) 1–15. DOI: 10.3390/molecules23010185
49. K. G. El-Rokiek1, M. E. Ibrahim, S. A. Saad El-Din and S. A. El-Sawi Using Anise (Pimpinella anisum L.) Essential oils as natural herbicide, *J. Mater. Environ. Sci.*, 11 (2020) 1689-1698
50. I. Vasilakoglou, K. Dhima, K. Paschalidis and C. Ritzoulis , Herbicidal potential on *Lolium rigidum* of nineteen major essential oil components and their synergy. *J. Ess. Oil Res.,* 25 (2013) 1-10. https://doi.org/10.1080/10412905.2012.751054
51. M. M. Özcan,. and J. C. Chalchat, Chemical composition and antifungal effect of anise (*Pimpinellaanisum* L.) fruit oil at ripening stage. *Ann Microbiol,* 56 (2006) 353–358. https://doi.org/10.1007/BF03175031
52. J. Usta, S.Kreydiyyeh, K. Knio, P. Barnabe, Y. Bou-Moughlabay and S. Dagher, Linalool decreases HepG2 viability by inhibiting mitochondrial complexes I and II, increasing reactive oxygen species and decreasing ATP and GSH levels, Chemico-Biological Interactions, 180 (2009) 39-46. https://doi.org/10.1016/j.cbi.2009.02.012
53. A. I. Hussain, F. Anwar, PS.Nigam, M. Ashraf and AH. Gilani, Seasonal variation in content, chemical composition and antimicrobial and cytotoxic activities of essential oils from four Mentha species. *J Sci Food Agric*, 90 (2010) 1827–1836. https://doi.org/10.1002/jsfa.10098

54. R. Pavela, Acute, synergistic and antagonistic effects of some aromatic compounds on the Spodoptera littoralis Boisd. (Lep., Noctuidae) larvae, *Industrial Crops and Products,* 60 (2014) 247-258. https://doi.org/10.1016/j.indcrop.2014.06.030
55. Z.Wanga Y. Xie, M. Sabier, T. Zhang, J. Deng, X. Song, Z. Liao, Q. Li, Sh. Yang, Y. Cao, X. Liu, G. Zhou, Trans-anethole is a potent toxic fumigant that partially inhibits rusty grain beetle (Cryptolestes ferrugineus) acetylcholinesterase activity, *Industrial Crops and Products,* 161 (2021) 113207 https://doi.org/10.1016/j.indcrop.2020.113207
56. W M.A. El-Nagdi1, M.M.A.; Youssef and K G. El-Rokiek, Allelopathic effect of dry leaves of lantana and guava for controlling root knot nematode, *Meloidogyne incognita* on cowpea and some associated weeds. *International Journal of Chemtech Research*, 9 (2016) 55-62.
57. I. S. Soliman and A M. Hamza, Effect of some herbicides on wheat characters and associated weeds with respect to its residues, *Egy. J. Plant Pro. Res*. 3 (2015) 29-47.

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