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EFFECT OF SOME PLANT EXTRACTS, PLANT OILS AND *TRICHODERMA* SPP. ON TOMATO FUSARIUM WILT DISEASE

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ABSTRACT: Plant extracts of *Aloe vera* and *Syzygium aromaticum* (clove) inhibited the growth and sporulation of *Fusarium oxysporum* f.sp. *lycopersici* (FOL) both under laboratory and green-house conditions. However, essential oils also reduced the growth and spore population of FOL significantly. The best results were obtained when clove oil was applied; followed by *Mentha arvensis* (mint) oil. *Trichoderma harzianum* and *T. asperellum* were the best tested *Trichoderma* spp. isolates in reducing the growth of FOL. Under green house and artificial soil infestation conditions, All the above-mentioned treatments reduced the wilt disease incidence and improved the growth of tomato plants; significantly.

Key words: *Fusarium oxysporum* f.sp*. lycopersici*. *Lycopersicon esculentum*. *Syzygium aromaticum*. *Mentha arvensis*. *Trichoderma harzianum*. *T. asperellum*.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae, is a popular vegetable widely grown in the tropics and is the second most important vegetable crop next potato in Egypt and all over the world, Hafez *et al*., 2012. The vascular wilt of tomato caused by *Fusarium oxysporum* f.sp. *lycopersici* (FOL) (Sacc.) Snyder and Hansen, is one of the most destructive diseases, resulting significant yield losses Anam *et al*., 2017 and Aleaghaee *et al*., 2018. *Aloe vera* plant extract had inhibitory effect on *Fusarium oxysporum in vitro* Taiga *et al*., 2008 and Ali *et al*., 2013. However, Yeole *et al*., 2016 reported that clove extract exhibited 100% inhibition of FOL spores at 5 and 10 ml/L. They mentioned that antifungal potential of clove extract was confirmed as compared to the efficacy of chemical fungicides. Farrukh Aqil *et al*., 2001 detected that the maximum antifungal activity of essential oils due mainly to clove followed by peppermint and eucalyptus. They also mentioned that *Fusarium chlamydosporum* was found to be most susceptible to essential oils in liquid as well as agar media. The antifungal activity of clove oil was also reported by many authors Abhishek Sharma *et al*., 2016 and Torre *et al*., 2016. Mohd Rajik *et al*., 2012 proved that *Trichoderma harzianum* and *T. viride* provided induced resistance in plant against *Fusarium oxysporum* f.sp*. lycopersici* resulting declined disease incidence from 100 to 7.69% and the maximum inhibition was noted by *T. harzianum*. *Trichoderma harzianum* was observed to be good biocontrol agent against FOL by several authors (Akrami and Yousefi 2015; Lakshman Prasad *et al*., 2016; Andleeb Zehra *et al*., 2017; and Mwangi *et al*., 2019). Prachi Singh *et al*., 2019 reported that *Trichoderma asperellum* showed maximum inhibition of *Fusarium oxysporum* f.sp. *lycopersici*. However, *Trichoderma asperellum* strains significantly reduced wilt disease incidence and severity compared to FOL only infected plants. Moreover, the application of *T. asperellum* promoted tomato plant growth irrespective of the presence or absence of FOL.

The aim of this study was to find out some ecofriendly methods to control tomato fusarium wilt. Plant extracts, essential oils and *Trichoderma* spp. isolates were used for this purpose.

MATERIALS AND METHODS

I- Isolation, purification and identification of the tested fungi:

Both the pathogenic and antagonistic fungi were respectively isolated from diseased and healthy tomato plants grown in Sadat city, Menoufia governorate. Disease tomato plants showing clear wilt symptoms were collected, roots and stem bases of such plants were gently washed by running tap water to remove the adhesive soil particles. The samples were surface sterilized by 70% ethanol, rinsed several times with sterilized distilled water, dried between sterilized filter papers, cut into small pieces and then planted on potato dextrose agar (PDA) medium contained antibacterial antibiotic (300 mg/l Streptomycin sulphate) to avoid the bacterial growth. Petri dishes were incubated at 25°C for and examined daily for the abundant growth. In the meantime, healthy tomato plants showing were collected from the same fields and the rhizosphere soil was used to isolate the associated microorganisms on PDA medium. War cup soil plate Ammar, 2003 and dilution plate method were followed to achieve such microorganisms.

Streak and/or dilute/plate methods were carried out to obtain single propagule unit cultures. Pure cultures were kept at 5°C for the further studies.

All the obtained isolates were identified at Botany Department, Faculty of Agriculture, Menoufia University.

II- Pathogenicity test experiments:

These experiments were carried out under greenhouse and sterilization condition at the Faculty of Agriculture, Menoufia University, during 2018 growing season. Clay loam soil was autoclaved twice at 121°C for an hour. Pots were sterilized by dipping in 5% formalin for 5 minutes and left for a week to allow formalin evaporation.

Inoculum were prepared by growing each isolate on sterilized Barley sand medium (75 g barley + 25 g sand + 100 ml water); using 500 ml flasks. Flasks which incubated 25°C for 2 weeks and shacked every second day to allow more fungal growth.

Soil infestation was conducted; separately; at the rate of 3% of soil weight. Potted soil was irrigated every second day for a week to allow the fungal distribution into the soil.

Tomato seedling (Cv. K-186) 24 days old were planted, after root sterilization in the infested soil. Control treatment had sterilized soil contained the same percentage of Barley medium (3%). The grown plants were examined every week for the wilt disease. After two months, the plants were picked up and longitudinal sections through stem bases and roots were caried out to measure the length of browning vesicles of each plant.

III- Laboratory experiments:

A complete randomized design (CRD) with three replicates was followed in these experiments.

III-1- Effect of some plant extracts on FOL growth and sporulation:

Two hundred grams of each tested plant (Aloe vera, clove, garlic, nigella and mint) were separately soaked in one-liter sterilized distilled water for 24h. The extracts were heated at 90°C for 30 m, filtered through filter paper, completed to be 1L and autoclaved at 90°C an hour. Extracts were added to PDA medium to obtain the concentrations of 5,10,15%

dilution method (Akaeze and Modupe, 2017).

III-2- Effect of some essential oils on FOL growth and sporulation:

Crude oils of clove, mint and garlic were obtained from El-Gomhouria company for oils, Cairo, Egypt. Each oil was emulsified with 3% (v: v) tween 20 and mixed with PDA medium to obtain 5, 10 and 15% concentrations (Fontes *et al*., 2018). Petri dishes contained Plant extracts or oils were inoculated with 5 mm disc of FOL (7days old PDA cultures and inoculated 25±2 °C for 7 days.

III-3- Effect of *Trichoderma* spp. on FOL fungal growth:

Five *Trichoderma* spp. isolates i.e., *T. hamatum, T. harzianum, T. koningii, T. asperellum* and *T. viride* were individually tested for their antagonistic effect(s) against FOL pathogen. Dual culture method was followed according to (Devi *et al*., 2015). Control plates had the pathogen disc 5mm in the middle. Petri dish were incubated at 25±2 °C for 7 days and examined daily.

III-4- Data recorded:

III-4-1- Growth diameter:

Three replicates were caried out per each treatment of the mentioned laboratory experiments. When a petri dish showed full growth; the average diameter of FOL fungal growth (mm) was recorded. Percent inhibition over control was calculated as per the formula (Sundaramoorthy and Balabaskar 2013):

$$PI\ \% = \frac{C-T}{C} \times 100$$

Where,
PI= percent inhibition over control
C: Mycelial radial growth in control
T: Mycelial radial growth in treatment

III-4-2- Spores population:

The tested isolate of FOL was grown on potato-dextrose agar (PDA) in darkness at 22-25°C for one week. By the aid of camel hair brush; the formed spores were gently removed using 10 ml sterilized distilled water. Spore suspension (10^2 spore/ml) was then, filtered through a layer of Mira cloth and the suspension was diluted and counted using haemocytometer (Jahanshir and Dzhalilov 2010). Fifty random squares of the haemocytometer served as replicates and finally the average number of spores/ml was calculated as per the formula:
No. of spore /ml = No. of spores x dilution x factor

IV- Greenhouse experiments:

These experiments were carried out under greenhouse conditions at the Faculty of Agriculture, Menoufia University. Sterilization of the pots, the soil and soil infestation were conducted as mentioned in Pathogenicity test experiments. Three Pots (15 cm in diameter) were used as replicates for each treatment.

IV-1- Effect of plant extracts and oils on FOL spore population in the soil:

Tomato seedlings of the cv. K-186 (24 days old) were planted in the infested soil with FOL (3%). The pots were irrigated by different plant extracts and /or plant oils (75 ml/pot); after 3 days of planting. The concentrations of either extracts or oils were 5, 10 and 15%. Control pots were irrigated with sterilized distilled water. Irrigation of the different treatments was accomplished every week. Ten days after planting; one-gram soil from the middle of each pot was picked up separately and add to 99 ml sterilized distilled water. Spores of FOL were counted in this dilution using haemocytometer (1/400 m2); NEBAUER IMPROVED, Germany (Starovic *et al*., 2016). The above-mentioned methods were carried out every 10 days (five times).

IV-2- Effect of plant extracts and oils on wilt disease incidence:

Both percentage and severity of infection with FOL were estimated after 55 days of sowing. Wilt disease percentage of infection (PI) was determined from according to this formula:

$$PI = \frac{\text{No. of diseased plants}}{\text{Total No. of plants}} \times 100$$

However, the severity of infection (SI) was estimated using 0-4 scale and the formula:

$$SI = \frac{\text{Sum of (disease grade x No. of plants in grade)}}{\text{No. of total plants x Max. grade infection}} \times 100$$

IV-3- Effect of plant extracts and oils on tomato growth parameters:

At the end of these experiments; average of plant height, number of branches and number of leaves/ plants were estimated.

IV-4- Effect of *Trichoderma* spp. on the disease incidence and plant growth:

Separate applications of five *Trichoderma* spp. isolates were tested for the disease control and tomato plants growth response. The biocontrol agents were individually added to the soil at 3% (w: w) and at the same time of soil infestation with FOL.

V- Statistical analysis:

All experiments were conducted in completely randomized design. Mean values were compared by the least significant difference (LSD) testing at p = 0.05. Duncan's multiple Range test at p = 0.05 was used to compare means. All statistical analyses were performed using Costate, Statistical Software.

RESULTS AND DISCUSSION

Six isolates of *Fusarium oxysporum* f.sp. *Lycopersici* (FOL) were observed and isolate No. 2 was chosen for this study where it produced more spores. All the obtained isolates were pathogenic to tomato plants. These results are in agreement with (Anam *et al*., 2017 and Aleaghaee *et al*., 2018).

In the meantime; five *Trichoderma* spp. isolates were obtained from the rhizosphere of healthy tomato plants. These isolates were identified as *T. harzianum, T. asperellum, T. viride, T. hamatum* and *T. koningii*.

I- Laboratory experiments:

I-1- Effect of plant extracts on the growth and sporulation of FOL:

Results present in Table (1) indicate that *Aloe vera* (cactus) and clove extracts completely inhibited the growth and sporulation of FOL even at the lowest tested concentration (5%). Such results were also obtained by Taiga *et al*., 2008 and Ali *et al*., 2013. However, Yeole *et al*., 2016 mentioned that antifungal potential of clove extract was confirmed as compared to the efficacy of chemical fungicides.

I-2- Effect of plant oils on the growth and sporulation of FOL:

Results shown in Table (2) clear that all tested concentrations of plant oils reduced the linear growth of FOL significantly; in comparison with control. It is of logic that increasing oil gives more significant effect in reducing the fungal growth. Clove oil followed by mint oil had the best efficiency in reducing both growth and sporulation of FOL. Complete spore inhibition was observed when clove oil (at all concentration) and mint oil (15%) were individually applied. The antifungal activity of clove oil was also reported by Abhishek Sharma *et al*., 2016 and Torre *et al*., 2016.

Table (1): Effect of different concentrations of some plant water extracts on the growth and sporulation of *Fusarium oxysporum* f.sp. *lycopersici*:

Plant extract	Conc. (%)	Linear growth (mm)	Growth reduction (%)	No. of. spores/ml (x1000)	Sporulation reduction (%)
Cactus	5	00.00i	100.00	00.00f	100.00
	10	00.00i	100.00	00.00f	100.00
	15	00.00i	100.00	00.00f	100.00
Clove	5	00.00i	100.00	00.00f	100.00
	10	00.00i	100.00	00.00f	100.00
	15	00.00i	100.00	00.00f	100.00
Garlic	5	43.33f	50.01	21.33e	82.61
	10	00.00i	100.00	00.00f	100.00
	15	00.00i	100.00	00.00f	100.00
Mint	5	65.67b	24.23	96.00b	21.74
	10	53.33c	38.47	53.33c	56.52
	15	47.67d	45.00	32.00d	73.37
Nigella	5	45.00e	48.08	32.00d	73.37
	10	35.33g	59.24	21.33e	82.61
	15	25.67h	70.38	16.00e	86.96
Control		86.67a	00.00	122.66a	00.00
L.S.D 0,05		1.52		6.40	

Table (2): Effect of different concentrations of some plant oils on the growth and sporulation of *Fusarium oxysporum* f.sp. *lycopersici:*

Plant oil	Conc. (%)	Linear growth (mm)	Growth reduction (%)	No. of. spores/ml (x1000)	Sporulation reduction (%)
Clove	5	00.00k	100.00	00.00i	100.00
	10	00.00k	100.00	00.00i	100.00
	15	00.00k	100.00	00.00i	100.00
Garlic	5	58.67f	32.31	64.00c	45.45
	10	55.33g	36.16	48.00d	59.09
	15	49.00h	43.46	26.66g	77.27
Mint	5	14.33i	83.47	16.00h	86.36
	10	10.00j	88.46	8.00i	93.18
	15	00.00k	100.00	00.00i	100.00
Control (tween)		86.33a	00.39	114.66a	2.27
Control		86.67a	00.00	117.33a	0.00
L.S.D 0,05		00.10		6.56	

I-3- Effect of different *Trichoderma* spp. isolates on the growth of FOL:

Results given in Table (3) clear that all tested *Trichoderma* spp. isolates inhibited the linear growth of FOL, significantly. In this request, *T. harzianum* and *T. asperellum* showed the best action while *T. hamatum* and *T. koningii* gave the least efficiency. Inhibition zones recorded 24.67, 24.33 and 20.67 mm between FOL in side and *T. viride*, *T. koningii*, and *T. hamatum* respectively in the other side. However, *T. harzianum* and *T. asperellum* overgrew on (FOL) colony. Such results were also observed by (Akrami and Yousefi 2015; Lakshman Prasad *et al*., 2016; Andleeb Zehra *et al*., 2017and Mwangi *et al*., 2019).

II-Green house experiments:

II-1- Effect of some plant extracts on FOL spore population in the soil:

Results present in Table (4) indicate that the application of any tested plant extracts to the infested soil with FOL decreased the population of the pathogen's spore; significantly, in comparison with control. The best results were obtained when *Aloe vera* plant extract was applied followed by clove one. Increasing the concentration of the plant extract resulted more reduction of FOL spore population. These results are in harmony with those obtained by Taiga *et al*., 2008; Ali *et al*., 2013 and Yeole *et al*., 2016.

II-2- Effect of some plant extracts on wilt disease incidence:

Results shown in Table (5) indicate that application of the plant extracts significantly decreased both percentage and severity of tomato wilt disease incidence. *Aloe vera* and clove plant extracts gave the best results where at the highest concentrations (15%), tomato plants were completely free of infection. However, at the lowest concentration (5%) of either *Aloe vera* or clove, severity of infection was 7.41 and 11.11% respectively. the nontreated control plants (FOL only) resulted 92.6% infection severity. It was noticed that more spore population in the soil resulted more disease incidence and vice versa such results are in logic and were also noticed by Yeole *et al*., 2016.

Table (3): Effect of different *Trichoderma* spp. isolates on the growth and sporulation of *Fusarium oxysporum* f.sp*. lycopersici*:

Trichoderma sp.	Linear growth (mm)	Growth reduction (%)	Mode of action	
			O. G* (mm)	I. Z ** (mm)
T. asperellum	37.33d	56.93	+	–
T. hamatum	51.33b	40.78	–	20.67
T. harzianum	36.00d	58.46	+	–
T. koningii	45.33c	47.70	–	24.33
T. viride	42.67c	50.77	–	24.67
Control	86.67a	00.00	–	
L.S.D 0,05	4.02			

*** O.G: over growth (mm)**

**** I.Z: Inhibition zone (mm)**

Table (4): Effect of some plant extracts on spore population / l gm soil infested with FOL:

Plant extract	Conc. (%)	10*	R*%	20*	R*%	30*	R*%	40*	R*%	50*	R*%
Cactus	5	4.3hi	58.1	3.3f	71.5	3.0de	73.0	2.7 de	80.1	2.3 fg	84.1
	10	3.7ij	64.5	2.7fgh	77.1	2.3efg	81.1	2.0 efg	85.7	1.3 hi	90.1
	15	2.7k	74.2	2.0h	82.9	1.7g	86.5	1.3 g	90.5	1.0 i	93.2
Clove	5	6.0ef	41.9	5.3de	54.3	4.7c	62.1	4.0c	71.4	3.3de	77.3
	10	4.3hi	58.1	3.0fg	74.3	2.3efg	81.1	2.3def	83.3	1.7gh	88.6
	15	3.0jk	70.9	2.3gh	77.5	2.0fg	83.8	1.7fg	88.1	1.3hi	90.1
Garlic	5	8.7b	16.1	8.0b	31.5	6.7b	45.9	5.7b	59.5	4.7bc	68.2
	10	6.7de	35.4	6.0cd	48.6	4.7c	62.1	4.0c	71.4	3.0ef	74.6
	15	5.3fg	48.4	4.7e	60.0	3.7d	70.2	3.0d	78.6	2.3fg	84.1
Mint	5	9.0b	12.9	8.3b	28.6	7.0b	43.2	6.0b	57.1	5.0b	65.9
	10	7.7c	25.2	6.7c	42.9	5.0c	59.5	4.7c	66.7	4.0cd	72.7
	15	7.0cb	32.2	6.0cd	48.6	4.7c	62.1	4.0c	71.4	4.0cd	72.7
Nigella	5	6.7de	35.4	6.0cd	48.6	5.0c	59.5	4.3c	69.1	3.7de	74.9
	10	4.7gh	54.8	3.3f	71.5	2.7ef	78.3	2.3def	83.3	2.0gh	86.4
	15	3.3jk	67.8	2.3gh	77.5	2.0fg	83.8	1.7fg	88.1	1.3hi	90.1
Control		10.3a		11.7e		12.3a		14.0a		14.7a	
L.S.D 0,05		0.7		0.8		0.8		0.7		0.7	

days after soil infestation R% Reduction of spore population %

Table (5): Effect of some plant extracts on the percentage and severity of infection with FOL:

Plant extract	Conc. (%)	Percentage of infection (%)	Severity of infection (%)
Cactus	5	11.1fg	7.4ijk
	10	11.1fg	3.7jk
	15	00.0g	00.0k
Clove	5	22.2efg	11.1hij
	10	11.1fg	4.9ijk
	15	00.0g	00.0k
Garlic	5	55.6bcd	33.3de
	10	44.4cde	25.9ef
	15	33.3def	20.4fgh
Mint	5	77.8ab	55.5b
	10	66.7bc	44.4c
	15	55.7bcd	34.0cd
Nigella	5	44.4cde	22.2fg
	10	33.3def	18.5fgh
	15	22.2efg	14.2ghi
Control		100.0a	92.6a
L.S.D 0,05		25.9	9.5

II-3- Effect of some plant extracts on tomato growth parameters:

Results shown in Table (6) clear that vegetative growth of tomato plants was positively improved by the application of variable plant extracts. The best results were observed when *Aloe vera* and clove plant extracts were individually applied to the infested soil with FOL. As example; plant height was more than two folds of control plants when the extracts of either *Aloe vera* or clove plants were applied. These results are in harmony with those obtained by Pattnaik *et al*., 2012.

II-4- Effect of some plant oils on FOL spore population in the soil:

Results present in Table (7) indicate that all tested plant oils had significant effect in reducing the population of FOL spores in the artificially infested soil. Clove oil gave the best effects were noticed up to 55 days after soil infestation. Spore population in the soil was decreased in response to the oil application whereas it was increased by time in control treatment (FOL only). Such results are confirmed by Farrukh Aqil *et al*., 2001 who detected that the maximum antifungal activity due mainly to clove oil followed by mint oil.

II-5- Effect of some plant oils on wilt disease incidence:

Results shown in Table (8) clear that all tested oils at all used concentration decreased both percentage and severity of infection with FOL significantly compared to control (-) treatment. The best results were obtained when clove oil and /or mint oil were applied to the infested soil at 15% concentration. As example; severity of infection with FOL recorded 5.6 and 7.4 % when clove oil and mint oil were individually applied to the soil at the concentration of 15%; respectively. The severity of infection with wilt disease recorded 94.4 and 0% in control (-) and control (+) treatments; respectively. The antifungal activity of clove and mint oils against FOL was also reported by Abhishek Sharma *et al*., 2018.

Table (6): Effect of some plant extracts on tomato growth parameters with FOL:

Plant extract	Conc. (%)	Plant height / (cm)	No. of branches (per plant)	No. of leaves (per plant)
Cactus	5	36.4bc	6.0bcd	31.0d
	10	38.0b	6.7ab	37.3b
	15	40.6a	7.3a	43.0a
Clove	5	30.3e	5.7cd	28.3e
	10	32.2de	6.3bc	31.7d
	15	34.3cd	6.7ab	37.3d
Garlic	5	21.5i	4.7ef	23.7h
	10	26.2gh	5.3de	24.3gh
	15	29.8ef	5.7cd	28.7e
Mint	5	18.7J	4.0fg	21.7i
	10	21.0i	4.3f	23.0hi
	15	25.5h	4.7ef	25.7fg
Nigella	5	27.8fg	5.3de	26.7F
	10	31.0e	6.3bc	30.7d
	15	33.5d	6.3bc	35.7c
Control		15.7k	3.3g	13.3J
L.S.D 0,05		2.2	0.8	1.4

Table (7): Effect of some plant oils on spore population / l gm soil of FOL:

Plant oil	Conc. (%)	10*	R*%	20*	R*%	30*	R*%	40*	R*%	50*	R*%
Clove	5	14.3d	21.8	8.0f	57.9	6.3g	66.7	4.7f	77.4	4.3de	80.6
	10	12.3f	32.7	7.3fg	61.4	5.0h	73.7	4.0f	80.6	3.0f	86.6
	15	10.3h	43.6	6.7g	64.9	4.0i	78.9	2.7g	87.1	2.0g	91.0
Garlic	5	18.3a	00.0	14.3b	24.6	11.0b	42.1	9.3b	54.9	8.0b	64.2
	10	15.3c	16.4	12.0c	36.8	9.7c	49.1	7.7c	62.9	6.3c	71.7
	15	13.7e	25.4	9.3e	50.9	9.0d	52.6	7.0cd	66.1	6.0c	73.1
Mint	5	16.3b	10.9	10.3d	45.6	8.0e	57.9	6.0de	71.0	5.0d	77.6
	10	14.0de	23.6	8.0f	57.9	7.3f	61.4	5.0ef	75.8	4.0e	82.1
	15	11.3g	38.2	7.0g	63.2	3.0j	84.2	2.3g	88.7	1.7g	92.5
Control (+)		8.0i	56.4	3.7h	80.7	2.0k	89.5	1.0h	95.2	0.0h	100.0
Control (-)		18.3a		19.0a		19.0a		20.7a		22.3a	
L.S.D 0,05		0.6		0.7		0.6		1.1		0.8	

Table (8): Effect of some plant oils on the percentage and severity of infection with FOL:

Plant oil	Conc. (%)	Percentage of infection (%)	severity of infection (%)
Clove	5	33.3cde	16.7cde
	10	16.7de	9.3e
	15	16.7de	5.6e
Garlic	5	83.3ab	42.6b
	10	66.7abc	35.2bc
	15	50.0bcd	29.6bcd
Mint	5	50.0bcd	20.4cde
	10	33.3de	13.0de
	15	16.7de	7.4e
Control (+)		00.0e	00.0f
Control (-)		100.0a	94.4a
L.S.D 0,05		43.1	18.0

II-6- Effect of some plant oils on tomato growth parameters:

Results given in Table (9) indicate that the average Plant height, No. of branches and No. of leaves per plant were significantly increased in response to the application of different oils to the infested soil. The best results were obtained when clove oil was applied and this was followed by mint oil. Such results were recommended by the abovementioned authors.

II-7- Effect of different *Trichoderma* spp. isolates on wilt disease incidence:

Results present in Table (10) clear that all tested *Trichoderma* spp. tested isolates had significant effects in reducing both percentage and severity of infection with FOL when applied to the infested soil; in comparison with control (-) treatment. *Trichoderma harzianum* and *T. asperellum* were the best tested biocontrol agents in reducing the disease

incidence. On the other hand, *T. hamatum* was the least effective one in reducing wilt disease incidence. However, Mohd Rajik *et al.,* 2012 proved that *Trichoderma harzianum* and *T. viride* provided induced resistance in plant against *Fusarium oxysporum* f.sp. *lycopersici* resulting declined disease incidence from 100 to 7.69%. *Trichoderma harzianum* was observed to be good biocontrol agent against FOL by several authors (Akrami and Yousefi 2015; Lakshman Prasad *et al*., 2016; Andleeb Zehra *et al*., 2017 and Mwangi *et al*., 2019).

II-8- Effect of different *Trichoderma* spp. isolates on tomato growth parameters:

Results present in Table (11) clear that *T.harzianum* and *T.asperellum* were the best biocontrol agents which improved tomato plant height, the average number of branches and number of leaves per plant. In comparison with control; all five tested *Trichoderma* species improved tomato growth parameters; significantly. This couldbe due to the resistance induction by *Trichoderma* spp. as mentioned by Andleeb Zehra *et al*., 2017 and / or the antifungal activity of *Trichoderma* spp. isolates as reported by many authors; mentioned before.

Table (9): Effect of some plant oils on tomato growth parameters grown in infested soil with FOL:

Plant oil	Conc. (%)	Plant height / (cm)	No. of branches (per plant)	No. of leaves (per plant)
Clove	5 10 15	25.8d 28.2c 37.3b	5.0bcd 5.7bc 6.7ab	24.3de 32.0bc 33.3b
Garlic	5 10 15	17.7g 19.5fg 20.5f	4.0cd 4.3cd 4.7bcd	15.7f 19.7ef 21.7e
Mint	5 10 15	23e 27.2cd 35.6b	5.0bcd 5.3bc 6.0bc	23.0e 28.3cd 31.0bc
Control (+)		46.2a	8.0a	48.3a
Control (-)		12.2h	3.0d	9.3g
L.S.D 0,05		2.1	1.4	4.4

Table (10): Effect of different *Trichoderma* spp. isolates on the percentage and severity of infection with FOL:

Trichoderma sp.	Percentage of infection (%)	severity of infection (%)
T. asperellum	22.2d	6.2cd
T. hamatum	77.7ab	41.9b
T. harzianum	11.1d	1.0d
T. koningii	55.5bc	20.1c
T. viride	33.3cd	12.3cd
Control	100.0a	93.8a
LSD 0.05	29.3	17.2

Table (11): Effect of different *Trichoderma* spp. isolates on tomato growth parameters grown in artificially infested soil with FOL:

Trichoderma sp.	Plant height / (cm)	No. of branches (per plant)	No. of leaves (per plant)
T. asperellum	40.0b	7.0ab	41.3b
T. hamatum	29.3e	5.0c	25.7e
T. harzianum	43.0a	7.7a	46.0a
T. koningii	33.1d	6.0bc	30.0d
T. viride	35.3c	6.3b	36.7c
Control	13.2f	3.0d	12.0f
LSD 0.05	1.8	1.2	3.0

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تأثير بعض المستخلصات النباتية، الزيوت العطرية وأنواع التريكوديرما على مرض الذبول الفيوزارمى فى الطماطم

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الملخص العربى

يهدف هذا البحث إلى مكافحة مرض الذبول الفيوزارمى فى الطماطم بإستخدام مركبات صديقة للبيئة بديلة عن المبيدات الفطرية. وأظهرت النتائج أن المستخلصات المائية لنبات الصبار والقرنفل تؤدى إلى إختزال معنوى لنمو وتجرثم الفطر (FOL) *Fusarium oxysporum* f.sp. *lycopersici* وذلك سواء تحت ظروف المعمل أو الصوبة فى التربة المعداه صناعيا بالفطر. كما أدت المعاملة بالزيوت النباتية إلى إختزال نمو الفطر FOL وتجرثمه بصورة معنوية ، وسجلت أقل نسبة إصابة أو شدة إصابة عند إستخدام زيت القرنفل يليه زيت النعناع. وكان الفطرين *Trichoderma harzianum*، *T. asperellum* هما أفضل أنواع جنس *Trichoderma* الخمسة المختبرة فى إختزال معدل نمو الفطر FOL .وتحت ظروف الصوبة والعدوى الصناعية للتربة بالفطر الممرض أدت المعاملة بأى من المعاملات المذكورة سابقا إلى نقص معنوى فى حدوث مرض الذبول الفيوزارمى وتحسن ملحوظ فى مواصفات النمو لنباتات الطماطم.

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