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EFFICACY OF BOTANICAL EXTRACTS FOR CONTROLLING THE SOIL-BORNE FUNGI OF TOMATO

Atta-Alla, S. I.*, A. E. El-Korany*, M. M. Mahros, M. A. El-Sheikh *, and G. M. Abd El-Whab***.**

* Plant Path. Dept., Fac. Agric., Damanhour, Alex. Univ.
** Plant Path. Res. Inst., Agric. Res. Center, Giza.
*** Plant Path. Res. Inst., Agric. Res. Station, Etay El-Barood.

ABSTRACT

Twenty six plant essential oils and watery plant crude extracts of twenty four plants widely grown in Egypt were tested for their inhibition effect against the soil-borne fungi of tomato. The *Syzygium aromaticum*, *Eucalyptus globulus* and *Majorana hortensis* plant essential oils as well as the *Ocimum basilicum, Melia azedarach* and *Eucalyptus globulus* watery plant crude extracts were highly inhibitory (≥80%) for the *in vitro* linear growth and sporulation of the soil-borne fungi of tomato. The *Jasminum grandiflorum, Jasminum sambac* and *Citrus aurantium* plant essential oils while they exhibited high inhibition effect (*i.e.* 81.7%, 77% and 65.9% ,respectively) against linear growth, the *Jasminum grandiflorum* and *Citrus aurantium* plant essential oils had lower inhibition effect (≤ 44.7%) against sporulation. The *Jasminum sambac*, however, inhanced sporulation by 2%. On the contorary, the *Ocimum basilicum* and *Mentha viridis* plant essential oils as well as the *Portulaca oleracea, Bougainvillea spectabilis* and *Lupinus termis* plant crude extracts while they exhibited low potential to inhibit the linear growth (10% – 52%), they exhibited higher potential (55% – 69.1%) for sporulation inhibition. Rest of the tested plant essential oils, *i. e. Rosa gallica, Citrus lemon* and *Nigella sativa* plant essential oils as well as the plant crude extracts of *Chenopodium album, Amaranthus cruentus, Conyza aegyptiaca, Conyza dioscoroidis , Ammi*

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visnaga, Salix purpurea **and** ***Pelargonium graveolens*** **exhibited inhibition of ≤ 26.4% for linear growth and sporulation. The greenhouse experiment supported the *in vitro* results. The obtained effect, however, was much lower. Suppression mean on the tested tomato cvs. was 68.7% compared to 92.8% (combined data) for the *in vitro* inhibition mean of the linear growth and sporulation. The *Syzygium aromaticum* plant essential oil was the most effective (80.9%) for suppressing the soil-borne fungi in the greenhouse experiment. This was not significantly different from the Vitavax–Captan effect (81.9%). Meantime, use of the botanical extracts was reflected in an increase of 47% – 259% dry weight of the infected untreated plants.**

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill*)* is one of the most important solanaceous vegetable crops worldwide under both outdoor and indoor conditions. The cultivated area in the 2002 growing seasons in Egypt reached about 373643 feddans in the old and the newly reclaimed land where El-Behera is considered a major area (Anonymous, 2002). Unfortunately, tomato in such area is negatively affected with a variety of soil-borne fungi which affect growth, yield, and quality of tomato. Systemic chemical fungicides were successfully used for controlling the tomato soil-borne fungi (Malony, 1993). However for several environmental concerns, naturally occurring eco-friendly compounds having antifungal properties were proposed to replace the chemical fungicides (Ushiki *et al*., 1996; Prakash and Rao, 1997; Srivastava and Tal, 1997). Several plant extracted essential oils as well as watery plant crude extracts and their constituents have shown success in checking plant pathogenic soil-borne fungi worldwide (Paran *et al*., 1996; Kurucheve *et al*., 1997; Lee *et al*., 2001). Not much work was conducted for using such natural products for controlling the pathogenic soil-borne fungi of tomato in Egypt. The present study, therefore, was conducted to (i) identify soil-borne fungi affecting

tomato plants in El-Behera governorate, (ii) evaluate the threat posed by the soil-borne fungi to tomato cultivation in this area, and to (iii) evaluate the efficacy of twenty six essential oils and crude extracts of plants widely grown in Egypt for controlling the pathogenic soil-borne fungi of tomato in El-Behera governorate, Egypt.

MATERIALS AND METHODS

Isolation and identification of the soil-borne fungi of tomato.

Tomato samples showing root rot, damping off and wilt symptoms were collected from different localities (El-Bostan, Kom-Hamada and Etay El-Barood) in El-Behera governorate, during the 2000-2001 growing seasons. Samples were washed in tap water, cut into small pieces, dipped in 1% sodium hypochlorite for 2mins and rinsed in sterile distilled water. Then, samples were dried in sterilized filter paper and plated onto PDA. Plates were incubated at 25^{o}C in darkness for 3-5 days. Developed cultures were purified by the single spore isolation or the hyphal tip technique. Purified fungi were identified according to Booth (1977) and Barnett and Hunter (1987).

Pathogenicity tests.

Pathogenicity tests were conducted in 25-cm pots previously sterilized with 5% formalin for 15mins. and air dried for one week. Pots were filled with autoclaved soil mixture of 1:1 (v/v) clay and clean sand. Inocula of the recovered fungi were prepared on corn meal sand medium (Sneh *et al.*, 1991) under aseptie conditions and incubated at 25^{o}C for 2 weeks. Sterilized potted soil was inoculated with fungal inocula at a rate of 5% (w/w). The same amount of autoclaved corn meal sand medium was added to pots to serve as a control.

Seeds of two cultivars of tomato, Castle Rock and Super Strain B, which widely grown in Egypt, were obtained from the Seed Dept., Ministry of Agriculture, Egypt. Seeds were surface disinfested with 0.1% sodium hypochlorite for 2mins, rinsed in sterile distilled water and sown in nursery trays (20 seeds/tray). Four weeks later, the good-looking healthy seedlings were transferred to

the previously prepared 25-cm pots as 5 seedlings/pot, four replicate pots for each tested fungus. Pots were watered as needed and treated according to the normal agricultural practices. Reisolation was conducted to ensure the association of the tested fungi with the developed disease.

Laboratory experiment.

Leaves, stems, flowers, and seeds of twenty four higher plants widely grown in Egypt and recorded of having antifungal effect (Ushiki *et al.*, 1996; Kurucheve *et al.*, 1997; Lee *et al*., 2001) were collected. Scientific name, common name, the used part and nature of the extracted material tested are shown in Table (1).

Extraction: Plant essential oils tested were water distillated and extracted according to Shaban (1987), while the watery crude extracts were extracted and condensed according to Ezhalin *et al.* (1994). Extraction and condensation were conducted up to the described end point to have a 100% stock solution of the extracted plant essential oils and the plant crude extracts. Stock solutions were sterilized through G4 filter.

Table (1): Plants used for their antifungal activity in the present study of extracting essential oils and crude extracts.

Scientific name	Common name	Plant part	Extracted material
Amaranthus cruentus L.	Prince's feather	Leaves	C. extr.
Ammi visnaga L.	Tooth pick	Leaves	C. extr.
Bougainvillea spectabilis Willd.	Bougainvillea	Leaves	C. extr.
Casuarina equisetifolia Forst.	Beef – wood	Stems	C. extr.
Chenopodium album L.	Lambsquarters	Leaves	C. extr.
Citrus aurantium L.	Sour orange	Leaves	E. oil
Citrus lemon L.	Lemon	Leaves	E. oil
Conyza aegyptiaca Ait.	Fleabane	Leaves	C. extr.
Conyza dioscoroidis Desf.	Fleabane	Leaves	C. extr.
Eucalyptus globules Labill.	Blue gum tree	Leaves	E. oil & C. extr.
Jasminum sambac Soland.	Arabian jasmine	Flowers	E. oil
Jasminum grandiflorum L.	Jasmine	Flowers	E. oil
Lupinus termis Forsk.	Lupine	Seeds	C. extr.
Majorana hortensis L.	Margoram	Leaves	E. oil
Melia azedarach L.	Chinaberry	Leaves	C. extr.
Mentha virids L.	Mint	Leaves	E. oil

Continue Table (1): Plants used for their antifungal activity in the present study of extracting essential oils and crude extracts.

Scientific name	Common name	Plant part	Extracted material
Momordica fistulosa L.	Bergamot	Leaves	E. oil
Nigella sativa L.	Nigella	Seeds	E. oil
Ocimum basilicum L.	Basil	Leaves	E. oil & C. extr.
Pelargonium graveolens L.	Geranium	Leaves	C. extr.
Portulaca oleracea var. sativa DC.	Purslane	Leaves	C. extr.
Rosa gallica L.	Rose	Flowers	E. oil
Salix purpurea L.	Willow	Leaves	C. extr.
Syzygium aromaticum	Clove	Flowers	E. oil

C. extr. = Crude extract E. oil = Essential oil

Molten autoclaved PDA medium was prepared and amended with the tested (100%) stock solution of the plant essential oils and crude extracts as 1:100 (v/v) prior to pouring the plates. Then, plates were centric inoculated with 5-mm discs taken from the actively growing margin of 7-day-old cultures of the tested fungi, four replicate plates for each. Inoculated plates were incubated at 25^{o}C in darkness. Radial growth and sporulation were determined six days after inoculation according to Zamonelli *et al.* (1996) and Mandel and Baker (1991).

Greenhouse experiment.

Plant essential oils and crude extracts which *in vitro* exhibited high inhibition effect (≥85%) for growth and sporulation of the tomato soil-borne fungi were selected and tested under the greenhouse conditions.

Four-week-old tomato seedlings of the cvs. Castle Rock and Super Strain B were treated by dipping their roots in the tested watery distillated 100% stock solution of the plant essential oils and crude extracts, singly, for 5 mins, as well as the chemical fungicide Vitavax-Captan (Kafr El-Zayat Co.) solution (1g/L) for comparison. Control seedlings were dipped in sterile distilled water. Treated tomato seedlings were immediately sown in potted soil artificially infested with the tested tomato soil-borne fungi. Pots were prepared, infested, and treated as previously described under pathogenicity tests. Seedlings were further treated 15 and 30 days after

transplanting with the same botanical extracts (5 ml/seedling) as soil drench.

Disease assessment.

Severity of the tested tomato soil-borne fungi was assessed in termis of severity of the disease developed on the tested tomato cultivars. This was conducted 8 weeks after transplantation according to O' Sulivan and Kavanagh (1991).

Dry weight assessment.

This was conducted 8 weeks after transplantation. Tomato plants in the different treatments were gently removed from pots. Plants were washed in tap water, air dried, cut into pieces, and dried in a hot air oven at 60^{o}C for 5 days. Dry weight was immediately assessed as g/plant.

Statistical analysis.

Data were statistically analysed according to Gomez and Gomez (1984) using the American Costat" programme. Means comparison was conducted according to Walter and Duncan (1969) using the LSD test at the 5% level of probability.

RESULTS

Isolation and identification of the soil-borne fungi of tomato.

Several fungi were recovered from the collected diseased tomato samples (Table 2). *Fusarium* spp., *Rhizoctonia solani*, and *Sclerotium rolfsii* were prevalent over the collected samples and recovered in frequencies of 86.9%, 67.1% and 50.0%, respectively. *Pythium* sp. and *Alternaria* sp. were also recovered but at much lower frequencies of 17.1% and 15.7%, respectively (Table 2).

Table (2): Frequency of soil-borne fungi recovered from tomato samples showed damping off, root rot, and wilt symptoms and collected from different fields in El-Behera governorate, during the 2000-2001 growing seasons.

Fungi	Frequency (%)*
Rhizoctonia solani	67.1
Fusarium oxysporum f. sp. *lycopersici*	64.3
Fusarium solani	22.6
Sclerotium rolfsii	50.0
Pythium sp.	17.1
Alternaria sp.	15.7

* Number of isolates recovered from 100 tomato samples plated on PDA.

Pathogenicity tests.

R. solani, F. solani, F. oxysporum f. sp. lycopersici and *S. rolfsii* were highly pathogenic to the seedlings of the tested tomato cvs. Castle Rock and Super strain B and incited 82.2%-96.0% disease severity severity. *Pythium* sp. and *Alternaria* sp. however, incited a lower disease severity of 8.4%-20.2% on the tested tomato cultivars (Table 3).

Table (3): Severity of disease developed on tomato, cvs. Castle Rock and Super strain B, grown in soil artificially infested with the soil-borne fungi of tomato.

Fungi	% Disease severity	
	C. Rock	S. Strain B
Rhizoctonia solani	95.0 c	83.4 b
Fusarium oxysporum f. sp. *lycopersici*	96.0 b	85.0 b
Fusarium solani	86.7 c	82.2 b
Sclerotium rolfsii	95.2 a	94.2 a
Pythium sp.	20.2 d	16.6 c
Alternaria sp.	12.2 e	8.4 d
Control (non-infected)	8.7 f	6.6 d
Mean (infected)	67.5 A	61.6 B

Values within a column or a row followed by the same letter are not significantly different at p=0.05.

Laboratory experiment.

Means of linear growth, assessed as colony diameter, of the tested soil-borne fungi of tomato significantly decreased to 0.7 cm, 1.1 cm, 1.2 cm, and 1.7 cm with the use of plant essential oils of *Syzygium aromaticum, Majorana hortensis, Eucalyptus globulus,* and *Jasminum grandiflorum,* respectively (Table 4). This compared to 9.0 cm for the non-treated control which means over 80% inhibition effect for these plant essential oils. The *Jasminum sambac, Citrus aurantium,* and *Ocimum basilicum* plant essential oils exhibited a lower inhibition effect (< 80% - > 50%) as means of linear growth were 2.1 cm, 3.1 cm. and 4.3 cm, respectively. Rest of the tested plant essential oils exhibited inhibition effect less than 50% while the *Nigella sativa* plant essential oil did not exhibit a significant effect (Table 4).

Means of sporulation of the tested fusarial isolates significantly decreased to 71, 300, and 316 conidia/ml with the use of *Syzygium aromaticum, Eucalyptus globulus*, and *Majorana hortensis* plant essential oils, respectively. This compared to 4060/ml for the non-treated control which means over 90% inhibition effect for these essential oils (Table 4). On the contorary, the *Rosa gallica* plant essential oils enhanced mean of sporulation of the tested fusarial isolates to 4749/ml. The *Jasminum sambac* plant essential oil, however, while it suppressed *F. solani* sporulation to 4600/ml, it inhanced the *F. oxysporum* sporulation to 4612 ml compared to the control (Table 4).

Concerning the effect of plant crude extracts, data in Table (5) showed that means of linear growth (as colony diameter) of the tested soil-borne fungi of tomato significantly decreased to 0.7 cm, 0.8 cm, and 1.8 cm with the use of *Ocimum basilicum, Melia azedarach ,* and *Eucalyptus globulus* plant crude extracts, respectively. This compared to 9.0 cm for the non-treated control which means inhibition effect over 80% for these plant crude extracts. Means of linear growth with the use of *Chenopodium album, Portulaca oleracea , Lupinus termis,* and *Casuarina equisetifolia* plant crude extracts were 6.1 cm, 6.2 cm, 6.9 cm, and 7.5 cm which means inhibition of 32.6%, 30.9%, 23.7%, and 19.1%, respectively. Means of linear growth with the rest of tested plant

crude extracts were 8.1 cm or higher which means inhibition of ≤10% for these plant crude extracts (Table 5).

Sporulation of the tested fusarial isolates was also affected with the tested plant crude extracts (Table 5). The *Ocimum basilicum, Melia azedarach* , and *Eucalyptus globulus* crude extracts significantly suppressed means of fusarial sporulation to 88-745 conidia/ml. This compared to 4060/ml for the non-treated control which means inhibition of >80% for these plant crude extracts. This was followed by *Lupinus termis*, *Portulaca oleracea*, and *Bougainvillea spectabilis* plant crude extracts as mean fusarial sporulation decreased to 1283, 1767, 1827 conidia/ml, this means an inhibition of 69.1%, 56.5%, and 55.4%, respectively. Meanwhile, the *Chenopodium album* plant crude extracts decreased sporulation to 2471/ml, *i.e.* inhibition of 39.2%. Rest of the tested plant crude extracts exhibited inhibition effect of ≤18.6% as means of sporulation for the tested fusarial isolates were 3294/ml or more (Table 5).

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Table (4): The *in vitro* effect of plant essential oils on linear growth and sporulation of the tomato soil-borne fungi.

Plants of the extracted oil**	Linear growth (cm)						Sporulation (conidia/ml)			
	F. solani	F. oxysporum	*R. solani*	*S. rolfsii*	Mean	%Inh. mean*	*F. solani*	F. oxysporum	Mean	%Inh. mean*
Jasminum sambac	2.81	4.37	0.75	0.73	2.1 g	76.6 d	4600	3691	4145 b	-2.0 f
Jasminum grandiflorum	2.43	3.20	0.70	0.78	1.7 h	81.7 c	2750	1683	2216 e	44.7 c
Ocimum basilicum	4.95	4.80	3.45	4.12	4.3 e	52.2 f	2238	1116	1677 f	59.7 b
Rosa gallica	6.72	6.10	9.00	9.00	7.7 b	14.4 i	5283	4297	4790 a	-18.0 g
Citrus lemon	8.51	7.50	5.13	5.45	6.6 c	26.6 h	3950	2782	3366 c	17.1 e
Mentha viridis	5.47	5.15	4.80	5.21	5.1 d	43.3 g	2400	1244	1822 f	55.1 b
Syzygium aromaticum	0.72	0.75	0.70	0.73	0.7 j	92.2 a	66	76	71 g	98.2 a
Nigella sativa	9.00	8.80	9.00	9.00	8.9 a	1.1 j	4050	2648	3349 c	17.5 e
Citrus aurantium	3.19	3.10	3.05	3.02	3.1 f	65.5 e	3150	2438	2794 d	31.1 d
Eucalyptus globulus	1.43	1.85	0.70	0.79	1.2 i	86.6 b	250	350	300 g	92.6 a
Majorana hortensis	1.37	1.65	0.70	0.77	1.1 i	87.7 b	233	400	316 g	92.2 a
Momordica fistulosa	5.41	5.60	5.00	4.43	5.1 d	43.3 g	4566	3290	3928 b	3.2 f
Control	9.00	9.00	9.00	9.00	9.0 a	0.0 j	4883	3237	4060 b	0.0 f
LSD at 5%	0.16	0.24	0.09	0.04			111	216		

** Extracted oils (100% stock solution) were added to PDA as 1:100 (v:v).

* Percentage of inhibition compared to the control.

Data are average of four replicate PDA plates, six days after inoculation.

- = increase over control.

Means within a column followed by the same letter are not significantly different at 5% of probability.

Plants of the crude extracts**	Linear growth (cm)						Sporulation (conidia/ml)			
	F. solani	F. oxysporum	*R. solani*	*S. rolfsii*	Mean	%Inh. mean*	*F. solani*	F. oxysporum	Mean	%Inh. mean*
Ocimum basilicum	0.75	0.75	0.70	0.71	0.7 i	92.2 a	100	77	88 j	97.8 a
Chenopodium album	4.61	4.80	7.10	8.03	6.1 g	32.2 c	3166	1776	2471 f	39.1 e
Amaranthus cruentus	7.33	7.40	8.70	9.00	8.1 d	10.0 f	4500	2490	3495 d	13.9 g
Portulaca oleracea	5.07	4.80	7.50	7.51	6.2 g	31.1 c	2411	1123	1767 g	56.4 d
Conyza aegyptiaca	7.29	7.90	9.00	9.00	8.3 c	7.7 g	4550	2668	3609 c	11.1 h
Conyza disocoroidis	9.00	9.00	9.00	9.00	9.0 a	0.0 i	4550	2942	3746 b	7.7 i
Ammi visnaga	7.91	8.50	9.00	9.00	8.7 b	3.3 h	4583	2725	3654 bc	10.0 hi
Melia azedarach	0.74	0.85	0.70	0.79	0.8 i	91.1 a	83	93	88 j	97.8 a
Eucalyptus globulus	2.21	2.40	0.80	2.11	1.8 h	80.0 b	650	841	745 i	81.6 b
Casuarina equisetifolia	5.91	6.30	8.85	9.00	7.5 e	16.6 e	3883	2705	3294 e	18.8 f
Salix purpurea	6.53	7.50	9.00	9.00	8.1 d	10.0 f	4056	2720	3388 e	16.5 f
Boughainvilla spectabilis	6.67	7.80	9.00	9.00	8.1 d	10.0 f	2583	1071	1827 g	55.0 d
Pelargonium graveolens	9.00	9.00	9.00	9.00	9.0 a	0.0 i	4716	3260	3988 a	1.7 j
Lupinus termis	7.64	6.61	6.30	7.09	6.9 f	23.3 d	1950	616	1283 h	68.3 c
Control	9.00	9.00	9.00	9.00	9.0 a	0.0 i	4883	3237	4060 a	0.0 j
LSD at 5%	0.16	0.15	0.14	0.11			204.8	131		

Table (5): The *in vitro* effect of plant crude extracts on linear growth and sporulation of the tomato soil-borne fungi.

** Crude extracts (100% Stock solution) were added to PDA as 1:100 (v:v).

* Percentage of inhibition compared to the control. Data are average of four replicate PDA plates, six days after inoculation.

Means within a column followed by the same letter are not significantly different at 5% of probability.

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Greenhouse experiment.

Data in Table (6) showed that treatment of tomato seedlings cv. Castle Rock with the tested plant essential oils and crude extracts significantly decreased means of severity of the soil-borne fungi on tomato to 23.3%-39.6%. This compared to 91.1% for the untreated infected control. The lowest severity of 23.3%, which means 74.4% inhibition effect, was recorded for the treatment with the *Syzygium aromaticum* plant essential oil. The obtained effect, however, was still significantly lower than of the fungicide Vitavax-Captan where inhibition of 78.3 % was revealed.

A typical trend was detected on the cv. Super Strain B of tomato (Table 6). However, means of severity of the soil-borne fungi were lower and ranged between 17.1% and 37.4%. The highest suppression effect was obtained by the *Syzygium aromaticum* plant essential oil. It decreased disease severity of the tomato soil-borne fungi to 17.1%. This was not significantly different from the 16.2% of the fungicide Vitavax-Captan (Table 6).

Treatments of tomato with the tested plant essential oils and crude extracts significantly improved tomato growth in termis of mean dry weight per plant (Table 7). This was in a range of 2.78-5.44 g/plant for cv. Castle Rock compared to 1.72 g/plant for the untreated infected plants. The *Syzygium aromaticum* plant essential oil was of the highest effect as it improved mean of dry weight to 5.44 g/plant which means an increase of 216%. This was followed by the *Ocimum basilicum* plant crude extract and *Eucalyptus globulus* plant essential oil where dry weights were 4.89 g/plant and 4.62 g/plant, respectively. The three previous effects were not significantly different from the Vitavax-Captan effect where dry weight was 4.81 g/plant. The *Melia azedarach* plant essential oil and the *Majorana hortensis* plant crude extracts exhibited the lowest effect where dry weight was 2.95 g/plant and 2.78 g/plant, respectively. However, this was still significantly higher than dry weight of the untreated infected plants, *i.e.* 1.72 /plant (Table 7).

A similar trend was revealed on the cv. Super Strain B of tomato (Table 7). The obtained effect, however, of the *Syzygium aromaticum* essential oil was more pronounced and improved dry

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Table (6): Effect of treatments of tomato seedlings, cvs. Castle Rock and Super Strain B, with plant essential oils and plant crude extracts on severity of the soil-borne fungi of tomato, under greenhouse conditions.

Tomato cvs. / Fungi / Treatments**	Castle Rock						Super Strain B					
	F. solani	F. oxysp.	**R. solani**	*S. rolfsii*	Mean	%Inh. mean*	*F. solani*	F. oxysp.	*R. solani*	**S. rolfsii**	Mean	%Inh. mean*
Syzygium aromaticum*(EO)*	20.9	24.5	23.4	24.7	23.3 e	74.4	15.9	18.6	15.3	18.7	17.1 e	80.9
Eucalyptus globulus(EO)	24.5	27.3	28.1	25.7	26.4 d	71.0	19.7	23.3	28.6	21.4	23.2 d	74.1
Majorana hortensis*(EO)*	36.8	40.8	39.3	42.2	39.6 b	56.5	34.9	37.3	37.2	40.4	37.4 b	58.3
Ocimum basilicum(CE)	23.3	27.0	28.1	31.6	27.5 d	69.8	15.3	23.8	23.0	28.6	22.6 d	74.8
Melia azedarach (CE)	32.2	35.2	35.2	38.3	35.2 c	61.3	32.5	33.1	32.1	37.1	33.7 c	62.5
Vitavax-Captan	16.8	18.4	21.5	22.3	19.7 f	78.3	14.1	16.0	13.4	21.4	16.2 e	81.9
Untreated infected plants	86.7	93.0	90.0	95.0	91.1 a		82.2	89.5	87.8	94.2	89.9 a	
Untreated non - infected plants	5.7	3.9	8.0	5.3	5.7 g		3.3	5.0	4.5	5.8	4.6 f	

** Plant essential oils and plant crude extracts were used as 100% stock solution.

* Percentage of inhibition compared to untreated infected plants.

EO = plant essential oil, CE = plant crude extract

Data are average of four replicate pots, five seedlings in each.

Means within a column followed by the same letter are not significantly different at 0.05 level of probability.

	Cultivars	Fungi	Treatments	Interaction		
	C	F	T	C×F	C×T	F×T	C×F×T
LSD at 5%	1.52	1.89	2.15	2.27	2.63	2.83	4.00

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Table (7): Effect of treatments of tomato seedlings, cvs. Castle Rock and Super Strain B, with plant essential oils and plant crude extracts on dry weight (g/plant) of tomato sown in soil artificially infested with the tomato soil-borne fungi, under greenhouse conditions.

Tomato cvs. / Fungi Treatments**	Castle Rock						Super Strain B					
	F. solani	F. oxysp.	**R. solani**	*S. rolfsii*	Mean	%Inc. mean*	*F. solani*	F. oxysp.	*R. solani*	**S. rolfsii**	Mean	%Inc. mean*
Syzygium aromaticum*(EO)*	5.98	5.44	5.69	4.69	5.44 ab	216	8.72	7.70	6.95	5.50	7.12 a	259
Eucalyptus globulus(EO)	4.79	4.36	5.01	4.33	4.62 b	168	7.65	6.88	5.28	4.93	6.15 bc	210
Majorana hortensis*(EO)*	2.75	2.51	2.78	2.68	2.78 d	61	2.95	3.19	2.70	2.97	2.93 e	47.9
Ocimum basilicum(CE)	6.22	4.28	4.79	4.28	4.89 b	184	7.10	5.38	5.86	3.62	5.49 c	177
Melia azedarach (CE)	2.89	2.99	3.48	2.46	2.95 c	71.5	2.66	4.36	4.18	2.97	3.53 d	78
Vitavax-Captan	4.35	4.64	5.38	4.91	4.81 b	179	7.58	5.79	5.50	5.40	5.93 bc	199
Untreated infected plants	1.96	1.60	1.75	1.59	1.72 e		2.03	2.35	1.83	1.72	1.98 f	
Untreated non - infected plants	6.40	6.40	6.40	6.40	6.40 a		6.67	6.67	6.67	6.67	6.67 ab	

** Plant essential oils and plant crude extracts were used as 100% stock solution.
EO = plant essential oil, CE = plant crude extract

* Percentage of increase compared to the untreated infected plants. Data are average of four replicate pots, five seedlings in each.

Means within a column followed by the same letter are not significantly different at 0.05 level of probability.

	Cultivar	Fungi	Treatments	Interaction			
	C	F	T	C×F	C×T	F×T	C×F×T
LSD at 5%	0.43	0.67	0.89	1.19	1.37	1.45	1.91

weight of tomato to 7.12 g/plant. This was significantly higher than of the Vitavax-Captan *i.e*., 5.93 g/plant. It was, also, not significantly different from 6.67 g/plant of the healthy untreated control (Table 7).

DISCUSSION

Several fungi were found to be associated with tomato showing root rot, damping off, and wilt symptoms sampled from affected fields in the newly reclaimed land in El-Behera governorate. *Fusarium* spp., *Rhizoctonia solani*, *Sclerotium rolfsii* were prevalent over the collected samples and recovered in frequencies of 86.9% , 67.1% and 50.0% respectively. *Pythium* sp., and *Alternaria* sp. were also recovered but at much lower frequencies of 17.1% and 15.7% respectively. *R. solani. F. solani, F. oxysporum* f. sp. *lycopersici,* and *S. rolfsii* were highly pathogenic to the tested tomato cvs. Castle Rock and Super Strain B and incited 82.2% – 95.2% disease severity. *Pythium* sp., and *Alternaria* sp., however, incited a lower disease severity of 8.4% – 20.2%. These results are in agreement with reports from Egypt and other parts of the world (Khalifa, 1991; Parveen *et al.*, 1991; Ristiano *et al.*, 1991; Asaka and Shoda, 1996; Duffy and Defago, 1999; Ghonim, 1999; Manoranjitham *et al.*, 2000).

Twenty six plant essential oils and watery plant crude extracts of plants widely grown in Egypt were found to have different potentials to suppress the soil-borne fungi of tomato. The *Syzygium aromaticum, Eucalyptus globulus* and *Majorana hortensis* plant essential oils as well as the *Ocimum basilicum*, *Melia azedarach* and *Eucalyptus globulus* watery plant crude extracts exhibited high inhibition effect (≥80%) against the *in vitro* linear growth and sporulation of the soil-borne fungi of tomato. The *Jasminum grandiflorum*, *Jasminum sambac* and *Citrus aurantium* plant essential oils while they exhibited high inhibition effect (*i.e*. 81.7%, 77% and 65.9% ,respectively) against the linear growth, the *Jasminum grandiflorum*, and *Citrus aurantium* had lower inhibition effect (≤ 44.7%) aginst sporulation. The *Jasminum sambac* plant essential oil, however, inhanced sporulation by 2%. On the contorary, the *Ocimum basilicum* and *Mentha viridis* plant essential oils as well as the *Portulaca oleracea , Bougainvillea spectabilis* and

Lupinus termis plant crude extracts while they exhibited lower potential to inhibit linear growth (10% – 52%), they exhibited higher potential (55% – 69.1%) for sporulation inhibition. The *Rosa gallica, Citrus lemon* and *Nigella sativa* plant essential oils as well as the *Chenopodium album, Amaranthus cruentus, Conyza aegyptiaca, Conyza dioscoroidis , Ammi visnaga, Salix purpurea* and *Pelargonium graveolens* plant crude extracts exhibited inhibition effect against linear growth and sporulation of ≤ 26.4%. These results are in agreement with Thakur *et al.* (1989); Pattnail *et al.* (1996); Zamonelli *et al.* (1996); Kurucheve *et al.*(1997); Wilson *et al.* (1997); Pinto *et al.* (1998); Abd El-Rasool (2002).

The greenhouse experiment supported the *in vitro* results. The obtained effect, however, was much lower. Suppression mean of the soil-borne fungi on the tested tomato cvs. Castle Rock and Super Strain B was 68.7% (combined data) compared to 92.8% (combined data) for the *in vitro* inhibition mean of the linear growth and sporulation. The *Syzygium aromaticum* plant essential oil was the most effective. Its effect on cv. Super Strain B (80.9%) was not significantly different from that of the Vitavax – Captan (81.9%). The differences observed between the high inhibitory effect (92.8%) revealed *in vitro* and suppression effect obtained in the pots assay (68.7%) might be explained by the fact that many factors are involved that could affect and modify the *in vitro* results when applied in field and greenhouse. These factors are such pH, temperature, moisture, soil type and nutrients availability. These factors should be always considered. These findings are in harmony with results of sveral investigators (Ezhalin *et al.*, 1994; Dean *et al.*, 1995; Penzes, 1995; Paran *et al.*, 1996; Prakash and Rao, 1997; Lee *et. al*, 2001; Abd El–Rasool, 2002).

Disease suppression obtained by the tested plant essential oils and plant crude extracts was reflected in a better plant vigour in termis of dry weight of tomato plants. An increase of 47.9% – 259% dry weight of the untreated infected control plants was revealed. This compared to 189% for the fungicide Vitavax-Captan. The highest effect on both cvs of tomato was linked to the *Syzygium aromaticum* plant essential oil. The obtained results are in agreement with Ziedan (1993), Rahhal (1997), and Srivastava and Tal (1997).

Consequently, such natural products, non-fungicidal, eco-friendly treatments should be considered for a safer control against the soil-borne fungi affecting tomato in El-Behera governorate, Egypt.

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الملخص العربي

فاعلية المستخلصات النباتية فى مقاومة فطريات الطماطم المحمولة بالتربة

سعيد إبراهيم عطاالله* ، أحمد السيد الكورانى* ، محمد محمد محروس،**
محمد أحمد الشيخ * ، جهاد محمد عبد الوهاب***

* قسم أمراض النبات، كلية الزراعة بدمنهور ، جامعة الإسكندرية.
** معهد بحوث أمراض النبات، مركز البحوث الزراعية، الجيزة.
*** معهد بحوث أمراض النبات، محطة البحوث الزراعية، إيتاي البارود.

فى دراسة لسته وعشرين من الزيوت الطبيعية والمستخلصات النباتية المائية لأربعة وعشرين من النباتات التي تنمو فى البيئة المصرية، أظهرت الزيوت الطبيعية للنباتات *Syzygium aromaticum* و *Eucalyptus globulus* و *Majorana hortensis* والمستخلصات النباتية للنباتات *Ocimum basilicum* و *Melia azedarach* و *Eucalyptus globulus* قدرة عالية (≤ 80%) لتثبيط النمو الطولى والتجرثم، معمليا، لفطريات الطماطم المحموله بالتربة هذا وبينما أظهرت الزيوت الطبيعية *Jasminum grandiflorum* و *Jasminum sambac* و *Citrus aurantium* كفاءة عالية لتثبيط النمو الطولى معملياً (81.7% - 77% - 65.9%، على التوالى) فقد أظهرت كفاءة أقل لتثبيط التجرثم (≤ 44.7%) بل أن *Jasminum sambac* أدى إلى تنشيط التجرثم بنسبة 2%. وعلى العكس من ذلك فإن الزيوت الطبيعية لـ *Ocimum basilicum* و *Mentha viridis* وكذا المستخلصات *Portulaca oleracea* و *Bougainvillea spectabilis* و *Lupinus termis* ثبطت التجرثم بنسبة (10–52%) بينما ثبطت النمو الطولى بنسبة أعلى (55 – 69.1%) وقد أظهرت الزيوت الطبيعية للنباتات *Rosa gallica* و *Citrus lemon* و *Nigella sativa* وكذا المستخلصات *Chenopodium album* و *Amaranthus cruentus* و *Conyza aegyptiaca* و *Conyza dioscoroidis* و *Ammi visnaga* و *Salix purpurea* و *Pelargonium graveolens* قدرة منخفضة على تثبيط النمو الطولى والتجرثم لم تتعدى 26.4%. وقد تأكدت هذه النتائج تحت ظروف الصوبة الزراعية إلا أن التثبيط الناتج لفطريات الطماطم المحمولة بالتربة على نباتات الطماطم كان أقل إذ لم يتعدى 68.7% فى المتوسط وذلك بالمقارنة بـ 92.8% لهذه المستخلصات المختبرة معملياً. وقد كانت الزيوت الطبيعية للنبات *Syzygium aromaticum* هى الأكثر كفاءة وقد كان تأثيره (80.9%) لا يختلف معنوياً عن المعاملة بالمبيد الفطرى فيتافاكس – كابتان (81.9%) على صنف الطماطم Super Strain B. هذا وقد كان التثبيط لشدة المرض على نباتات الطماطم مصحوباً بزيادة فى نمو النباتات المصابة فقد أدت المعاملة بالزيوت الطبيعية والمستخلصات النباتية المختبرة فى الصوبة الزراعية إلى زيادة المادة الجافة (47% - 259%) مما يشجع الإتجاه إلى أستخدام هذه البدائل الطبيعية لمقاومة الفطريات المحمولة بالتربة التى تصيب نباتات الطماطم فى مصر.