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Efficacy of Some Essential Oils in Productivity and Management of Some Insect Pests Pre and Post-Harvest of Coriander A- Pre Harvest Study

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Abstract: Coriander (*Coriandrum sativum*) as a spice comes under minor aromatic annual condiment spice crop used in food and pharmaceutical industries. The main method for controlling insect pests is the use of synthetic insecticides, while developing insect resistance, environmental pollution, harmful effect on humans and non-target organisms and the demand for organic crops created a need for alternative approaches. Therefore, this investigation (during 2017/2018 and 2018/2019 seasons) was planned to study the effect of Dill (*Anethum graveolens*) and Citronella grass (*Cymbopogon nardus*) essential oils as an alternative tool for insect pests management (aphid, whitefly and leaf miner) as well as improving the productivity of coriander. The results revealed that, plants treated with dill essential oil significantly increased in the number of umbels/ plant with 40.92 %, fruits yield (g/plant) with12.82 %, seed index (g/1000 seeds) with 23.58 %, germination percentage with 14.22 %, volatile oil percentage with 36.51% and Linalool percentage with 12.26%, respectively over control plants of coriander (average of the two seasons). Moreover, dill and citronella grass essential oils had an insecticidal effect on infestation at all recording times mortality percentage of the insect pests with the superiority of dill essential oil followed by citronella grass for reduction in insect pests numbers as compared to control. This field study has demonstrated that, dill and citronella grass essential oils have a good insecticidal activity against coriander pests and improve the coriander productivity (in terms of number of umbels, seed yield (g/plant), volatile oil yield (ml/plant), germination % volatile oil % and linalool%) of coriander without insects resistance, or toxicity to humans, or environment and non-target insects. This gives them the chance to be used in integrated pest management programs as an alternative one.

Key words: Coriander · Yield · Volatile oil · Essential oils insecticidal · Insect pests · Insecticides

INTRODUCTION

More than 20, 000 pre and postharvest pests' species destroy about one/third of the world's food production, which valued annually at more than $100 billion. Among that the highest losses (43% of potential production) occur in the developing countries of African and Asian [1].

The decline in the natural resources and the environmental damage inflicted by current agricultural practices have become a major limitation in conventional agriculture. Against this background, agroecology offers an important scientific approach that takes into account the current societal concerns linked to the economy, agriculture and particularly to the environment [2].

Medicinal and aromatic plants are the dominant form of medicine in numerous countries. Recently, the cultivation of medicinal and aromatic plants has been given much attention in order to cover the increasing demands of the local industries, as well as export purposes. *Apiaceae* family includes many herbs, spices and medicines, would rank among the most important families of aromatic and medicinal plants. The coriander (*Coriandrum sativum* L.) is a hardy annual member of the *Apiaceae* family. It is the most widely consumed popular ingredient in the world as a domestic spice, traditional medicine and flavoring agent [3]. Its dried fruits are ground and widely used in food products or as condiment or spice which are acclaimed throughout the globe for enormous uses [4].

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Fruits essential oil is known to exhibit pharmacological activities as lipolytic, cognition improvement, anxiolytic and myorelaxant [5].

Coriander fruits essential oil chemical composition is characterized by the occurrence of many components with economical values. The major component linalool (about 64.4%); is the most used ingredient in food industries and has potential use as antispasmodic, immunostimulatory and antinociceptive [6]. Also p-cymeneand hexadeconoic acid, γ-terpinenegeranyl acetate and α-pinene are other important components in the essential oil of coriander [5].

Phytophagous insects can cause more damage to the different grown crops, which may range anywhere between 10 and 90% (with an average of 35–40%) for the potential food and fiber crops [7, 8]. The amount of losses caused by pests depends on many factors as the grown species, climatic conditions, population density of the pests or low incidence of their natural enemies and plant nutrition [9].

Most of the controlling methods for insect pests in different crops are usage of synthetic insecticides. Synthetic pesticides have been considered as the most effective and accessible means for controlling insect pests. However, there is a global concern about the negative impacts of synthetic insecticides on environmental pollution, ozone, toxicity to non-target organisms and pesticide residues. The adverse effects of synthetic pesticides have amplified the need for effective and biodegradable pesticides [10].

Besides a direct negative effect of synthetic pesticides active substances are associated with the changes in the natural biological balances. In addition, it was found that pesticides can play a role in the cancer process by either non-genotoxic mechanisms or by affecting the carcinogenic process. According to the WHO’s estimate, 3 million cases of pesticide poisoning occur every year, resulting in more than 250, 000 deaths, mostly due to the intentional poisoning or inexpert handling and application [11-13].

Aphids, leafminer flies and whiteflies are economic pests causing much crop losses and the excessive use of broad-spectrum insecticides. The damage caused by aphids includes sucking the plant sap by their piercing-sucking mouthparts, in addition to the transmission of viral diseases [14, 15]. Leafminer flies feeding of larval in the spongy mesophyll layer of the leaf as well as, feeding and oviposition punctures of females [15]. Whiteflies can seriously injure plants by sucking juices from them, causing leaves to yellow, shrivel and drop prematurely. The whitefly has been difficult to be controlled with the conventional insecticides in the horticultural production and the agronomic systems. In the last10 years [17, 18].

The ideal insecticide should control target pests adequately and has to be target-specific, rapidly degradable, as well as low toxicity to humans and other mammals. Plant essential oils (EOs) could be an alternative source for insect pests controlling because of the rich content of bioactive constituents (commonly used as flavoring agents in foods). Moreover, EOs may be applied to food crops shortly before harvest without leaving excessive residues. In addition, the medically safe of these plant derivatives has emphasized also [19].

Currently, essential oils are considered as a very promising group of secondary plant metabolites suitable for the development, production often exhibits mutual synergistic effects [20-23]. Also they are renewable, non-persistent in the environment and relatively safe to non-target organisms and humans. The main components of essential oils could be applicable to the management of insect pests to decrease the ecologically detrimental effects of synthetic insecticides [10].

In general, botanical insecticides degrade rapidly in air and moisture and are readily broken down by detoxification enzymes. This is very important because the rapid breakdown means less persistence in the environment and reduced risks to non-target organisms [24]. Moreover, the application of biocontrol agents in soil supplemented with botanicals was found more bene?cial effects in enhancing plant growth and yield attributes [25].

Researches are now strongly focused on the use of agroecological principles to minimize potentially harmful chemical inputs and manage ecological relationships and agro-biodiversity.

Therefore, our investigation aimed to examine the effect of dill and citronella essential oils on yield, essential oil and controlling some insect pests (aphid, leafminer and white fly) in coriander.

MATERIALS AND METHODS

Field Location, Analysis, Preparation and Sowing: Two field experiments were carried out during two successive winter seasons of 2017/2018 and 2018/2019, at El-Baramoon Research Farm (31°08’11.3’’N31°28’19.6’’E), Mansoura Horticulture Research Station, HRI, ARC, Egypt. Soil was silt clay loam in texture with pH 8.11 and organic matter 1.8%.

Coriander seeds were obtained from the Medicinal and Aromatic Plants Research Department, HRI, ARC. Egypt. The experimental filed was prepared and shaped to ridges 75 cm apart, each experimental plot was 4 x 6 m and contained 5 ridges. Seeds were sown on October (mid) in both seasons in hills at 35 cm apart and then thinned for one plant/hill after one month from sowing. Agricultural practices were done as recommended by Egyptian Ministry of Agriculture and Land Reclamation.

Plant Materials: Tested essential oils of dill and citronella were obtained through hydro distillation for 3 hours of plant materials using the Clevenger apparatus according to Egyptian Pharmacopoeia [26]. The extracted essential oils in pure form were stored at 4°C in clean amber glass bottles till using and analysis.

Experimental Design: A complete randomized block design with three replicates was followed. Each replicate included 5 treatments which were in recommended doses (from pesticides brochures and research literatures like El-Gamal and Ghonem [27] and Abd Alla and Shoraky [28] as follows:

- T1: Control (distilled water)
- T2: Commercial pesticide 1 at the rate of 1 cm^3 / L.
- T3: Commercial pesticide 2 (1cm^3 / L.).
- T4: Dill essential oil at the rate of 1 cm^3 / L.
- T5: Citronella essential oil (1 cm^3 / L.).

Pesticides components and essential oils (citronella and dill) analysis (Tables 1 and 2, Figure 1):

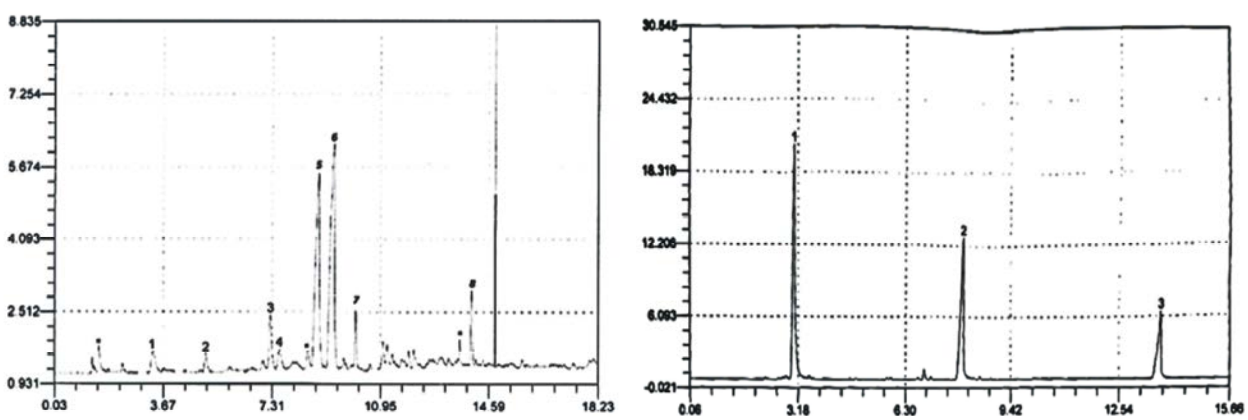
Treatments Application: Plants were sprayed twice, after 45 day from sowing and at the beginning of flowering with previously mentioned treatments just to cover plant foliage completely till drip with an aqueous solutions. A hand atomizer was used for spraying plants after adding tween 20 (0.5%) as surfactant.

Insects Protocol and Samples: As protocol, aphid (*Aphis gossypii),* lefminer *(Liriomyza sativae)* and whitefly (*Bemisia tabaci)* treatments were taken directly before spraying and after 3, 5 and 10 days from spraying in case of *L. sativae*. In case of *A. gossypii* and *B. tabaci*, the leaves were taken after 24, 3, 7 and 10 days, 30 leaves from 10 plants were taken in each replicate. However, 10 leaves were taken from each replicate in case of *L. sativae*.

Table 1: Commercial pesticides formula and active ingredients

Commercial pesticide Compounds (PC1&PC2)				
Chemical Formula	Frist pesticide (PC1)	5-amino [2, 6- dichloro -4- (trifluoromethyl) phenyl] -4- [(IR, S) – (trifluoromethyl) sulfinyl] -111- pyrazole –3- carbonitrite.		
	Second pesticide (PC2)	(+) –1- [3- chloro -4- (1, 1, 2- trifluoro -2- trifluoromethoxy) phenyl] -3- (1, 6- difluorobenzoyl) Urea.		
Active Ingredients	Frist pesticide (PC1)	Fipronil 5% (W/V)	Emulsifier (W/V)	Solvents (W/V)
	Second pesticide (PC2)	Novaluron 10% (W/V)	Emulsifier 30%	Solvents 60%

Citronella Dill



1-Myrcene 2- Limonene 3- Linalool
4- Citronellol 5- Geraniol 6- Citronellal
7- Geranyl acetate 8- Eugenol 9-*Unidentified

1-β–phellandrene 2-Carvone 3- Apiol

Fig. 1: Dill and Citronella essential oils constituents %

Table 2: Essential Oils active constituents %

Essential Oil				Essential Oil Constitutes %						
				Citronella oil						
								Unidetified		
Myrcene	Limonene	Linalool	Citronellol	Geraniol	Citronellal	Geranyl acetate	Eugenol	1	2	3
3.17	2.03	6.14	2.59	31.37	41.22	4.32	7.52	0.63	0.48	0.55
					Dill oil					
β – phellandrene					Carvone					Apiol
36.46%					44.26%					19.28%

Harvesting, Data Recorded, Hydro-Distillation and GC Analysis: At harvest stage when the secondary umbels colour was changed to green-yellow according to El Gamal and Ahmed [29], the number of umbels per plant, fruit yield per plant and 1000 fruit weight (seed index) were recorded. In addition, fruit germination percentage was conducted using 300 fruits (three replications of 100 fruits) per each treatment ISTA [30].

Moreover, the volatile oil percentage was determined at harvest stage fruits (were subjected to hydro-distillation for 3 hours) using a modified Clevenger apparatus according to the method described by Egyptian Pharmacopoeia [26]. The GC analysis of the second season volatile oil samples were carried out using Gas chromatography instrument, Laboratory of Medicinal and Aromatic Plants Res. Dept., HRI., ARC with the following specifications: DsChrom 6200 Gas Chromatograph equipped with a flame ionization detectorColumn: BPX-5, 5% phenyl (equiv.) polysillphenylene-siloxane 30m x 0.25mm ID x 0.25µm film., Sample size: 1µl, Temperature program ramp increase with a rate of 10° C / min from 70° to 200°C, Detector temperature (FID): 280 °C, Carrier gas: nitrogen, Flow rate: N2 30 ml/min; H2 30 ml/min; air 300 ml/min. Main compounds of the volatile oils were identified by matching their retention times with those of the authentic samples injected under the same conditions. The relative percentage of each compound was calculated from the area of the peak corresponding to each compound.

Statistical Analysis: The collected data were tabulated and statistically analyzed by Statistical Analysis of variance using COSTAT (version 6.3.0.3.) Statistical software and the significant differences among treatment means were determined by Duncans' multiple range test at P<5% as published by Duncan [31].

RESULTS AND DISCUSSIONS

This investigation revealed the promoting effect of dill and citronella essential oils on yield attributes of coriander and as biopesticides agents.

Fruit Yield Characters: Data presented in Table 3 revealed that, dill or citronella essential oil at 1 cm^3/ L. increased significantly coriander yield characters in terms of number of umbels per plant, fruit yield/plant as well plant seed index in the two growing seasons. It could be noticed that spraying coriander with dill essential oil (T4) showed the higher significant increases in all studied yield characters (number of umbels: 25.33 and 26.33, fruit yield: 42.75 and 43.53 g/plant and seed index 12.02 and 12.29 (g/1000 seeds) in the first and second seasons, respectively) compared with control (T1) and other treatments during both seasons. On the other hand, control plants (T1) gave the lowest values of all the studied characters of yield (number of umbels:18.33 and 19.33, fruit yield: 37.77and 38.69 g/plant and seed index 9.65 and10.02 (g/1000 seeds) in the first and second seasons, respectively).

This findings are in the same trend of Abd Alla and Shoraky [28] results which revealed significant differences among various growth attributes, total head yield (ton/fed) and the head quality due to essential oils and microorganisms. As well as results of Khan *et al.* [25], they found that, all the botanicals treatments significantly ($p \leq 0.05$) improved the number of umbels per plant and seed yield of coriander in comparison to control. Dill essential oil was found superior in enhancing the yield (Table 3). The superiority of dill essential oil could be attributed to its constituents (Table 2).

Volatile Oil %, Volatile Oil Yield Ml /Plant and Germination Behavior: Data presented in Table 4 indicate that there are significant difference between treatments on their effects coriander volatile oil %, volatile oil yield ml /plant and germination percentage. Generally, essential oil treatments (T4 and T5 with the superior of dill oil) increased the values of the above mentioned characters over pesticides treatments (T2 and T3) and control treatment (T1). Germination percentage exhibited its highest values when coriander plants sprayed with dill oil followed by citronella oil, second pesticide (PC2), first pesticide (PC1) and finally control plants.

Table 3: Effect of different pesticides and essential oils foliar application treatments on coriander number of umbels/plant, fruit yield/plant and seed index during 2017/2018 and 2018/2019 seasons

	Number of umbels/ plant		Fruit Yield g/plant		Seed Index (g/1000 seeds)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T 1	18.33 e	19.33 e	37.77 c	38.69 c	9.65 d	10.02 d
T2	20.33d	20.67 d	39.47 b	40.57 b	10.24 cd	10.63 cd
T 3	22.67 c	23.00 c	40.42 b	41.40 b	10.66 bc	11.09 bc
T4	25.33 a	26.33 a	42.75 a	43.53 a	12.02 a	12.29 a
T 5	24.33 b	24.67 b	41.85 a	42.77 a	11.45 ab	11.70 ab

-Means having the same letter (s) in a column are not significant at 5% level.
-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil.

Table 4: Effect of different pesticides and essential oils foliar application treatments on coriander fruits germination %, volatile oil percentage and volatile oil yield per plant during 2017/2018 and 2018/2019 seasons

	Germination%		Volatile Oil %		Volatile Oil Yield ml /plant	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T 1	70.67 c	72.33 c	0.60 d	0.65 d	0.23 d	0.25 d
T2	73.00 b	74.33 b	0.69 c	0.73 c	0.27 c	0.29 c
T 3	73.67 b	75.33b	0.72 c	0.74 c	0.29 c	0.30 c
T4	80.67 a	82.67 a	0.85 a	0.87 a	0.36 a	0.38 a
T 5	79.67 a	81.67 a	0.79 b	0.82 b	0.33 b	0.35 b

-Means having the same letter (s) in a column are not significant at 5% level.
-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil

Foliar application of dill oil (T4) increased coriander volatile oil percentage by 37.6% and volatile oil yield ml /plant by 54.17% over the control as average of two seasons.

In general, germination percentage, volatile oil percentage and volatile oil yield ml /plant as seed and oil quality parameters responded positively and significantly affected by different foliar treatments.

These results are in the same trend of Khan *et al.* [25] findings. They worked on coriander and reported that, there was an overall increase in plant biomass and yield characters as well as reduction in disease intensity when botanicals were added.

Coriander Volatile Oil Constituents: The changes in coriander volatile oil active constituents in response to essential oils and pesticides treatments during both growing seasons are shown in Table 5 and Figure (1). Both dill and citronella essential oils promoted the content of the principal active constituent Linalool (as a percentage) with the superiority of dill oil. Twelve components of coriander volatile oil were identified and quantified for the second season samples. Foliar application with dill and citronella essential oils improved the quality of coriander volatile oil by increment the major component (linalool) percentage in oil (68.57% and 64.00%) as compared with untreated plants (control, 61.08%). On the other hand, the different pesticides decreased linalool percentage in oil to reach the least values of (59.55) for the first pesticide (T2) and (53.28) for the second pesticide (T3) than the control (T1).

On contrast, some of major components as β-caryophyllene (ranged from 3.90% to 13.62%), Borneol (ranged from 3.29% to 5.12%), ñ? Cymene (ranged from 5.00% to 7.31%) were positively affected by foliar application of pesticides (T2 & T3). However, α–pinene (ranged from 1.02% to 5.53%) was negatively affected by pesticides foliar application. It could be observed that, dill and citronella essential oils foliar application stimulated the formation of the principal component Linalool which is responsible for the medicinal activity and the most used ingredient in food industries. In addition these essential oils treatments stimulated the formation of the important component α –pinene.

Plants possess the ability to synthesize aromatic secondary metabolites, these compounds have been reported to serve as plant defense mechanisms Das *et al.* [32].

The Integrated Pest Management of Coriander

Aphid Management: Results in Table 6 showed the increase in the reduction of aphid population for all treatments after 1, 3, 7 and highly increased after 10 days.

Table 5: Effect of different pesticides and essential oils foliar application treatments on coriander volatile oil constituents at 2018/2019 season

Treatments	Coriander Volatile Oil Constitutes (%)													
	α-pinene	Camphene	Myrcene	β-pinene	ρ-Cymene	Linalool	Geraniol	Borneol	Linalyl acetate	Geranyl acetate	β-caryophyllene	β-caryophyllene oxide	Unknown 1	Unknown 2
T 1	1.02	3.03	0.67	1.81	5.00	61.08	0.66	4.69	4.23	1.07	13.62	1.88	0.61	0.63
T2	1.16	3.33	0.65	1.23	7.31	59.55	0.62	5.12	4.14	0.98	13.33	1.87	0.12	0.60
T 3	3.95	1.27	1.59	1.25	7.00	53.28	0.94	4.72	3.09	3.20	16.23	4.08	0.63	0.93
T4	5.53	0.86	0.85	1.29	6.93	68.57	0.39	3.29	3.03	1.90	6.90	0.43	--	--
T 5	3.97	0.59	0.70	1.32	5.19	64.00	0.42	3.66	2.76	3.30	3.90	0.38	--	--

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil.

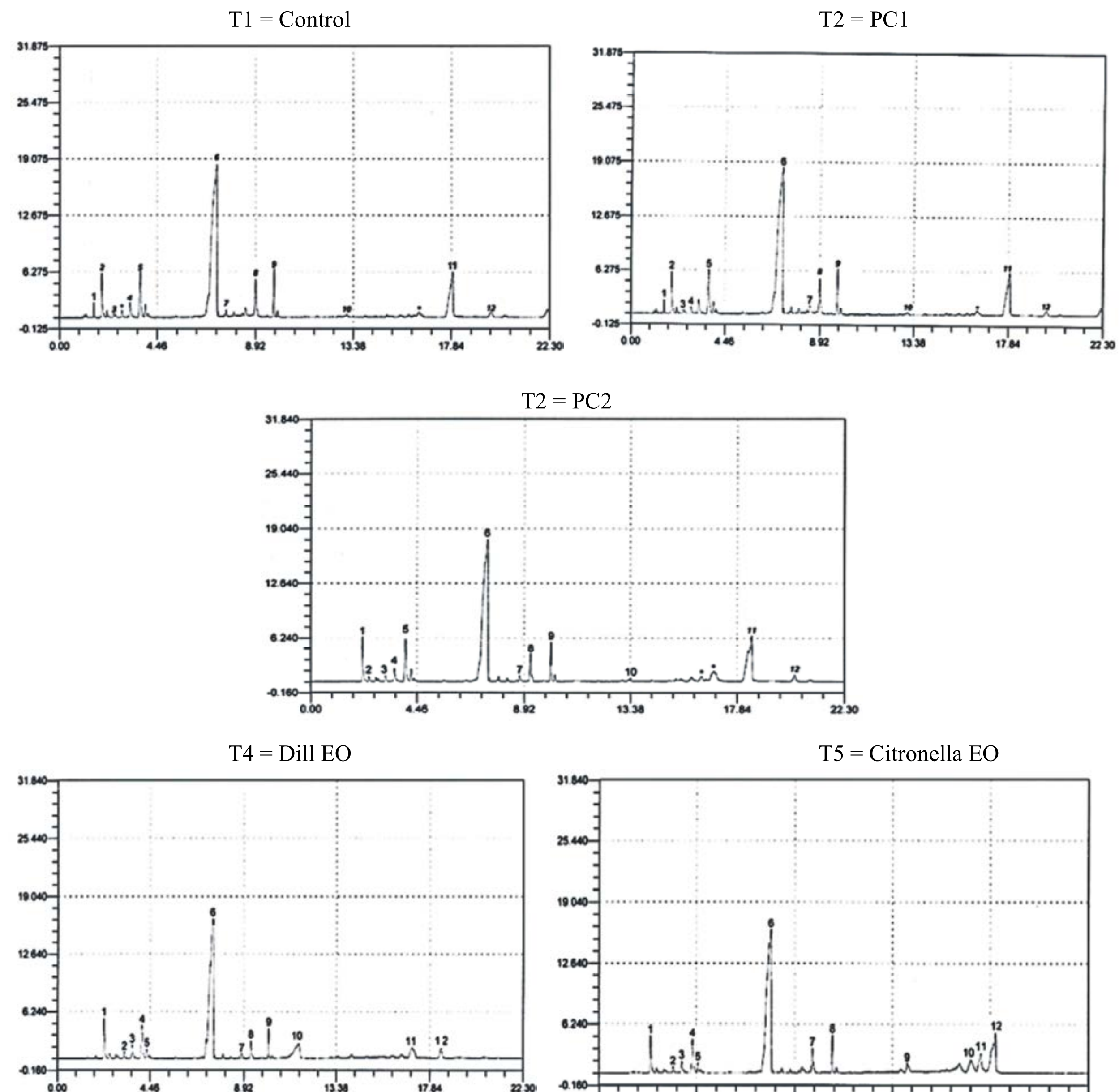


Fig. 2: Effect of essential oils and pesticides foliar application and control treatments on the coriander volatile oil components (%) during 2018 / 2019 season

1-α-pinene 2-Camphene 3-Myrcene 4-β-pinene 5-ρ-Cymene 6-Linalool 7-Geraniol 8-Borneol 9-Linalylacetate 10-Geranyl acetate 11-β-caryophyllene 12-β-caryophyllene oxide *Unidentified compounds

Table 6: Effect of different pesticides and essential oils foliar application treatments on reduction of aphid (an average of 2017/2018 and 2018/2019 seasons)

	1st replicate			2nd replicate			3rd replicate			4th replicate			Treatment efficiency		
	Pest number			Pest number			Pest number			Pest number			Pest number		
Treatments	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Total Red. %
After 1 day															
T 1	70	70		70	60		80	80		60	62		70	68	
T2	65	2	96.92	55	2	95.76	80	6	92.5	60	2	96.77	65	3	95.49
T 3	40	0	100	60	8	84.44	60	2	96.67	90	10	89.25	62.5	5	85.90
T4	80	14	82.5	50	10	76.67	75	13	82.67	50	15	70.97	63.75	13	78.20
T 5	55	18	67.27	85	12	83.53	70	18	74.29	60	16	74.19	67.5	16	74.82
After 3 days															
T 1	70	72		70	72		80	84		60	65		70		
T2	65	2	96.92	55	6	89.39	80	10	88.60	60	8	87.69	65	6.5	90.65
T 3	40	0	100	60	1	98.38	60	2	96.83	90	2	97.95	62.5	1.25	98.29
T4	80	7	91.49	50	6	88.33	75	8	89.84	50	8	85.23	63.75	7.25	88.72
T 5	55	12	78.79	85	17	80.56	70	15	79.92	60	10	84.62	67.5	13.5	80.97
After 7days															
T 1	70	75		70	75		80	86		60	66		70		
T2	65	5	92.82	55	3	94.91	80	7	91.86	60	5	92.42	65	5	93
T 3	40	5	88.33	60	4	83.78	60	4	93.80	90	8	91.92	62.5	5.25	89.46
T4	80	5	94.17	50	0	100	75	7	91.32	50	2	96.36	63.75	3.5	95.46
T 5	55	10	83.03	85	14	84.63	70	12	84.05	60	10	84.85	67.5	11.5	84.14
After 10 days															
T 1	70	80		70	77		80	87		60	68		70		
T2	65	5	93.27	55	5	91.74	80	10	88.51	60	8	88.24	65	7	90.44
T 3	40	3	93.44	60	6	90.91	60	6	90.80	90	10	90.20	62.5	6.25	91.34
T4	80	4	95.63	50	2	96.36	75	3	96.32	50	0	100	63.75	2.25	97.08
T 5	55	5	92.05	85	7	92.51	70	6	92.12	60	3	95.59	67.5	5.25	93.07

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil

Table 7: Mean of total reduction of different pesticides and essential oils treatments against aphid (an average of 2017/2018 and 2018/2019 seasons)

Treatments	Mean reduction of 1st scan	Mean reduction of 2nd scan	Mean reduction of 3rd scan	Mean reduction of 4th scan	Mean of total reduction
PC1 (T 2)	95.49	90.65	93	90.44	92.40
PC2 (T3)	85.90	98.29	89.46	91.34	91.25
Dill oil (T 4)	78.20	88.72	95.46	97.08	89.87
Citronella oil (T5)	74.82	80.97	84.14	93.07	83.25

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil.

Table 7, illustrated the mean of total reduction of treatments against aphid. Drill oil reduction was nearly the reduction of insecticides.

From the previous results, we concluded that, natural essential oils reduced aphid population nearly as the reduction of the insecticides. However, aphid lion population increased with only essential oils.

Our results are in harmony with those of Tripathi *et al.* [33], they concluded that, essential oil compounds and their derivatives are considered to be an alternative means of controlling many harmful insects and their properties as rapid degradation in the environment have increased specificity that favors beneficial insects. Also, Dancewicz [34], evaluated the effect of essential oils from caraway, anise, oregano, thyme, summer savory and rosemary on pea aphid and peach potato aphid. They concluded that, oregano, caraway, rosemary and summer savory essential oils had the strongest deterrent effect on pea aphid, while anise and thyme essential oils were the strongest deterrents for peach potato aphid.

Moreover, Pavela [35] who revealed that, Plant products (Botanicals) as biopesticides and as new basic substances offer an important perspective of being widely used in the protection against harmful insects due to their multiple undoubted benefits.

White Fly Management: Results in Tables 8 and 9 indicated the whitefly management. Table 8 showed reduction in white fly population for all treatments after 1, 3, 7 and 10 days. All treatments caused reduction and the

Table 8: Effect of different pesticides and essential oils foliar application treatments on reduction of white fly (an average of 2017/2018 and 2018/2019 seasons)

	1st replicate			2nd replicate			3rd replicate			4th replicate			Treatment efficiency		
	Pest number			Pest number			Pest number			Pest number			Pest number		
Treatments	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Red. %	Before	After	Total Red. %
After 1 day															
T 1	170	170		160	155		175	170		180	175		171.25	167.5	
T2	110	10	90.91	100	5	94.84	105	5	95.10	110	10	90.65	106.25	7.5	92.88
T 3	110	15	86.36	100	15	84.52	120	20	82.84	110	10	90.65	112.5	15	86.09
T4	150	30	80	150	20	13.76	130	20	84.16	140	30	77.96	142.5	25	63.97
T 5	125	25	80	100	20	79.35	120	20	82.84	120	30	74.29	116.25	23.75	79.12
After 3 days															
T 1	170	175		160	160		175	180		180	180		171.25	173.75	
T2	110	5	95.58	100	5	95	105	0	100	110	0	100	106.25	2.5	98.75
T 3	110	0	100	100	5	95	120	0	100	110	8	92.73	112.5	3.25	96.93
T4	150	10	93.52	150	20	86.67	130	20	85.04	140	20	85.71	142.5	17.5	87.74
T 5	125	20	84.46	100	15	85	120	15	87.85	120	20	83.33	116.25	17.5	85.16
After 7days															
T 1	170	180		160	165		175	180		180	185		171.25	177.5	
T2	110	5	95.71	100	0	100	105	0	100	110	0	100	106.25	1.25	98.93
T 3	110	2	98.28	100	8	92.24	120	2	98.38	110	10	91.15	112.5	5.5	95.01
T4	150	5	96.85	150	10	93.54	130	10	92.52	140	10	93.05	142.5	8.75	93.99
T 5	125	10	92.44	100	10	90.30	120	12	90.28	120	12	90.27	116.25	11	90.82
After 10 days															
T 1	170	185		160	165		175	185		180	190		171.25	181.25	
T2	110	5	95.82	100	5	95.15	105	5	95.50	110	5	95.69	106.25	5	95.54
T 3	110	5	95.82	100	10	90.30	120	5	96.06	110	10	91.39	112.5	7.5	93.39
T4	150	0	100	150	5	96.77	130	5	96.36	140	5	96.62	142.5	3.75	97.44
T 5	125	8	94.12	100	7	93.21	120	10	92.12	120	5	96.05	116.25	7.5	93.88

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil.

Table 9: Mean of total reduction of different pesticides and essential oils treatments against white fly (an average of 2017/2018 and 2018/2019 seasons)

Treatments	Mean reduction of 1st scan	Mean reduction of 2nd scan	Mean reduction of 3rd scan	Mean reduction of 4th scan	Mean of total reduction
PC1 (T 2)	92.88	98.75	98.93	95.54	96.53
PC2 (T3)	86.09	96.93	95.01	93.39	92.86
Dill oil (T 4)	63.97	87.74	93.99	97.44	85.79
Citronella oil (T5)	79.12	85.16	90.82	93.88	87.25

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil.

proportion of this reduction increased in the 7th day. Table 9 illustrated the mean of total reduction of material against white fly. Citronella oil reduction was nearly as reduction of coach insecticides but the reduction of white fly as the result of PC1 (T2) insecticide was the highest.

Foliar application of essential oils (EOs) as pesticides agents caused reduction in harmful insects as compared to control. EOs are natural products that contain natural flavors and fragrances grouped as monoterpenes (hydrocarbons and oxygenated derivatives), sesquiterpenes (hydrocarbons and oxygenated derivatives) and aliphatic compounds (alkanes, alkenes, ketones, aldehydes, acids and alcohols) that provide characteristic odors. Among components of EOs, terpenes especially monoterpenoids and sesquiterpenes have been shown to be toxic to a variety of insects [36-38].

In this respect, Cosimi *et al.* [39] revealed that, essential oils (*Eo*s) provide various functions for plants including attracting or repelling insects and utilizing chemical constituents in the oil as defense materials. In general, they are complex mixtures of organic compounds which could be useful alternatives to synthetic insecticides in organic food production in developing countries and they can be a means of low cost protection in industrialized countries.

Table 10: Effect of Effect of different pesticides and essential oils foliar application treatments on reduction of leafminer (an average of 2017/2018 and 2018/2019 seasons)

Treatments	1st replicate Pest number Before	After	Red. %	2nd replicate Pest number Before	After	Red. %	3rd replicate Pest number Before	After	Red. %	4th replicate Pest number Before	After	Red. %	Treatment efficiency Mean Pest number Before	After	Total Red. %
After 3 days															
T 1	4	7		5	5		6	6		6	7		5.25	6.25	
T2	5	0	100	4	1	75	4	0	100	7	1	87.76	5	0.5	90.69
T 3	3	0	100	5	0	100	5	1	80	7	1	87.76	5	0.5	91.94
T4	4	1	85.71	3	3	0	6	2	66.67	2	2	14.29	3.75	2	41.67
T 5	5	2	77.14	5	2	60	5	2	60	2	0	100	4.25	1.5	74.29
After 7days															
T 1	4	8		5	9		6	10		6	11		5.25	9.5	
T2	5	1	90	4	0	100	4	0	100	7	2	84.42	5	0.75	93.61
T 3	3	1	100	5	1	88.89	5	1	88	7	1	92.21	5	1	92.28
T4	4	0	100	3	0	100	6	0	100	2	0	100	3.75	0	100
T 5	5	0	100	5	0	100	5	0	100	2	0	100	4.25	0	100
After 10 days															
T 1	4	8		5	10		6	11		6	9		5.25	9.5	
T2	5	0	100	4	1	87.5	4	0	100	7	2	80.95	5	0.75	92.11
T 3	3	0	100	5	0	100	5	1	89.09	7	2	80.95	5	0.75	92.51
T4	4	1	87.5	3	1	83.33	6	0	100	2	0	100	3.75	0.5	92.71
T 5	5	1	90	5	0	100	5	0	100	2	0	100	4.25	0.25	97.5

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil.

Table 11: Mean of total reduction of different pesticides and essential oils treatments against leafminer (an average of 2017/2018 and 2018/2019 seasons)

Treatments	Mean reduction of 1st scan	Mean reduction of 2nd scan	Mean reduction of 3rd scan	Mean of total reduction
PC1 (T 2)	90.69	93.61	92.11	92.14
PC2 (T3)	91.94	92.28	92.51	92.24
Dill oil (T 4)	41.67	100	92.71	78.13
Citronella oil (T5)	74.29	100	97.5	90.60

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil

Table 12: Effect of Effect of different pesticides and essential oils foliar application treatments on beneficial insects increasing (an average of 2017/2018 and 2018/2019 seasons)

Treatments	Mean increasing of 1st scan 1ST	2ND	Mean increasing of 2nd scan 1ST	2ND	Mean increasing of 3rd scan 1ST	2ND	Mean increasing of 4th scan 1ST	2ND
T1	*	*	*	*	*	*	*	*
T2	*	*	*	*	*	*	*	*
T3	*	*	*	*	*	*	*	*
T4	****	****	****	****	****	****	****	****
T5	***	***	***	***	***	***	***	***

-Mean numbers of beneficial insects (*Coccinella septempunctata* and *chrysopa perla*) of coriander sampling of treatments during winter seasons 2017/2018 and 2018/2019 as an average, per plot expressed in a four level scale: 0–5% (*), 6–20% (**), 21–50% (***) and 51–100% (****).

-T1: Control, T2: 1st pesticides, T3: 2nd pesticides, T4: Dill oil, T5: Citronella oil

It was reported that, essential oils of Apiaceae family plants could be used to control a large number of pests in various ways showing lethal toxicity against different insect pests that published. In other words these essential oils and other phytochemicals isolated from the Apiaceae family may be safe replacements and efficacious also for conventional the synthetic pesticides Ebadollahi, [19]. He also reported that, Essential oils constitute a rich source of bioactive components and are commonly used as flavoring agents in foods industries. These bioactive components could be applied to food crops shortly before harvest without leaving excessive residues. Moreover, they medically safe and has emphasized. Because of that, much effort has been focused on the plant essential oils or their active components as potential sources of insect pests control agents. In addition, Wagan *et al.* [40] studied ethanol-extracted of 3 essential oils from sweet flag, cow parsnip and wild asparagus and revealed that, all 3 essential oils had a fumigant toxicity, deterrent potential and anti-oviposition properties against the whiteflies female (*Bemisia tabasci*) under laboratory and greenhouse condition.

Leafminer Management: Results in Tables 10 and 11 illustrated the leafminer management. Table 10 showed reduction in leafminer population for all treatments after 3, 7 and 10 days. All treatments caused reduction and the proportion of this reduction increased in the 7th day.

Table 11 indicated the mean of total reduction of material against leafminer. Citronella oil reduction was nearly as the reduction of used insecticides.

From the previous results, it could be concluded that, essential oils (dill and citronella) reduced leafminer population nearly as the reduction of the insecticides, but the dill oil recorded a less number of reductions in comparison with citronella oil and insecticides.

The essential oils physiological actions on insects are little known, while the various essential oils treatments or their constituents caused symptoms which suggested a neurotoxic mode of action Kostyukovsky *et al.* [41].

A survey of the essential oils literature on the biopesticidal potential of the essential oils from the 2000 year onwards showed that, the following families essential oils: Apiaceae. Myrtaceae, Asteraceae, Lamiaceae, Rutaceae are highly targeted for the anti-insect activities against the specific insects orders like Coleoptera, Lepidoptera, Diptera, Hemiptera and Isoptera. The essential oils of the previously mentioned plant families have been explored for the repellent, larvicidal, adulticidal and fumigant activities against the insects of the above orders Tripathi *et al.* [33].

In addition, the insecticidal activity of many Eos from Apiaceae (dill is a member). The isolation and identification of the bioactive compounds from Apiaceae plants EOs are of utmost importance because of their potential application in controlling insect pests can be fully exploited Regnault *et al.* [38].

Moreover, recently, more studies on the insecticidal properties of essential oils from Apiaceae family (lethal: larvicidal, pupicidal, ovicidal and adulticidal) and (sublethal: repellent, antifeedant, deterrent and oviposition as well as growth inhibitory and progeny production) activities of Apiaceae family plants essential oils and their main components. These features indicate that the pesticides based on Apiaceae essential oils could be used in a variety of ways for controlling a large number of pests. As well As, essential oils and phytochemicals which isolated from Apiaceae family plants may be efficacious and safe replacements for the conventional synthetic insecticides Ebadollahi, [19].

Encouragement of Beneficial Insects Presence: Mean numbers in Table 12 showed the beneficial insects (*Coccinella septempunctata* and *chrysopa perla*) of coriander sampling of treatments which increased with essential oils of dill and citronella essential oils.

These results were in harmony with Tripathi *et al.* [33] results. They concluded that, plants essential oils have been recognized as natural important sources for safety pesticides. Their compounds and derivatives were considered to be an alternative way for the management of many harmful insect pests. Also, essential oil rapid degradation in the environment has increased the specificity which favors beneficial insects.

Finally, it could be said that essential oils as bio stimulants and bio insecticides keep attracting more attention from small farmers and the environment worldwide, they are considered a suitable alternative to the synthetic insecticides. This increasing interest may be attributed to their relatively safe status, their wide acceptance by consumers and their exploitation for potential multi-purpose functional uses for achieving sustainable food production, socioeconomic impacts, safety aspects and sustainability.

CONCLUSIONS

From our study, we could conclude that the foliar application of dill essential oil improved yield characters and volatile oil yield of coriander plants as well as controlling insects as new IPM tool. So, it can also be demonstrated that essential oils can be used concomitantly for the management of coriander insects whit a yield and volatile oil enhancement effect.

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