EVALUATION OF ANTIMICROBIAL ACTIVITY OF EXTRACTS FROM MEDICINAL PLANTS AGAINST PATHOGENIC MICROORGANISMS TO CONTROL LATE BLIGHT OF TOMATO.

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ABSTRACT

This study aimed to evaluate the antimicrobial activity of 11 different essential oils such as *Allium sativum, Cinnamomum cassia, Dianthus caryophyllus, Eucalyptus globulus, Majorana hortensis, Marticaria chamomilla, Mentha piperita, Nigella sativa,* against 6 pathogenic fungi. While all tested plant extracts produced of antifungal activities, *Eucalyptus globules, Marticaria chamomilla* and *Thymus vulgaris* were the most active plants extracts that showed potent antifungal activity. Minimum inhibitory concentration (MIC) of the most efficient extracts against all tested microorganisms and with special reference of *Phytophthora infestans* was determined. The MIC of the plant extract ranged between 144.7to 166.2µg/ml. According to MIC effect, pot experiment was conducted to test the selected extracts in controlling late blight of tomato plant. *Thymus vulgaris* oil extract gave the best results in inhibiting of *Phytophthora infestans* in concentration of 600µl/ml.

Keywords: plant extracts, MIC, antifungal activity, late blight disease.

INTRODUCTION

Historically, plants have been placed at top among the sources of novel drugs with antimicrobial activity, as traditional medicine based

on plants and plant extracts have made considerable contributions to human health and well-being. Plants provide a natural blue print for the developments of new drugs (**Cragg *et al*., 1997 and Iwu *et al*., 1999).** Plant based antimicrobial represent a vast untapped source of medicines and they provide enormous therapeutic potential. They are effective in the treatment of infectious diseases while simultaneously mitigating many of the side effects that are often associated with synthetic antimicrobials and they offer more affordable treatment **(Murray, 1995 and Iwu *et al*., 1999)**.

The use of biologically based compounds in plant extracts may be an alternative to currently used fungicides to control phytopathogenic fungi, because they virtually constitute a rich source of bioactive chemicals such as phenols, flavonoids, quinons, tannins, alkaloids, saponins and sterols **(Isman,2000 and Burt, 2004)**. Essential oil extracts of various plants have been reported to have inhibitory effect against diverse type of microorganisms including Gram-positive and Gram-negative bacteria, fungi and viruses and they also possess insecticidal and antioxidant properties**(Sue *et al*., 2000 ; Burt, 2004 and Kordali *et al*., 2005).**

Muto *et al.* (2005) tested the extracts derived from fresh and dry tissues of 14 plant species against *Phytophthora infestans* and *Alternaria solani*. Suspensions and extracts of medicinal plants reduced foliar blight of potatoes (*P.infestans)* significantly in wet room experiments (**Krebs *et al*., 2006).**

Plants proved to be a good source of antimicrobial substances which pave the way to identify and isolate new pharmaceutical compounds **(Khanna and Khannabiran, 2008)**

Furthermore, majority of medicinal plant species are rich in bio-molecule contents which can cope with health hazard and recently antimicrobial activity of many plant species have been reported by **Pandey and Mishra (2010)**.

Tomato (*Solanum Lycopersicum*) which belongs to the family solanaceae is the second most important vegetable crop next to potato. Tomato fruit is rich in vitamins A and C and contains an antioxidant, lycopene **(Jones, 1999**).

Recently, bio-control methods based on inhibition of the spore germination of causal agents are apparently the most acceptable approach. Some of the advantages of these methods over chemical methods include absence of residual toxicity, the harmlessness to the

nature and costless (**Paranagama *et al*. 2003**).Stated that of the bio-control methods is the use of natural plant protectants that have pesticidal activity. Essential oils are plant volatiles containing monoterpenes, sesquiterpenes and phenyl propionoids. The essential oil has a long history of use as a topical antiseptic and has been used in Australia as an antiseptic since the 1920s **(Carson *et al*., 2006).**

The current work presents an evaluation of antimicrobial activity of essential oils from medicinal and aromatic plants against tested fungi to select the most efficient extract which has potent antifungal activity to control late blight disease of tomato plant.

MATERIALS AND METHODS

Medicinal and aromatic plants used

Essential oils were isolated by distillation apparatus **(British pharmacopeia, 1988).** *Allium sativum, Cinnamomum cassia, Dianthus caryophyllus, Eucalyptus globulus, Majorana hortensis, Marticaria chamomilla, Mentha piperita, Nigella sativa, Ocimum basilicum, Pimpinella anisum* and *Thymus vulgaris* were collected from Sikam farm and EL-Captain Company (Cap pharm) which cultivate medicinal and aromatic plants and Cairo market of herbs.

Test microorganisms

Six pathopathogenic fungi in stance *Alternaria solani, Asperigellus niger, Fusarium oxysporum, Phytophthora infestans Rhizoctonia solani and Candida albicans*.

Sources of microorganisms, soil and seedlings

The Fungal cultures were obtained from Department of Plant Pathology, Faculty of Agriculture, Ain Shams Univ., Egypt.

A sandy soil was used for pot experiment and pots were placed in Unit of Biofertilizers net, Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Cairo, Egypt.

Seedlings (Strain-B) of tomato were obtained from the seedling greenhouse of ministry of Agriculture.

Total chlorophyll

Total chlorophyll was measured in the fifth leaf after 30, 60 and 90 days from planting of the season using Konic Minolta cholorophyll

Meter Sbad Conic. The fifth leaf from the top was randomly selected to be measured from 5 plants in each of the three replicates.

Assay of antifungal activity

The inhibitory effect of essential oils was tested using the disc-diffusion method**.** Fungal suspensions were prepared by inoculating 1% pepton water **(Difco, 2003).** and incubated for 48h at 30 °C to give a final concentration of 10^7 cfu /ml and the medium Potato dextrose agar (PDA) **(oxoid manual, 1990)** in petri dishes were inoculated individually with 1 ml of each fungal strain. Filter paper disc Whatman No. 42 (5mm in diameter) placed onto the inoculated appropriate medium. The Essential oil concentrations were prepared at10 to 100 to 600µl /ml, in a volume of 100 ml of sterilized water or alcohol or mixed of alcohol and sterilized water at rate of 70:30. Each tube was placed in a vortex at 3000 rpm to homogenize the mixture of water and oil. Thereafter, petri dishes were placed in refrigerator for 1 h. Control treatment consisted of sterile-distilled water or alcohol or alcohol and distilled water at rate (70:30). Three replicates were made for each treatment. The plates were incubated 5-7 days at 30 ºC for fungal, then examined and the results recorded (**Basim *et al.*, 2005**).the fungal radical growth was observed and the diameter of each colony was measured. Results were recorded as the average of the five diameter measurements.

Determination of minimal inhibitory concentration (MIC)

Serial concentrations of selected most efficient plant extracts were prepared and their inhibitory effects against test microorganisms were determined. The Minimal inhibitory concentration (MIC) was determined after 3-4 days at 28 ºC for fungal strains and at 37 ºC after 24-48 for bacteria. The MIC means in microbiology the lowest concentration of an antimicrobial that will inhabit the visible growth of microorganism and it is important in diagnostic laboratories to confirm resistance of microorganisms **(Das *et al.*, 2010)**.

Greenhouse pot experiment

A greenhouse pot experiment was conducted to study the effect of selected essential oils *in vitro* on controlling tomato late blight disease caused by *Phytophthora infestans* race 6. Seven days old Czapek's agar medium (**Eaton *et al.*, 1998).**plate culture of *Phytophthora infestans* surface flooded and its surface was gently

rubbed by sterilized small brush to dislodge fungal spores and to enable filtering the suspension through clean cheesecloth to remove mycelia fragments. The concentration of fungal spores was adjusted to approximately 10^5 spore ml^{-1} (**Bankole and Joda, 2004)**. The root of tomato seedlings (Strain-B) of 30days old were gently washed with distilled water. These seedlings were used in a green pot experiment carried out at unit of Biofertilizers net, Faculty of Agriculture, Ain Shams University. Three seedlings were transplanted into 30 cm diameter polyethylene pots containing about 5kg of washed sandy soil. Seedling were irrigated daily and treated (fertilized foliar application) weekly with a filter-sterilized liquid fertilizer (Primo product produced by The Egyptian Co. for Development & Chemical Industries, contented 3:3:43 N:P:K, 0.1% [vol/vol]).Temperatures were varied between 22-26 °C during the day and 15-19 °C at night. Plants were placed in the green house for 7 days without any treatment to notice the death of any seedling which discarded at this case. After 8 days of transplanting, a concentration of the essential oils (100, 200,300,400,500 and 600) µl /ml of *Thymus vulgaris, Marticaria camomilla* and *Eucalyptus globulus* were used for foliar spraying amendment of tomato plants since it gave the highest reduction of *Phtophthora infestans* growth *in vitro*. After 20 days of transplanting, tomato plants were infested (at 4- 5 true leaf stage) by foliar spraying method with *Phtophthora infestans*using 5 ml^{-1} per plant. The disease severity was estimated after 2 and 4 weeks of inoculation as mentioned by **Shishido *et al.* (2005).** Plants were grown for 3 months. Measurements of height, number of leaves and leaf chlorophyll level during the vegetative period at the first month were carried out. At the second month, the number of flowers during the flowering period was determined. Finally, the number, weights and volume of fruits during fruiting period were measured. Control treatment was supplemented with the same amount of distilled water.

Disease severity

Disease severity of *Phytophthora infestans* caused late disease was estimated using the disease scale from 0 to 4 suggested by **Cohen *et al.* (1991)**as follows:

0 = no leaf lesion; 1 = lesion on < 25% of leaf area; 2 = lesion on 26 – 50% of leaf area; 3 = lesion on 51- 75% of leaf area and 4 = lesion on 76 up to 100% of leaf area.

Then the following formula was used:

$$D.S. = \Sigma (n \times c) / N$$

Where:
D.S = Intensity of attack, n = Number of infected plants per category, c = Category number and N = Total exam.

Statistical analysis

The obtained data were exposed to the proper statistical analysis according to **Snedecor and Cochran (1991).**The least significant differences. Using Costat computer program V 6.303 (2004). LSD at 5% level as significance was used to differentiate between means.

RESULTS AND DISCUSSION

The antimicrobial activity of the 11medicinal and aromatic plant extracts under investigation against test microorganisms against fungi and yeast was studied. Plant extracts showed high microbial activities *in vitro* was further used in greenhouse pot experiment.

***In vitro* antimicrobial activity of aqueous and ethanolic plant extracts against microorganisms strains.**

Effect of ethanolic plant extracts.

The maximum inhibition zones for ethanolic plant extracts against test microorganisms are shown in Table (1). The results indicated that the selected ethanolic plant extracts showed various inhibitory effects with varying magnitudes.

The results indicated that the selected ethanolic plant extracts showed antimicrobial activity with one or more of tested fungi

According to the effect of ethanolic plant extracts against fungi and yeast strains, it was found that out of 11 ethanolic plant extracts tested, 7 showed antifungal activity against one or more of tested fungi. *Cinnamomum cassia, Dianthhus caryophyllius, Majorana hortensis* and *Ocimum basilicum* failed to inhabit any of the fungal and yeast tested strains. In general *Candida albicans* and *Phytophthora infestans* were inhibited by 6 and 4 oils respectively, followed by *Fusarium oxysporum* (3 oils). The maximum inhibition zones were recorded by essential oils of *Eucalyputs globulus*, *Matricaria chamomilla*, *Nigella sativa, Thymus vulgaris, Eucalyptus globulus* and *Thymus vulgaris* giving 14, 14, 14, 14, 13 and 13 mm against *Fusarium oxysporum, Phytophthora infestans, F. oxysporum,*

Phytophthora infestans, Candida albicans and *F. oxysporum* respectively. **Conner and Beuchat (1984)** investigated the antimicrobial effect of essential oils of anise (*Pimpinella anisum)* and stated that these oils had only mild effects on all tested yeasts, which is consistent with our findings. **Arango *et al.* (2011)** reported that *Eucalyputs* oil had a fungicidal effect at a $3gL^{-1}$ concentration and a fungicidal activity at small concentrations against *Fusarium oxysporum*. **Ghomi *et al.* (2008)** stated that the *Pimpinella aurea* may be useful as a moderate antioxidant and antimicrobial agent following extensive investigation. Particularly, the extract of *Pimpinella aurea* may be potentially useful source of natural antioxidant principles.

Effect of aqueous plant extracts.

Data in Table (2) clearly reveal that the aqueous extracts of all the plants screened showed various inhibitory effects. In agreement with earlier studies have reported better antimicrobial activity for *Eucalyptus globulus*oil (**Cimanga *et al.*, 2002 and Takarada *et al.*, 2002**).Our study showed high inhibitory activity of *Eucalyptus* oil extract against test microorganisms. In addition, *Cinnamomum cassia* (cinnamon) oil inhibited the growth of molds, yeast and bacteria (**Matan *et al.*, 2006)**.

Out of 11 aqueous plant extracts tested, 6 showed antifungal activity against one or more of fungal strains (Table 2). Obtained results indicated that essential extracts of *Allium sativum*, *Cinnamomum cassia*, *Dianthus caryophyllus***,** *Majorana hortensis* and *Ociimum basilicum* have no Antifungal activity against tested fungi and yeast strains. Oils extracts of *Matricaria chamomilla*, *Thymus vulgaris* and *Eucalyptus globulus* showed remarkable inhibitory effect against *Phytophthora infestans* giving 15, 15 and 14mm receptively, while *Fusarium oxysporum* was inhibited by *Eucalyptus globulus* and *Thymus vulgaris* with inhibition zone of 13 and 12 mm receptively.Moderate effects were seen in *Eucalyptus globulus*, *Mentha piperita*, *Nigella sativa*, *Pimpinella anisum* and *Thymus vulgaris* against *Candida albicans*. Obtained results is agreement with findings reported by **Janssen (2011)** who tested 53 essential oils against *Candida albicans* using the agar overlay technique, the differences between the inhibition zones were too small for a differences of the antimicrobial activities of the essential oils. Correlation matrix shows the relationships of the microorganisms as to the activity patterns of the essential oils.

Table (1): Inhibition zone of microbial growth affected by ethanolic plant extracts.

Test microorganisms	*Allium sativum*	*Cinnamomum cassia*	*Dianthus caryophyllus*	*Eucalyptus globulus*	*Majorana hortensis*	*Matricaria chamomilla*	*Mentha piperita*	*Nigella sativa*	*Ocimum basilicum*	*Pimpinella anisum*	*Thymus vulgaris*
Fungal strains	zone of inhibition (in mm diameter)										
Alternaria solani	0	0	0	0	0	0	0	0	0	0	0
Aspergillus niger	0	0	0	0	0	0	0	0	0	0	0
Fusarium oxysporum	0	0	0	14	0	0	0	14	0	0	13
Phytophthora infestans	0	0	0	11	0	14	10	0	0	0	14
Rhizoctonia solani	0	0	0	0	0	0	0	0	0	0	0
Yeast strain											
Candida albicans	11	0	0	13	0	0	12	11	0	12	9

Table (2): Inhibition zone of microbial growth affected by aqueous plant extracts.

Test microorganisms	zone of inhibition (in mm diameter)										
	Allium sativum	*Cinnamomum cassia*	*Dianthus caryophyllus*	*Eucalyptus globulus*	*Majorana hortensis*	*Matricaria chamomilla*	*Mentha piperita*	*Nigella sativa*	*Ocimum basilicum*	*Pimpinella anisum*	*Thymus vulgaris*
Fungal strains											
Alternaria solani	0	0	0	0	0	0	0	0	0	0	0
Aspergillus niger	0	0	0	0	0	0	0	0	0	0	0
Fusarium oxysporum	0	0	0	15	0	0	0	0	0	0	12
Phytophthora infestans	0	0	0	14	0	15	11	0	0	0	15
Rhizoctonia solani	0	0	0	0	0	0	0	0	0	0	0
Yeast strain											
Candida albicans	0	0	0	10	0	0	12	10	0	10	9

Minimum inhibitory concentration (MIC) for plant extracts against microorganisms strains.

Minimum inhibitory concentration of tested ethanolic plant extracts

Minimum inhibitory concentration effect of plant extracts were tested against fungal and yeast strains. It is clear from data in Table (3) that Minimum inhibitory concentration of tested ethanolic plant extracts have various values.Minimum inhibitory concentration values ethanolic plants extract against fungal and yeast strains was also determined. Obtained results in cont. Table (4) show that maximum activity with MIC values were obtained with *Matricaria chamomilla* (144.78 µg ml^{-1}) followed by *Eucalyptus globulus* (159.06 µg ml^{-1}) and *Thymus vulgaris* (166.2µg ml^{-1}) against *Phytophthora infestans*. However *Eucalyptus globulus* and *Thymus vulgaris* gave MIC values of 159.06 and 166.2µg ml^{-1} respectively against *Fusarium oxysporum*. The trend of MIC values in the case of *Candida albicans* was the same as in *Phytophthora infestans* with the same plant extracts. **Daferera *et al*. (2003)** stated that *Thymus* oil extract showed an inhibitory activity against growth of *Fusarium oxysporum* mycelia.

Minimum inhibitory concentration of tested aqueous plant extracts.

The MIC of the aqueous plant extracts took the same trend in the case of MIC of the ethanolic plants extracts with some exception of essential oils values against some bfungal strains. Also, The same trend in values of essential oils MIC were found in fungal and yeast strains subjected to extracts of tested medicinal and aromatic plants, except *Allium sativum* extract gave some variable values. Among all the oils, the essential oil of cinnamon was most effective, followed by the essential oil of thymus, eucalyptus oil and chamomil oil **(Aggarwal *et al*., 2000).**

Essentials oils of higher plants have also been evaluated against pathogenic microorganisms (bacteria, fungi and yeast) by many other workers, The present result is agreement with those obtained by **Rasooli & Rezaei (2002) and Ozcan (2003)**.

Table (3): Minimum inhibitory concentration (MIC) of tested ethanolic plant extracts against microorganisms strains.

Test microorganisms	MIC in (µg ml^{-1})										
	Allium sativum	*Cinnamomum cassia*	*Dianthus caryophyllus*	*Eucalyptus globulus*	*Majorana hortensis*	*Matricaria chammomilla*	*Mentha piperita*	*Nigella sativa*	*Ocimum basilicum*	*Pimpinella anisum*	*Thymus vulgaris*
Fungal strains											
Alternaria solani	697.50	0	0	0	0	0	0	0	0	0	0
Aspergillus niger	523.14	0	0	0	0	0	0	0	0	0	0
Fusarium oxysporum	523.14	0	0	159.06	0	0	0	0	0	0	166.2
Phytophthora infestans	697.50	0	0	159.06	0	144.78	186.2	0	0	0	166.2
Rhizoctonia solani	697.50	0	0	0	0	0	0	0	0	0	0
Yeast strain											
Candida albicans	0	0	0	159.06	0	0	186.2	0	0	0	166.2

Table (4): Minimum inhibitory concentration (MIC) of tested aqueous plant extracts against microorganisms strains.

Test microorganisms	*Allium sativum*	*Cinnamomum cassia*	*Dianthus caryophyllus*	*Eucalyptus globulus*	*Majorana hortensis*	*Matricaria chamomilla*	*Mentha piperita*	*Nigella sativa*	*Ocimum basilicum*	*Trigonella anisum*	*Thymus vulgaris*
Fungal strains	MIC in ($\mu g\ ml^{-1}$)										
Alternaria solani	0	0	0	0	0	0	0	0	0	0	0
Aspergillus niger	0	0	0	0	0	0	0	0	0	0	0
Fusarium oxysporum	348.76	0	0	159.06	0	0	0	0	0	0	166.2
Phytophthora infestans	0	0	0	159.06	0	144.78	186.2	0	0	0	166.2
Rhizoctonia solani	0	0	0	0	0	0	0	0	0	0	0
Yeast strain											
Candida albicans	348.76	0	0	159.06	0	0	0	0	0	0	166.2

Application of the selected efficient essential oil extracts to control tomato late blight disease.

A greenhouse pot experiment was conducted in season 2011 using selected plant extracts *Eucalyptus globulus*, *Thymus vulgaris* and *Matricaria chamomilla* showing high inhibitory effect against *Phytophthora infestans* caused late blight disease of tomato. It was observed that essential oils showed antifungal effects at most concentrations tested. Current data present in Table (5) obviously show that plant highest was significantly influenced by applying foliar spray of plant extracts. Plants treated by *Matricaria chamomilla* extract gave the maximum height of tomato plants being 78.5 cm at the extract concentration of 400 µl ml^{-1} followed by *Thymus vulgaris* and *Eucalyptus globulus* extracts giving 74 and 73.33cm at the same extract conc. of 600 µg ml^{-1} respectively, while *Eucalyptus globulus* extract gave the highest number of leaves (per plant) 77 leaves $plant^{-1}$, this was followed discerningly by treating with *Thymus vulgaris* and *Matricaria chamomilla* extracts giving 73 and 72.25 leaves plants $^{-1}$ respectively at the same concentration of plant extract being 600µl ml^{-1}. Result for number of flowers (per plant) were varied using the 3 plant extracts against fungal phytopathogenic of tomato. Higher number was 16.66flowers plant $^{-1}$ at 400 µl /ml concentration of *Eucalyptus globulus* extract, while the leaves number were decreased in infected tomato plants treated with *Thymus vulgaris* and *Matricaria chamomilla* extracts. It is clear from data in Table (5) that chlorophyll content of infected plants which treated with extracts of 3 plants was significantly increased with increasing the concentration of each plant extract used to suppress the fungal pathogen in this experiment. The chlorophyll content of tomato plants treated with *Thymus vulgaris*, *Matricaria chamomilla* and *Eucalyptus globulus* extracts were 62.3, 62 and 61 mg g^{-1} $plant^{-1}$ respectively at the same extract concentration (600 µl /ml).

Number, weight and volume of fruits have variable measurements. The infected tomato plants which treated with *Thymus vulgaris* extract at the concentration of 300 µl /ml gave the highest number and weight of tomato fruits being 8.5 fruits $plant^{-1}$ and 56.25g $plat^{-1}$. However, treatment of *Matricaria chamomilla* extract maximized the tomato fruits volume (63.75$plant^{-1}$). It is obvious from data in table (5) that the growth of tomato plants expressed as fresh

and dry weights of shoots was significantly affected by treatments of essential oils extracts. It was found that maximal fresh and dry weight of infected tomato plants treated with *Matricaria chamomilla* extract being 46.75 and 24.75g plant $^{-1}$at the same concentration of plant extract (600 µl /ml), while the lowest fresh and dry weight was found in the treatment with *Eucalyptus globulus* extract and *Thymus vulgaris* gave a moderate weight of shoot.

Data presented in Table (5) indicate that foliar spray with *Thymus vulgaris* and *Matricaria chamomilla* extracts10days before infestation with *Phytophthora infestans* reduced late blight severity to 18.75 and 25 % at the concentration of each plant extract of 600 and 400 µl /ml, while reduced to 8.33 and 0.0% at the plant extract concentration of 100 to 600 µl /ml respectively.

Knobloch *et al.* (1989) suggested that the alterations caused by thymol due to its ability to damage the cellular membranes and to interfere with the membrane enzymatic reactions which are fundamental for cellular metabolism. However, **Soylu *et al.* (2006)** confirmed that essential oils from aromatic plants such as thyme, oregano, lavender, rosemary, laurel and fennel are possessed antimicrobial activity against the *Phytophthora infestans*.

Medicinal and aromatic plants contain thousands constituents and are valuable sources of biologically active molecules possessing antimicrobial property. The results of this study clearly indicated the capacity of essential oil of *Thymus vulgaris* as an important inhibitor as well as fungicide agent could be used as potent biocide to treat late blight disease in plants caused by *Phytophthora infestans* as it showed maximum activity.

Table (5): Effect of *Eucalyputs globulus*, *Thymus vulgaris* and *Matricaria chamomilla* oil extracts on growth parameters and severity of infected tomato plants with *Phytophtera infestans* race 6.

Growth parameters	*Eucalyptusglobulus*						*Thymus vulgaris*						*Matricaria chamomilla*						Infected plants	unInfected plants (control)
	Concentration of extracts (µl /ml)																			
	100	200	300	400	500	600	100	200	300	400	500	600	100	200	300	400	500	600		
Height	52.66 fgh	54 efg	58 efg	59 cdefg	54 fgh	73.33 abc	38.75 hi	51 gh	52.5 fgh	54.5 efg	68.25a bcde	74 ab	67 abcdefg	70 abcd	70.25 abcd	78.5 a	77 a	47.5 gh	33.5 i	61.25 bcdfg
Nember of leaves (per plant)	52.66 efg	54 efg	58 cdef	59 bcdef	59 bcdef	77 ab	52 fg	55.75 defg	56.5 defg	58.25 cdef	62.5 bcdef	73 a	57.25 defg	62.5 bcdef	65 abcdef	66.75 abcde	72.25 abcd	43.75 abc	24.25 gh	33.75 hi
number of flowers (per plant)	7.66 cd	11.66 bc	16 ab	16.66 a	16.66 a	15.66 ab	4.25 defg	5 defg	5.5 def	5.75 de	6 de	7 de	6.75 de	4.5 defg	3.5 defg	2.5 defg	0 efg	3.25 fg	0.5 defg	3.75 defg
chlorophyll content (mg g^{-1} $plant^{-1}$)	42 ef	42.76 def	0 h	48.66 abcdef	45.66 cdef	61 a	45 cdef	56 abc	55.75 abcd	54.5 abcde	47 bcdef	62.3 ab	60.42 ab	60.25a b	61 ab	61.5 a	61.7 a	62 a	29.25 g	38.92 fg
Number of fruits (per plant)	0 c	1.66 abc	0.66 bc	0.66 bc	0.66 bc	0 c	4.25 bc	8 ab	8.5 ab	6.76 bc	6.76 a	2 ab	6.76 bc	0.25 bc	0.25 bc	0.5 bc	0.5 c	0.5 bc	0 c	6.78 a
weight of fruits (g $plant^{-1}$)	0 c	0 c	0 c	0 c	`15 bc	0 c	30.83 abc	31.25 ab	56.25 a	55.25 bc	52.5 a	31.2 5ab	8.5 bc	8.25 bc	9 bc	16.3 bc	17 c	55 a	0 c	15 bc
volume of fruits (per plant)	0 def	0 def	0 def	0 def	16.66 cdef	0 def	37.5 abcd	40 abc	53 ab	50.5 ab	46.25 ab	35.5 bcd	31.66 bcde	33.25 bcd	37 abcd	40 abc	47.25 ab	63.75 a	0 def	15.75 cdef
fresh weight (g $plant^{-1}$)	0 f	0 f	0 f	0 f	41 bcd	0 f	40.25 bcd	41.75 bcd	43.65 bc	43 bc	42.25 bc	24.2 e	30.75 de	34.75 cde	35.5 bcde	43.5 bc	45.25 bc	46.75 b	34 cde	66.25 a
Dry weight (g $plant^{-1}$)	0 f	0 f	0 f	0 f	15.66 def	0 f	19.5 abcde	21.5 abc	24.75 a	22.25 abc	22.75 ab	16.5 bcde	16. 2 bcde	16.5 cdef	16.5 cdef	16.4 cdef	16.3 cdef	24.75 a	14.25 ef	25 a
total soluble solids	0 d	0 d	0 d	0 d	4.33 cd	0 d	28.75 ab	33.25 a	26.9 ab	25.5 cd	24 ab	14.5 bcd	6 cd	9 d	11.75 d	3.751 cd	14.76 bcd	19 abc	0 d	4 cd
Disease severity%	0 d	0 d	0 d	0 d	0 d	0 d	8.33 d	41.66 cd	66.5 abcd	85.75 abc	85.75 cd	18.7 d	0 d	85.75 ab	43.75 bcd	25 d	8.33 d	0 d	91.66 a	0 d

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تقييم نشاط مستخلصات من النباتات الطبية ضد الكائنات الحية الدقيقة الممرضة للتحكم في مرض اللفحة المتأخرة للطماطم

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تهدف هذه الدراسة-الى تقييم تأثير أحدى عشر مستخلصا من الزيوت النباتية المختلفة مثل الثوم، القرفة، القرنفل، الكافور، البردقوش، البابونج، النعناع الفلفلى، حبة البركة، الينسون و الزعتر ضد ستة من الفطريات الممرضة.وبينما أظهرت جميع المستخلصات النباتية المختبرة نشاطات مضادة للفطريات فإن مستخلصات الكافور، البابونج و الزعتر كانت الأكثر فعالية ضد الفطريات.وتم دراسة أقل تركيز مثبط (MIC) من المستخلصات الأكثر فاعلية ضد جميع الكائنات الحية الدقيقة المختبرة بالإضافة إلي إختبارها علي وجه الخصوص ضد فطر *Phytophthora infestans* وقد تراوح أقل تركيز مثبط للمستخلصات النباتية مابين ١٤٤،٧ و ١٦٦،٢ ميكروجرام / ملى. ووفقا لتأثير الحد اللأدنى من التركيز المثبط، تم إجراء تجربة أصص لأختبار المستخلصات المختارة فى مقاومة مرض اللفحة المتأخرة فى نبات الطماطم. وقد أعطى مستخلص زيت الزعتر أفضل النتائج فى تثبيط *Phytophtora infestans* بتركيز ٦٠٠ ميكروليتر / ملى.