Egypt. J. Hort. **Vol. 51**, No. 2, pp. 251-262 (2024)

Egyptian Journal of Horticulture
https://ejoh.journals.ekb.eg/

Evaluation of Garlic and Thyme Oils Activity Against Powdery Mildew Disease of Caraway (*Carum carvi,* L.)

Saleh, F.E.M. [1], Reem M. Abd-Elraouf [1] and Hoda A.M. Ahmed [2]
[1]*Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.*
[2] *Plant Pathology Research, Institute, Agricultural Research Center, Giza, Egypt.*

THIS study aims to evaluate the effectiveness of garlic (*Allium sativum*) and thyme (*Thymus vulgares*) essential oils for controlling powdery mildew disease (*Erysiphe heraclei* fungus*)* on caraway (*Carum carvi* L.) plant. Green house and field experiments were set up as split-plot design with7 treatments; garlic and thyme essential oils at 0.5% and 1.0% concentrations (severally), chemical fungicide (Flint 500) at 0.2 and 0.4 g/L. concentrations and control (sprayed with distilled water).The spray application of these treatments were applied at two different stages (before and after appearance of disease symptoms) for three times with one week interval. All treatments significantly reduced the powdery infection compered to control. Under the field conditions, garlic oil showed the highest resistance response of caraway plants against powdery mildew. This was reflected on yield and quality components of caraway crop, whereas the umbel number, fresh weights (g), per plant, weight of 1000 seed (g), seed yield and oil percentage in all treatments were significantly improved compared with control. Whereas the spray application before the symptoms appeared being more effective in this regard. When gas chromatography-mass spectrometry analysis for caraway seed essential oils of the different treatments, a differences were appeared in constituents and their percentages. The main components were carvone and limonene in the all treatments. consequently, it could be concluded that plant essential oils valuable for controlling powdery mildew disease as a safe alternative option to chemical fungicide.

Keywords: *Carum carvi,* Essential oils, Gas chromatography mass spectrometry, Anti-fungal.

Introduction

Caraway is a herbaceous annual plant that be a member of family *Apiaceae* represents one of the most important herbal medicinal plant used as a condiment in foods and in pharmaceutical preparations (Samira and Sara, 2016). Their seeds contain volatile oil (3-7%) and the major constituent being carvone (50- 60%), then the limonem up to 40% and other small constituents (Almarie et al.,2019). There are some caraway diseases that may harm, or even kill plants. Among the diseases, serious damage produces the diseases to be facing are powdery mildew. Powdery mildew infection caraway is caused by the air-borne fungus *Erysiphe heraclei* (Odstrčilová1 et.al, 2002 and Zalewska 2015). The pathogen spread to the inflorescences, umbels and fruits which resulted in significant weakening of plant health, small size of umbels and causing severe losses in yield and quality, consequently fruits have poor flavour, and do not store well (Kabir et al., 2011 and Zalewska, 2015).

In agriculture, the massive amount of chemical fungicides used for the control of powdery mildew with the high concern for counteractive effects of fungicides on human health and the environment. Nowadays there has been growing interest in the application of plant product in agriculture as alternatives to the use of fungicides in order to obtain healthy crops and more environmentally sustainable crop production systems.

*Corresponding author: Full E.M Saleh, E-mail: fullsaleh@yahoo.co.uk.
(Received 14/01/2024, accepted 23/05/2024)
DOI: 10.21608/EJOH.2024.258150.1267

Essential oils are one of the natural products that are extracted from plants by different methods. They are natural, complex, multi-component systems composed mainly of terpenes in addition to some other non-terpene components (Edrir, 2007). Essential oils may be found in organs of all the aromatic plant species and have important roles such as the protection of the plant against microorganisms; herbivorous animals and insects (Pauli, 2006). Plant oils were shown to be fungicidal against powdery mildew diseases in the early 1930 (Martin, H. and Salmon, 1930). *Thymus vulgaris* is an aromatic flowering plant in family *Lamiaceae* used for medicinal and spice purposes almost everywhere in the world, its essential oil showed a high content of oxygenated monoterpenes and low contents of monoterpene hydrocarbons, sesquiterpene hydrocarbons and oxygenated sesquiterpenes, and thymol was the predominant compound among the essential oil components (Al.Maqtari et al., 2011). Rezabala et.al. (2022) studied the chemical analysis of thyme essential oil and reported that the active compounds were thymol 45–48%, p-cymene 37-40%, linalool 3-4%, β-pinene 4-5%. 1,8-ceneole 1-2%, myrcene 1-2%, camphene 1% and limonene < 1%. The previous studies outlined the potential of thyme essential oil in controlling gray mold and wilt disease and producing systemic acquired resistance in tomato plant (BenJabeur et al. 2015). Similarly, plants of the *Allium* genus belong to the family *Liliaceae* are perennial and herbaceous plants have been known for their antimicrobial activity since ancient times, due to the presence of allicin in their content (Harris et. Al., 2001 and Leyva et. Al., 2015). Recently, many studies concluded that garlic oil and its active constituents; polyphenols, flavonoids, thiosulfinates and allicin showed antioxidant, antibacterial and antifungal properties (Shang et.Al., 2019). Leite et. al. (2011) reported fungistatic vigor of garlic extract for controlling grapevine downy mildew disease. Consequently garlic essential oil can be used as antimicrobial feed additives or as a pesticide to control crop pests or other plant pathogenic fungi (Zeng et. al., 2012 and Ross et. al., 2001).

The purpose of the investigation is to study the effectiveness of some essential oils as natural fungicides against the causal agent of caraway powdery mildew.

Materials and Methods

Treatments and trial management

During 2020/2021 and 2021/2022 seasons, two experiments; under greenhouse and field conditions were carried out at the Experimental Farm of the Arab-El-Awamer-Agricultural Research Station, Assiut Governorate, Egypt. The experiments were done to evaluate the effects of essential oils of thyme and garlic supplied by Organic company for Natural Oil (Commercial Registration No.2381,Egypt) on the severity of powdery mildew disease and consequently on growth, yield and quality of caraway plant in the conditions of natural infestation with powdery mildew.

Isolation and Identification of the pathogen.

The causative fungus of powdery mildew of caraway isolated from infected plant collected from caraway field at the Experimental Farm of the Arab-El-Awamer Agricultural Research Station , Assiut Governorate, Egypt.Then the isolates were maintained on living plants till identified.

The two experiments were carried out in a Randomized Complete Block as split plot design.

1- Greenhouse experiment

Surface sterilized seeds were sown in sterilized pots (35 cm in diameter) that contain sterilized soil. Each pot was sown with 5 seeds and 3 pots were used as replicates.The planted pots were separated to two groups

1- The first group: the first spray with the treatments was applied before the appearance of the symptoms of powdery mildew disease at mature stage of plant.

2-The second group: the first spray with the treatments was applied after the first indicator of symptoms of powdery mildew disease of natural infection.

The treatments were applied three times with one week interval to run off with the essential oils solutions and fungicide separately

2- Field experiment

The field experiment was carried out during the two cultivated seasons at the Experimental Farm. Split plot design with three replicates and seven treatments were adopted in this respect. The main plots were represented by the time of application at two stages (before and after appearance of disease symptoms) and Sub-plots were represented by seven treatments; the tested essential oils of thyme and garlic at 2 levels of

0.5% and 1.0% concentrations, which emulsified with 0.05% Tween 20 before application (Reuveni *et al.,*1996), flint fungicide at 0.2 and 0.4 g/ L.concentrations as a chemical plant protection product used against this pathogen (standard) and control treatment plants were sprayed with distilled water only. Sterilized seeds of caraway were sown on 10 th of November (for the two cultivated seasons). Five seeds were drop in each hill at 30 cm apart and then were thinned (at the age of 30 days) to one plant. The cultivated plants received the farming practice as needed. The experiment was performed under conditions of natural infection by the disease (powdery mildew). At the first stage, the spray application was applied before appearance of disease symptoms (precaution) and the second stage, spray application was carried out as soon as appearance the first signs of the symptoms observed (curative). Then sprayed the plants three times with one week interval by a hand atomizer for each treatment. Apply essential oils after holding fruits while a fungicide application should begin from early flowering strategically as part of a program when conditions favour disease development.

Data collection

Observations on disease intensity were recorded from randomly selected five plants from each treatment in the two experiments after 7 days from the last spray according to the scale mention.

Disease assessment

Disease severity was estimated on an arbitrary scale of (0-5) of Horsfall and Barrett (1945) and Singh (2006), where Disease scale from 0 to5 was used as flowing:

0= no powdery mildew lesions, 1= 25 or less

2= 26-50 3= 51-75

4= 76-100% of infected leaf area. 5= more than 75 percent affected

$$DS\% = \frac{\text{Sum of all numerical ratings}}{\text{Total plants examined x Maximum disease grade (5)}} \times 100$$

Percentage of infected plants = No. of infected plants / all numbers of plants × 100

Vegetative growth and seed yield

Five plants were selected at random per replicate to determine plant height (cm), number of branches, umbel number, plant fresh weight and seed yield per plant (g), weight of 1000 seeds (g) then total seed yield per feddan (kg) was calculated and also essential oils percentage as well as their constituents(GC-MS analysis) for caraway seeds were assessed.

Extraction and determination of essential oil

The caraway seeds were ground and one hundred grams of dried powdered of seed samples in 0.5 L water from each treatment was subjected to hydro-distillation for 3 hours in an all glass Clevenger-type apparatus according to the method recommended by the European Pharmacopoeia (Stainier, 1975). The samples of extracted oil were dried using anhydrous sodium sulphate and stored in closed vials at 4°C.The yield of the oil (v/w %) was calculated and GC/ mass spectrometry (MS) analysis was done.

Gas chromatography–mass spectrometry (GC-MS) analysis

The samples were performed by a Thermo Scientific, USA with a Thermo mass spectrometer detector ISQ Singular Quadrupole Mass Spectrometer equipped with a TR5 MS capillary column (30 m,1.25mm and 0.25µm film thickness). For detection of GC/MS, ionization energy of 70 e V of an electron ionization system was utilized. Helium was the carrier gas used at a fixed flow rate of 5ml/min. The injector as well as MS transfer line temperature were carried out at 280ºC. For analysis of essential oil the temperature of oven was programmed at a primary temperature 40ºC to 280ºC as a latest temperature at a growing rate of 5ºC/min. (hold 5 min.). Recognition of the essential oil ingredients was carried out by visitation of Wiley275 LGC/ MS database, observed kovates index and by parallel retention time and mass fragmentation model to those of the helpful references and the published data in the literature (Adams, 2001).

Statistical analysis

Data were analyzed by using analysis of variance (split plot design). All analysis were performed by the Software statistics, version 8.1 (Steel et. al., 1997) and carried out for Multiple and All-pairwise comparisons between means and data followed by Tukey,s comparison test to compare means at the significance level $P < 0.05$.

Results

Effect of essential oils on the disease severity

In the our study during the two years of plant cultivation on all plantations of *Carum carvi* plants, powdery mildew (*Erysiphe heraclei*)

symptoms appeared abundantly on the surface of the upper parts of plants. Data presented in Tables (1 and 2) represent the effects of spraying the caraway plants with *Garlic sativum* and *Thymus vulgaris* oils at 0.5 and 1.0 % concentrations and fungicide (Flint 0.2 and0.4 g/L concentrations) on powdery mildew severity in greenhouse and field condition. The effects of plant essential oils when used as preventive or curative treatment were varied in reducing the disease severity and the infected plants compared with the control. Under greenhouse conditions **(**Table1) the disease reduction was significant ($p<0.05$) at two stages; before and after disease symptoms. Generally all concentrations of garlic and thyme oils when applied as a preventive treatment were more effective in decreasing disease severity than as a curative treatment and also the essential oil of garlic was more effective than that of thyme in decreasing powdery mildew infection parameters. The results in Table (2) showed the effects of various concentrations of all treatments under field conditions which represented a significant reduction of powdery mildew severity and number of infected plants compared with untreated plants, either as before or after disease symptoms. The highest reduction in disease severity was obtained by fungicide Flint (4.18% and10.33%) followed by garlic oil that reduced the disease at the rate of 8.40 and 12.58% with the two tested concentrations respectively as preventive treatments. Scanning electron microscope findings showed the mycelial morphology changes, folding and constricted of hyphae, no branching showing and also spore inhibition. Additionally, spores of *E. heraclei* did not germinate comparing to untreated plants (Figures 1; B and A respectively).

Effect of essential oils on vegetative growth and yield:

Data of growth and yield components and quality of the C*arum carvi* affected by disease severity and accordingly by treatment with the tested essential oils. The results in the Table (3) showed the branches and number of umbels were affected by using essential oils as natural fungicidal or fungi-static. Caraway plants served by garlic oil at 1% concentration had the highest branches and number of umbels which were 15.56 and 20.66 per plant respectively, as well as chemical fungicide differed significantly with the other treatments in the two stages of applications. Significantly increased of seed per plant (g) accordingly seed yield per feddan (kg.) were observed clearly in all studied treatments as compared to the control (Table 4). The highest weight of caraway seeds per plant was observed with garlic oil as curative treatment (15.12g/plant) and the superior yield of seeds/fed. was observed also with the same treatment (710.85 kg/fed.) which was the best among all treatments in this respect. With regard to weight of 1000 seed, caraway plants recorded the highest and significant results (6.65 and 6.43 g) after treatment with fungicide and garlic oil respectively comparing to control. Seasonal variations might have the same effects, where the two experimental seasons took approximately similar tendency. After treatments, we observed changes in the oil percentage of caraway seeds which ranged between 2.6 and 3.16% of the seed weight (Figure, 2).The significant increased in content of essential oils was recorded (3.04 and 3.02 %) after treated with garlic and thyme oils respectively at the first stage. while fungicide recorded the highest (3.16%) content when applied after disease symptoms appeared.

Effect of essential oils on the chemical composion of caraway oil

The essential oils of caraway seeds that obtained after treated plants with the highest concentrations of all treatments severally were analyzed by GC-MS. There were some variations appeared in constituents and their percentages in the essential oils derived from different treatments. Twenty seven compounds (Table 5) and structures of the dominant and the common compounds (Table 6) were listed as the most abundant compounds in all treatments. The main components were carvone (54.02%, 42.14%,40.13% and 50.10%) and limonene (36.96%, 27.06%, 34.10% and 30.01%) in the control, garlic, thyme and fungicide respectively, as well as caraway essential oil consists of other components in small amounts such as cis,cis,cis-2,4,6-Octatriene (7.96%),1à,8àDimethyl1,4,4aá,4bá,5,8,8aá,9aà-octahydro-9H-fluoren-9-one (13.33%),

1-(4Methylphenyl)ethanol(10.21%), trans-Carveol, Pinene, á-Myrcene, Terpinen, Carveylacetate, trans Caryophyllene, Copaene, (-)-á-Elemene, cis-Ocimcis, Cubebene and 2-Adamantylamine, (2RS,3RS)3Hydroxy2phenylazetidine and other compounds in small traces some of which not reported in this literature.

Discussion

Our results compatible with the finding of Zalewska et.al., (2015) where they reported at temperature reaching up to 28°C and low

relative humidity a disease of powdery mildew *Erysiphe heraclei* appeared on caraway and decrease the quality and quantity of the plant material. A significant negative correlation was showed between parameters of vegetative growth, productivity of caraway plant and the parameters of powdery mildew disease severity. Disease severity negatively affected on the number of seed, plant weight, the average weight of 1000 seeds, seed yield/plant and yield/fed. as well as the second metabolites which decreased as disease severity increased (control). The infection by powdery mildew disease involved in photosynthesis and respiration leading to reduce fruit yield, inadequate ripening and miserable flavor (Goni et.al., 2009).

Our results showed that the application of garlic and thyme oils before or after disease symptoms appear led to inhibit *E. helicae fungus* in caraway which led to increase of yield parameters and improved the quality of the plant than the diseased plants. This increase may be tied by decreases of infection with pathogen of powdery mildew and spraying plants with essential oils gave a protection to plants from infestation with pathogen. Our results was agree with Amagase et.al, (2001) which reported that most of the experiments showed the ability of essential oils to stop the development and growth of the pathogenic fungi, where some of them show fungicidal and some other fungi-static effect. The efficiency of the essential oils as a fungicide or fungi-stat is dependent on their contents, active components and functional groups presented in their active components, and their synergistic interactions (Omar and Kordali, 2019 and Dorman and Deans, 2000). This behaviour was also observed in previous studies, Tohamy et al.,(2002) reported that these results could be attributed to the anti-fungal compounds in the essential oil which completely prevented infection in the preventive treatment.

Essential oils could affect the germination of spore, elongation of germ tube and suppress the growth of fungal mycelia (Sivakumar, and Bautista-Baños, 2014). Significant increases in the number of fruits in the garlic sprayed plots can be attributed to the growth regulatory properties present in the garlic (Morsy *et al.,* 2009). These results concur with the findings of Grozav and Foarce (2005), they concluded that the essential oils of garlic significantly increased the height and root length of both monocotyledonous and dicotyledonous plants, sequence higher yield was recorded in plots sprayed with garlic compared to the other treatments. *A. sativum* (garlic) essential oil showed a good antifungal activity in caraway powdery disease. In agreement with our study, Tsao and Yin (2001) reported that GC/MS results of the garlic oil showed the disulfides, trisulfides, and monosulfides were the most constituents. And also, it was reported that disulfide bonds are an important factor in determining the antimicrobial capabilities of the sulfides (Harris et al. 2001). Moreover, *A. sativum* had a high content of polyphenols which increased their antimicrobial effect. Garlic oil can penetrate the plasma membrane because of their lipophilicity character (Nogueira et al. 2010).

Furthermore, our study outlined the possibility of thyme essential oil for controlling powdery mildow disease and inducing resistance in caraway plant. Similarly, Momol et al.,(2005) and Rezabala et.al.,(2022) reported on the utilize of thymol compound and thyme oil under field conditions and they proved that these plant products stimulated the defense system of tomato plants infected by early blight pathogen (*A. linariae)***.** Modes of action appeared to include disruption of cell membrane integrity by altering protein reactions (Walsh et al., 2003). Combrinck et al. (2011) proved that thyme essential oil represent the most effective inhibitor where inhabited all the tested pathogens at 1000 µL.L-1 concentrations and lower. On other hand, some researches reported that the whole EO has a stronger an bacterial activity than the individual major components (Mourey and Canillac, 2002), demonstrating that the minor constituents are also important for anti-microbial activity and have a synergistic effect (Burt , 2004 and Karami et.al., 2010).

Chemical characterization of the tested essential oils of caraway seeds displayed major compounds with higher area percentage. The main components were carvone and limonene in the all treatments. Our results also agree with Laribi et al.(2012) investigated the essential oils of two Tunisian caraway ecotypes and reported the same main compounds were present in both ecotypes but there were differences in their proportions.The other main compound; 1(4methylphenyl) ethanol (10.21%) was identified in the garlic oil treatment which also was identified previously as one of the constituents of the essential oil derived from

*Clausena anisum-olen*s leaves (You et. al., 2015), and 1à,8àDimethyl1,4,4aá,4bá,5,8,8aá, 9aà-octahydro-9H-fluoren 9 one was identified after thyme oil treatment and previously reported as a component of onion oil (Abdel-Meguid, et. al., 2022). Goudarz et. al., (2011) reported that GC-MS was applied to identify the chemical compounds of dry fruits essential oil of *Carum copticum* and found γ-terpinene (36.5%) and ρ-cymene (21.1%) were the major constituents of the fruits oil.

Conclusion

The obtained results during this experiment concluded the success of spray application of garlic and thyme essential oils as resistance inducers for controlling powdery mildew disease of caraway plants in comparison with the control. Also essential oils as a bio- control and bio-stimulants used in the current experiment on caraway plant had a positive variable effects on growth and yield parameters such as seed yield and oil contents, further studies are needed on the effects of foliar application by plant products on the oil composition of treated plants. our results hold a promise for the use of these plant products as a safe and cheap control method against plant disease.

Acknowledgment

The authors would like to thank everyone from workers to professors who participated in this work.

Funding statement

The authors confirmed that no external funding for this study.

Conflict of interest

All authors declared that no conflict of interest between them in the publication of this paper.

TABLE1. Effect of essential oils on disease severity and Infected plants (%) of powdery mildew diseases of caraway plants under greenhouse.

Treatments	Before infection		After infection	
	Disease severity	Infected plant (%)	Disease severity	Infected plant (%)
Control	72.22a	71.89 a	71.72a	71.89 a
Garlic 0.5%	9.88def	6.66 f	11.77d	9.88e
Garlic 1.0%	6.66f	4.997fg	10.11def	4.99fg
Thyme 0.5%	13.22cd	10.22 e	18.44b	14.44cd
Thyme 1.0%	11.66de	4.99 d	16.55bc	13.33d
Fungicide 0.2g/L.	8.22 ef	3.44g	20.00 b	18.44 b
Fungicide 0.4g/L.	6.66f	3.22g	13.33cd	16.78bc
Mean	18.36b	15.06 b	23.13a	21.39a

Values within raw followed by the same letter did not show significant differences according to Tukey,s test at P<0.0 5%

TABLE 2. Effect of essential oils on disease severity and infected plants (%)of powdery mildew diseases on caraway plants under field during the seasons of 2020/2021 and2021/2022.

Treatments	Before infection				After infection			
	Disease severity		Infected plant %		Disease severity		Infected plant %	
	Season1	Season2	Season1	Season2	Season1	Season2	Season1	Season2
Control	93.49a	96.60 a	95.55a	91.11a	93.49 a	96.60 a	95.55a	91.11a
Garlic 0.5	12.58bcd	12.79cd	8.33cd	10.33 c	14.02cd	15.02 d	13.00cd	12.00 cd
Garlic 1.0	8.40de	9.01ef	7.33cd	7.00cd	10.42d	10.73 e	9.00 d	9.33 d
Thymus 0.5	17.32 b	17.78 b	14.66 b	16.00 b	21.65 b	22.31b	20.00 b	19.33b
Thymus 1.0	15.01bc	16.05bc	12.00bc	13.00 c	18.43bc	20.15bc	18.66bc	17.33 bc
Fungicide 0.2g/L.	10.33cde	11.10de	8.00 cd	9.00 cd	19.59bc	19.00 c	16.66bc	16.66bc
Fungicide 0.4g/L.	4.18 e	4.66 f	4.00 d	5.00 e	14.35cd	19.00 c	14.0bcd	13.66bcd
Mean	23.04a	23.99a	21.41a	21.63a	27.42b	28.43b	26.69b	25.63b

Values within raw followed by the same letter did not share significant differences according to Tukey,s test at P<0.05%.

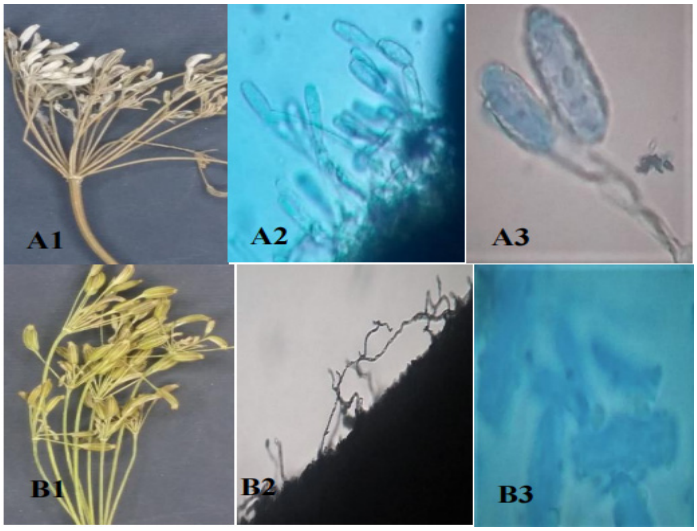


Fig. 1. Effect of garlic oil treatment on mycelial morphology and spor germination comparing to control
1-Control: (A1) powdery mildew on *Carum carvi,* ,(A2) stained conidiophore and (A3) stained germinated conidia. 2-Treated plant: (B1) treated plant,(B2)stained conidiophore in treated plant and (B3) stained conidia in treated plant.

TABLE 3. Effect of certain essential oils compared with the fungicide on growth and yield components in caraway plant diseased by powdery mildew fungus under field conditions during the seasons of 2020/2021 and2021/2022.

Treatments	Before infection			After infection		
	Plant height (cm)	Branch number/ plant	Umbel number/ plant	Plant height (cm)	Branch number/ plant	Umbel number/ plant)
			Season 1			
Control	90.20f	10.89ef	16.45ef	90.20f	10.89f	16.45ef
Garlic 0.5%	94.43d	10.89ef	15.56g	91.67e	14.00abc	18.45d
Garlic 1.0%	92.22e	15.56a	20.66b	93.89d	13.56bcd	19.33c
Thyme 0.5%	89.97f	11.33ef	16.89e	94.44d	12.00def	19.33c
Thyme 1.0%	98.89b	14.44abc	18.22d	89.97f	12.00def	19.55c
Fungicide 0.2g/L.	96.67c	11.11ef	18.11d	92.20e	14.45ab	25.78a
Fungicide 0.4g/L.	99.97a	12.65cde	16.22f	88.89g	13.66bcd	16.67ef
Mean	94.62a	12.410b	17.44b	91.61b	12.94a	19.37a
			Season 2			
Control	88.33g	9.89h	18.53f	88.33g	9.89h	18.53f
Garlic 0.5%	98.66ab	10.22g	19.33ef	89.97f	11.00d	22.56b
Garlic 1.0%	99.54a	11.56b	19.99cde	92.77e	14.00a	25.99a
Thyme 0.5%	92.77e	11.67b	19.66de	96.10d	11.11cd	19.44ef
Thyme 1.0%	99.00ab	10.44f	19.78cde	94.99d	11.22c	22.22b
Fungicide 0.2g/L.	97.77bc	10.33fg	19.11ef	93.33e	10.66e	20.78c
Fungicide 0.4g/L.	97.39c	11.56b	20.55cd	99.77a	11.00d	20.44cd
Mean	96.21a	10.81b	19.57b	93.61b	11.27a	21.42a

Values within raw followed by the same letter did not share significant differences according to Tukey,s test at P<0.05%

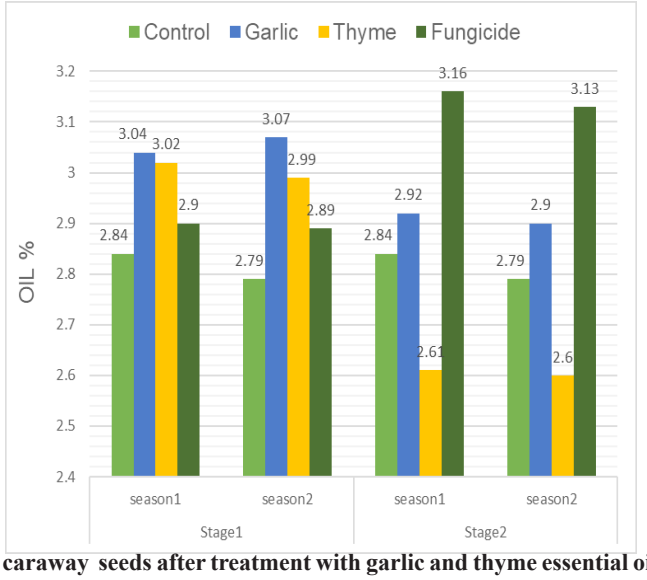


Fig.2. Essential oil % from caraway seeds after treatment with garlic and thyme essential oils and fungicide comparing to control during the two seasons

Stage1 : spray treatments before disease symptoms appear

Stage2 :spray treatments after disease symptoms appeared

TABLE 4. Effect of certain essential oils compared with the fungicide on growth and yield components in caraway plant diseased by powdery mildew fungus under field conditions during the seasons of 2020/2021 and2021/2022.

Treatments	Before infection				After infection			
	F.w./ Plant (g)	W. of seed/ plant (g)	W.of seed /fedd. (kg)	W.of 1000 seeds (g)	F.w./ plant (g)	W.of seed/ plant (g)	W.of seed /fedd. (kg)	W.of 1000 seeds (g)
Season 1								
Control	91.33h	9.99h	499.00k	4.78g	91.33h	9.99h	499.00k	4.78g
Garlic 0.5%	103.33g	11.83def	572.20f	6.43ab	116.43cde	13.7b	625.03c	5.23ef
Garlic 1.0%	113.80de	11.05g	502.78k	5.23ef	129.19b	15.12a	710.85a	6.07bc
Thyme 0.5%	104.44fg	11.53efg	515.70j	5.83cd	117.97cd	11.19fg	516.27j	4.83g
Thyme 1.0%	113.89de	12.13de	556.43h	6.35ab	119.67c	12.47cd	586.35e	4.93fg
Fungicide 0.2g/L.	105.00fg	11.72ef	539.92i	5.26ef	113.00e	12.513cd	562.67g	5.44de
Fungicide 0.4g/L.	108.33f	13.01c	604.50d	5.93c	135.33a	15.00a	704.80b	6.65a
Mean	105.73b	11.61b	541.50b	5.69a	117.56a	12.86a	600.71a	5.42a
Season 2								
Control	98.33i	8.33i	418.10h	5.01g	98.33i	8.33i	418.10h	5.01g
Garlic 0.5%	105.00gh	13.74bc	625.05c	6.00c	120.20d	13.55c	664.99b	5.73de
Garlic 1.0%	117.67de	11.34h	500.79g	6.37b	135.97b	15.37a	710.54a	5.97c
Thyme 0.5%	106.09 g	11.53gh	525.07f	5.93cd	130.11c	11.27h	574.95e	5.47f
Thyme 1.0%	116.12ef	12.73d	621.03cd	6.36b	132.43bc	11.83f	481.88g	5.63ef
Fungicide 0.2g/L.	102.50h	11.80fg	562.05e	5.67ef	113.67f	12.37e	576.03e	5.73de
Fungicide 0.4g/L.	106.00g	13.87b	606.23d	6.00c	154.33a	13.66bc	703.78a	7.03a
Mean	107.39b	11.91b	551.19b	5.78a	126.43a	12.34a	590.04a	5.79 a

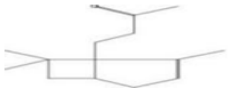
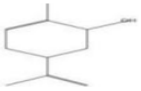
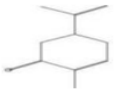
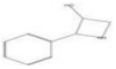
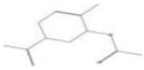
Values within raw followed by the same letter did not share significant differences according to Tukey,s test at P<0.05%.

TABLE 5. Chemical constituents of the essential oils derived from *Carum carvi* seeds treated with garlic and thyme essential oil separately at 1% concentration, and treated with synthetic fungicide at 0.4g /L. concentration comparing to control.

No.	Compound	M. formula	M.W	Area %			
				T1	T2	T3	T4
1	à-PINENE,	C10H16	136	0.01	tr	tr	-
2	á-Myrcene	C10H16	136	0.09	-	0.11	-
3	Limonene	C10H16	136	36.96	27.06	34.10	30.01
4	cis-Ocimcis-Ocimene	C10H16	136	1.17	-	tr	-
5	ç-Terpinene	C10H16	136	0.35	0.30	-	1.4
6	2',7',7'Trimethylbicyclo[4.1.0]hept-2'-)4 en1'-y l)-3-butan-2-one	C14H22O	206	4.60	-	-	-
7	Carveyl acetate	C12H18O2	194	0.23	0.01	-	0.29
8	trans-Caryophyllene	C15H24	204	0.25	0.07	tr	1.43
9	Copaene	C15H24	204	0.03	tr	tr	1.21
10	á-Cubebene	C15H24	204	0.37	0.44		0.97
11	1-(4Methylphenyl)ethanol	C9H12O	136	-	10.21	-	-
12	2-Adamantylamine	C10H17N	151	-	2.78	-	0.02
13	(2RS,3RS)3Hydroxy2phenylazetidine	C9H11NO	149	-	5.86	-	-
14	cis,cis,cis-2,4,6-Octatriene	C8H12	108	-	7.96	-	-
15	Cembrene C	C20H32O2	340	-	0.54	-	-
16	(-)-Carvone	C10H14O	150	54.02	42.14	40.13	50.10
17	(-)-á-Elemene	C15H24	204	-	0.05	-	0.23
18	1à,8àDimethyl1,4,4aá,4bá,5,8,8aá, 9aà-octahydro-9H-fluoren-9-one	C15H20O	216	-	-	13.33	-
19	1-Vinyl-8-oxabicyclo[3.2.1] oct-6-en-3-one	C12H13NO5	150	-	-	6.50	-
20	trans-Carveol	C10H16O	152	-	-	3.59	-
21	Ethyl 2-hydroxybenzylsulfone	C9H12O3S	200	-	-	-	1.82
22	N(Methylsulfonyl)benzaldimine	C8H9NO2S	183	-	-	-	2.71
23	1-Isopropylidene-3-n-butyl-2-cyclobutene	C11H18	150	-	-	-	1.95
24	3-methyl-1-propyl-6,7,8,9-tetrahydro5Hcyclohepta[c]pyridine	C14H21N	203	-	-	-	2.81
25	Widdrene	C15H24	204	-	-	-	0.51
26	1-methylbicyclo[3.2.2]n on-6-en-2-one	C10H14O	150	-	-	-	0.35
27	Anethole	C10H12O	148	-	-	-	0.99
Total %				98.08	97.42	97.76	96.8

T1:control, T2: treatment with garlic essential oil at 1% concentration, T3: treatment with thyme essential oil at 1% concentration, and T4: treatment with synthetic fungicide at 0.4g /L concent

TABLE 6. Structures of dominant and common compounds of caraway seeds essential oils.

1-Vinyl-8oxabicyclo[3.2.1]oct-6-en-3- one 	á-Myrcene 	Limonene 	Cis Ocimene 	Terpinene 
4(2',7',7' Trimethylbicyclo[4.1.0hep2'-en1'-yl)-3-butan-2-on 	1(4Methylpheny l) ethanol 	trans-Carveol 	Carvone 	2,4,6-Octatriene 
1à,8à-Dimethyl 1,4,4aá , 4bá,5,8,8aá,9aà-octa hydr o-9H-fluoren-9-one 	(2RS,3RS)-3Hydroxy-2-phenylazetidine 	1Isopropylide n e-3 n-butyl 2-cyclobutene 	à-PINENE, 	Carveyl acetate 

References

Abdel-Meguid, A. D., Ramadan, M. Y., Khater, H. F. and Radwan, I. T. (2022) Louicidal Efficacy of Essential Oils against The Dog Louse, *Trichodectes canis* (Mallophaga: Trichodectidae) Egypt. *Acad. J. Biology. Sci.,* **14** (1),1-16

Adams, R. P. (2001) Identification of Essential Oil by Gas Chromatography Quadrupole Mass Spectrometry. Allured Publishing Corporation, Carol Stream, Illinois, USA. P. 455.

Al Maqtari, M.A.A., Alghalibi, S.M., Ebtesam, H.A. (2011) Chemical composition and antimicrobial activity of essential oil of *Thymus vulgaris* from Yemen. *Turk. J. Biochem.,* **36**,342-349

Almarie, A. A., Al-Salmani Sinan, A.A. and Almohammedi Ali F. (2019) Response of caraway (*Carum carvi* L.) plants to organic manures in replacement of chemical fertilization. *March*, *Res. J. Biotech* **14** (Special Issue I),283

Amagase, H., Petesch, B.L., Matsuura, H., Kasuga, S. and Itakura, Y. (2001) Intake of garlic and its bioactive components. *J. Nutr.,* **131**, 955S-962S.

Ben Jabeur, M., Ghabri, E., Myriam, M. and Hamada, W. (2015) Thyme Essential Oil As Defense Inducer Of Tomato Against Gray Mold And *Fusarium* Wilt. *Plant Physiol., Biochem* **94**, 35-40.

Burt, S. (2004) Essential Oils: Their Antibacterial Properties and Potential Applications in Foods. a review. *Int. J. Food Microbiol*, **94**, 223-53.

Combrinck, S., Regnier, T. and Kamatou, G. P. P. (2011) *In vitro* activity of eighteen essential oils and some major components against common post-harvest fungal pathogens of fruit. *Industrial Crops and Products*, **33**(2), 344-349.

Dorman, H.J.D. and Deans, S.G. (2000) Antimicrobial agents from plants: Antibacterial activity

of plant volatile oils. *J. Appl. Microbiol,* **88**, 308-316.

Edrir, A. E. (2007) Pharmaceutical and therapeutic potentials of essential oils and their individual volatile constituents. A review. *Phytother. Res.* **21**, 308-323.

Goñi, P., López, P., Sánchez, C., Gómez-Lus, R., Becerril, R. and Nerín, C. (2009) Antimicrobial activity in the vapour phase of a combination of cinnamon and clove essential oils. *Food Chemistry,* **116** (4), 982-989.

Goudarzi, Gh. R., Saharkhiz, M. J., Sattari, M. and Zomorodian, K. (2011) Antibacterial Activity and Chemical Composition of Ajowan (*Carum copticum* Benth. & Hook) Essential Oil. *J. Agr. Sci. Tech.,* **13**, 203-208.

Grozav, M. and Foarce, A. (2005) Preliminary study on the biological activity of *Allium sativum* L. essentialoil as potential plant growth regulators. *Electronic Journal of Environmental, Agricultural and Food Chemistry* **4**, 1138-1142.

Harris, J.C., Cottrell, S.L., Plummer, S. and Lloyd, D. (2001) Antimicrobial properties of *Allium sativum* (garlic). *Appl. Microbiol. Biotechnol.,* **57**, 282-286.

Horsfall, J.C. and Barratt, A.A. (1945) An improved grading system for measuring plant diseases. *Phytpathology*,**35,** 655-658.

Kabir, L., Sang-Woo, K., Jin, H.J., Yun, S.K., Kyoung, S.K. and Youn, S.L. (2011) Inhibition effects of silver nanoparticles against powdery mildew on cucumber and pumpkin. *Microbiology* **39**(1), 26-32.

Karami-Osboo, R., Khodaverdi, M. and Akbari, A.F. (2010) Antibacterial Effect of Effective Compounds of *Satureja hortensis* and *Thymus vulgaris* Essential Oils against *Erwinia amylovora. J. Agr. Sci. Tech.,* **12**, 35-45.

Laribi1, B., Kouki,1.K. , Bettaieb,T. , Mougou, A. and Marzouk, B. (2012) Comparative Analysis of Growth, Seed Yield, Essential Oil and Fatty Acid Composition of Two Tunisian Caraway (*Carum carviL.*) Ecotypes Medicinal and Aromatic. *Plant Science and Biotechnology* **7** (1), 33-39.

Leite, C.D., Botelho, R.V., Faria, C.M.D.R. and Maia, A.J. (2011) Extrato De Alho e Óleo Vegetal No Controle Do Míldio Da Videira. *Revista Brasileira De Fruticultura, Jaboticabal*, **33** (2), 429-36.

Leyva, J.M., Ortega-Ramirez, L.A. and Ayala-Zavala, J.F. (2015) Garlic (*Allium sativum* Linn.) oils. In Essential Oils in Food Preservation, Flavor and Safety. 1st ed.; Academic Press: London, UK, pp. 441–446.

Martin, H. and Salmon, E. S. (1930) Vegetable oils as fungicides. Nature 126:58.

Momol, M.T., Olson, S.M., Pradhanang, P.M. and Jones, J.B. (2005) Evaluation of thymol as

biofumigant for control of bacterial wilt of tomato under field conditions *Plant Disease*, **89**,497-500.

Morsy, S.M., Dragham, E.A. and Mohamed, G.M. (2009) Powdery Mildew Diseases and Growth Characteristics of Cucumber. *Egyptian Journal of Phytopathology* **3**, 35- 46.

Mourey, A. and Canillac, N. (2002) AntiListeria Monocytogenes Activity of Essential Oils Components of Conifers. *Food Control*, **13**, 289-292.

Nogueira, J.H.C., Gonçalez, E., Galleti, S.R., Facanali, R., Marques, M.O.M. and Felício, J.D. (2010) Ageratum conyzoides essential oil as aflatoxin suppressor of *Aspergillus flavus. Int J Food Microbiol* **137**, 55-60.

Odstrčilová, L., Ondřej, M., Kocourková, B. and Růžičková, G. (2002) Monitoring of Incidence and Determination of Fungi on Caraway, Fennel, Coriander and Anise, Consideration of Disease Importance and Possibility of Chemical Protection. *Plant Protect. Sci.,* **38**(2), 340-343.

Omar, M. S . and Kordal, Ş. (2019) Review Of Essential Oils As Antifungal Agents For Plant Fungal Diseases . Ziraat Fakültesi Dergisi **14** (2),294-301.

Pauli, A.(2006) Anticandidal low molecular compounds from higher plants with special reference to compounds from essential oils. *Med. Res. Rev*. **26**, 223-268.

Reuveni, M., Agapov, V. and Reuveni, R. (1996) Controlling powdery mildew caused by *Sphaerotheca fuliginea* in cucumber by foliar sprays of phosphate and potassium salts. *Crop Protection* **15**, 49-53.

Rezabala, L. A. S., Silveira ,P. R. D., Tavares, D. G., Moreira S. I., Magalhães, T. A., Botelho, D. M.D.S. and Alves, E. (2022) Thyme Essential Oil Reduces Disease Severity and Induces Resistance against *Alternaria linariae* in Tomato Plants. *Horticulturae* **8**, 919

Ross, Z.M., O'Gara, E.A., Hill, D.J., Sleightholme, H.V. and Maslin, D.J. (2001) Antimicrobial properties of garlic oil against human enteric bacteria:evaluation of methodologies and comparisons with garlic oil sulfides and garlic powder. *Appl Environ Microbiol* **67**(1),475-480.

Samira, N., and Sara, N. (2016) Biosynthesis of Silver Nanoparticles Using *Carum carvi* Extract and its Inhibitory Effect on Growth of *Candida albicans. Avicenna J. Med. Biochem*., **4**(2), 2-6

Shang, A., Cao, S.Y., Xu, X.Y., Gan, R.Y., Tang, G.Y., Corke ,H., Mavumengwana, V. and Li, H. (2019) Bioactive compounds and biological functions of garlic (*Allium sativum* L.). *Foods,* **8**, 246.

Singh, A.K. (2006): Evaluation of fungicides for the control of powdery mildew disease in coriander. *Journal of Spices and Aromatic crop*, **15**(2),123-124.

Sivakumar, D. and Bautista-Baños, S. (2014) A review on the use of essential oils for postharvest decay control and maintenance of fruit quality during storage. *Crop Protection,* **64**, 27–37.

Stainier,C. (1975) Role and functions of the European Pharmacopoeia. *Ann Ist Super Sanita*, **11**(3-4), 211-219.

Steel, R.G., Torrie, J.H. and Dickey, D. (1997) Principles and Procedures of Statistics. Biometrica Approach The McGraw-Hill Co., Inc, New York.

Tohamy, M.R.A., Aly, A.Z., Abd El-Moity, T.H. and Abd El- Moneim, M. L. (2002) Evaluation of some plant extracts in controlling damping- off and mildew diseases of cucumber. *Egypt. J. Phytopgathol*., **30**(2), 71- 80.

Tsao, S.M. and Yin, M.C. (2001) In-vitro antimicrobial activity of four diallylsulphides occurring naturally in garlic and Chinese leek oils. *J Med Microbiol,* **50**,646-649

You, C.X., Jiang, H.Y., Zhang, W.J., Guo, S.S., Yang, K., Lei, N., Ma P.,Geng, Z. F. and Du, S. S. (2015) Contact Toxicity and Repellency of the Main Components From the Essential Oil of *Clausena anisum-olens* Against Two Stored Product Insects. *J. Insect Sci*., **15**(1), 87

Walsh, S.E., Maillard, J.Y., Russell, A.D., Catrenich, C.E. and Charbonneau, D.L. (2003) Activity and mechanisms of action of selected biocidal agents on Gram-positive and Gram-negative bacteria. *J. Appl. Microbial*., **94**, 240-247.

Zalewska, E.D., Machowicz-Stefaniak, Z. and Król, E.D. (2015) Fungi Colonizing Caraway (*Carum Carvi* L.) In Different Regions Of Cultivation. *Acta Sci. Pol. Hortorum Cultus*, **14**(6) 175-188

Zeng T., Zhang C.L., Song F.Y., Zhao X.L. and Xie K.Q., (2012) Garlic oil alleviated ethanol-induced fat accumulation via modulation of SREBP-1, PPAR-α, and CYP2E1. *Food Chem Toxicol* **50**,485-491.

تقييم نشاط الزيوت الطيارة لكل من الثوم والزعتر ضد مرض البياض الدقيقى فى نبات الكراوية

فل الندى محمد صالح عريبى[1] ، ريم محمد عبد الرؤوف الحسينى[1] وهدي عبد الفتاح مصطفي [2]

[1] قسم بحوث النباتات الطبية والعطرية - معهد بحوث البساتين - مركزالبحوث الزراعية - الدقى- الجيزة - مصر.
[2] معهد بحوث امراض النبات - مركز البحوث الزراعية - الجيزة - مصر.

الملخص

اجريت هذه الدراسة خلال الموسمين الشتويين 2020/2021 و2021/2022 على نبات الكراوية فى مزرعة محطة بحوث عرب العوامر مركز البحوث الزراعية بمحافظة اسيوط.
فى تجربتين منفصلتين احداهما فى قصارى فى الصوبة والاخرى فى الحقل حيث صممت التجارب بنظام القطع المنشقة بهدف دراسة تاثير الزيوت الطيارة مقارنة بالمبيد الفطرى الكيميائي المخلق على مرض البياض الدقيقى فى نبات الكراوية.

تم رش النباتات على فترتين: الاولى قبل ظهور اعراض المرض والثانية بمجرد ظهور اعراض المرض على النبات بالمعاملات الاتية: الزيت الطيار لكل من الثوم البلدى والزعتر بتركيزات 0.5 و1.0% (كل على حدى) ومضاد للفطريات فلينت بتركيزات 0.2 و 0.4 جم / لتر بالاضافة الى معاملة الرش بالماء (المعاملة المقارنة) تم الرش بالمعاملات ثلاث مرات متتالية فرق اسبوع بين الرشة والتى تليها.

- اظهرت النتائج ان كل المعاملات المستخدمة اثرت بشكل واضح وبدرجات متفاوتة على شدة المرض مقارنة بالمعاملة المقارنة
- اوضحت النتائج ان تركيز 1.0% من الزيت الطيار للثوم هو الافضل فى هذا الصدد ويليه المعاملة بالمبيد الفطرى بتركيزيه وبالتالى كانت افضل النتائج من حيث المحصول البذرى والجودة من حيث نسبة الزيت الطيار فى بذور نبات الكرا وية عند تلك المعاملات التى اثرت على الفطر
- وعلى ذلك نوصى باستخدام الزيت الطيار لنبات الثوم البلدى كمنتج نباتى امن غير مكلف للقضاء على مرض البياض الدقيقي فى نبات الكراوية.