

Fungitoxic Properties of Some Plant Extracts Against Tomato Phytopathogenic Fungi

Ashraf A. Mostafa¹, A.N. Al-Rahmah¹, Ahmed Abdel-Megeed^{1,2},
Essam Nageh Sholkamy¹, Abdullah A. Al-Arfaj¹ and Mohamed S. El-shikh¹

¹Botany and Microbiology Dept. Collage of Science, King Saud University,
P.O. 2455, Riyadh, 1145, Kingdom of Saudi Arabia.

²Faculty of Agriculture (Saba Basha), Alexandria University, Egypt.

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Activity of five methanolic plant extracts obtained from *Lantana camara*, *Salvadora persica*, *Thymus vulgaris*, *Zingiber officinale* and *Ziziphus spina-christi* were investigated for their antifungal effect on tomato phytopathogenic fungi (*Fusarium oxysporum*, *Pythium aphanidermatum* and *Rhizoctonia solani*) the causative agents of tomato damping-off diseases. Three of five plant extracts were effective against tomato phytopathogenic fungi. *T. vulgaris* and *Z. officinale* extracts were strongly active and showed fungistatic and fungicidal activities against the phytopathogenic fungi with MIC of 4 mg/ml and MFC of 8 mg/ml except *F. oxysporum* which was less sensitive and its MFC reached to 16 mg/ml of *Z. officinale* extract. On the other hand, *S. persica* extract showed a moderate antifungal activity while *L. camara* and *Z. spina-christi* were not effective against tomato phytopathogenic fungi except *P. aphanidermatum* which was completely inhibited at 10 mg/ml of *L. camara* extract. Carbendazim fungicide was more effective than all methanolic plant extracts inhibiting mycelial growth of all phytopathogenic fungi at 8 ppm and a huge concentration reached to 8 mg/ml of the effective plant extract was required to attain the same effect. Analysis of the effective plant extracts by GC/MS revealed that *T. vulgaris* extract was mainly composed by thymol (38.73%), carvacrol (19.31%), α -cimene (10.13%) and α -terpinolene (5.94%) while *Z. officinale* was mainly composed by Gingerol (46.85%), cedrene (8.39%), zingiberene (7.41%) and α -curcumene (7.32%) respectively. These effective plant extracts may contribute to development of potentially effective and environmentally safer alternative fungicide to control tomato damping-off phytopathogenic fungi.

Key words: Fungicides, Plant extracts, Fungitoxic properties.

Seedlings damping-off caused by *Pythium aphanidermatum* and *Rhizoctonia solani* and Fusarium wilt caused by *Fusarium oxysporum* *F. sp Lycopersici* are regarded as the most important diseases that affect the tomato crop causing serious economic losses to the producers (Schwarz & Grosch, 2003 and Song *et al.*, 2004). The chemical control of these pathogens is responsible for the increase in the productivity

and quality of the crop but its inappropriate and nondiscriminatory use has put human and animal health at risk, as well as contaminating the environment (Pandy, 2003 and Kumar *et al.*, 2007). In an attempt to modify this condition, some alternative methods of control have been adopted. Within this context is the utilization of plant extracts which are natural sources of antimicrobial substances, regarded as safe and degraded by natural soil microbes, they don't pose any health residual or environmental problems at any concentration which they are used (Kim *et al.*, 2004 and Yang *et al.*, 2010).

* To whom all correspondence should be addressed.
Tel.: +966-562061061;
E-mail: Ashraf812@yahoo.com

The biological inhibitions of different natural substances, such as plant extracts have been investigated on fungal activity. For example, there are studies evaluating the inhibitory activity of plant extract on fungi; Ushiki *et al.*, (1996) tested suppression of soil borne plant diseases by medicinal plant extracts; Ejechi *et al.*, (1999) studied pepper extract against tomato rot fungi; Jasso de Rodriguez *et al.*, (2005) evaluated fungal activity of Aloe vera pulp on mycelial growth of *Rhizoctonia solani* and *Fusarium oxysporum*. They reported that this extract reduced colony growth rate of *R. solani* and *F. oxysporum* at concentration 105 µl/l. Curir *et al.*, (2005) determined phytoalexin inhibitory effect involved in carnation against *F. oxysporum* *F. sp* causative agent of Fusarium wilt.

Eucalyptus leaf extracts were found to be effective against most Gram +ve bacteria and can inhibit mycelial growth of *Rhizoctonia solani*, *Phytophthora*, *F. oxysporum* and many other fungi in concentrations above 20% (Ceron *et al.*, 1999, Arora and Kaushik, 2003, and Gupta and Bansal, 2003).

The extracts of *Thymus vulgaris* leaves in concentrations 400 and 800 ppm can inhibit mycelial growth and cause degeneration of hyphae of *Pythium ultimum* and *Colletotrichum lindemuthianum* (Zambonelli *et al.*, 1996 and Ramanathan *et al.*, 2004) while *Thymus vulgaris* essential oil exhibit broad fungitoxic spectrum against eight fungal strains including *F. oxysporum* with concentration 0.7 µl/ml (Kumar *et al.*, 2008). The cedar leaf extract of concentrations ranged from 2.5% to 5% v/v can inhibit growth of *Ophtostoma piceae*, *Avreobasium piceae*, *Alternaria alternate* and *Gliocladium viride* (Dawson-Andoh *et al.*, 2000). In case of ginger (*Zingiber officinale*), Arora and Kaushik (2003) screened ginger with forty different plant extracts for their activity against soybean fungal pathogens as *F. oxysporum* and they reported that ginger inhibit mycelial growth of *F. oxysporum*. However Singh *et al.*, (1998) and Dubey *et al.*, (2000) recorded fungitoxicity of ginger extract against a range of fungi among which *Rhizoctonia solani* was present. Also, composts has been used to control seedling damping-off caused by *R. solani* (Termorshuizen *et al.*, 2007), *Pythium* (Scheuerell *et al.*, 2005) and several species of *Fusarium* (Borrero *et al.*, 2004).

Arak (*Salvadora persica*) has traditionally used as tooth brushes in Arabian area as it exhibit antimicrobial effect against aerobic and anaerobic bacteria recovered from teeth with necrotic pulps (Ahmed *et al.*, 2008). Presently, the control of seedlings damping-off diseases is mainly based on the application of fungicides and the adverse effects of these fungicides on environment and human health have focused the efforts on developing environmentally safe, long lasting and effective biocontrol agents. So the objective of this work was to evaluate the fungitoxic effect of some plant extracts as *Lantana camara*, *Salvadora persica*, *Thymus vulgaris*, *Zingiber officinale* and *Ziziphus spina-christi* against seedlings damping-off diseases of tomato caused by *Pythium aphanidermatum* and *Rhizoctonia solani* and *Fusarium* wilt caused by *Fusarium oxysporum* *in vitro*.

MATERIALS AND METHODS

Plant materials

Plant materials (leaves, rhizomes or bark) of five plant species belonging to (5) botanical families included in this study (Table, 1) were collected from Riyadh region of Saudi Arabia. The collected plant was carried in polyethylene bags to the laboratory, washed with tap water, disinfected by immersion in 2% sodium hypochlorite solution for 30 minutes, rinsed with sterile distilled water to eliminate residual hypochlorite and dried in shade for 23 days. The shade-dried material of each plant species was grounded into a powdered material using a blender to pass 100 mm sieve and the mince was sealed in polyethylene bags until extraction.

Preparation of plant extracts

For investigations, methanolic plant extracts were prepared by soaking 50 gm of dry powder plant material from each plant species in methanol (10 ml of methanol /gm of plant material) with stirring for 48 hrs then filtered through double layers of muslin, centrifuged at 9000 rpm/min for 10 minutes and finally filtered again through Whatman filter paper No. (41) to remove leaf debris and obtain a clear filtrate. The filtrates were evaporated and dried under reduced pressure and temperature below 40 °C. The yield of the dry residues in relation to the starting plant material was calculated.

Fungal cultures

Fungal cultures of *Pythium aphanidermatum*, *Fusarium oxysporum* and *Rhizoctonia solani* were isolated from tomato crop by hyphae point and monsporic technique (Anguiz, 1989) and preserved in slants containing potato dextrose agar (PDA) till used. The tomato phytopathogenic fungi were provided from the culture collection of Botany and Microbiology Department, King Saudi University, Riyadh, K.S.A

Antifungal activity of plant extracts

Antifungal activity was evaluated on tomato phytopathogenic fungi using the food poisoning technique (Kumar *et al.*, 2008). The plant extract residues were re-dissolved in (5ml) of methanol, sterilized in disposable Millipore filter (0.22 µm pores) and mixed with sterile potato dextrose agar medium (P.D.A) to obtain the final concentration of 10 mg ml⁻¹ of each plant extract then poured in sterile Petri dishes (90 mm diameter)

For control, five ml of Millipore-sterilized methanol was added to (P.D.A) medium and discs of 7 mm diameter of phytopathogenic fungi were cut from the periphery of 6 days old cultures and inoculated aseptically to the center of poured Petri dishes of treatment and control sets and incubated at 25 °C ± 2 °C for 7 days. Fungal colony diameter of treatments and control sets were measured and percentage of mycelial inhibition was calculated using the following formula.

Percentage of mycelial inhibition = $[C - T / C] \times 100$ (Where, C and T are the growth diameter (mm) in control and treatment respectively)

Fungicidal analysis of the effective plant extracts compared with reference fungicide (Carbendazim)

The effective plant extracts including *Thymus vulgaris* and *Zingiber officinale* were used to determine minimal inhibitory concentration (MIC) and minimal fungicidal concentrations (MFC) of these effective plant extracts. Different concentrations of each plant extracts (0.0, 2.0, 4.0, 8.0 and 16.0 mg/ml) were prepared separately by dissolving their requisite amount in 5 ml of methanol, sterilized through Millipore filter and mixed with (PDA) medium to obtain the final concentrations. To compare efficacy of plant extracts with that of fungicide (Carbendazim) in controlling the tomato phytopathogenic fungi,

different concentrations (0.0, 2.0, 4.0, 8.0 and 16.0 ppm) of Carbendazim of 98% active ingredients were prepared by mixing weighted powder of fungicide with a known volume of sterile (PDA). Fungal plugs (0.7 mm in diameter) were obtained and placed at the center of Petri dish in potato dextrose agar medium (PDA) with plant extracts of various concentrations and fungicide. The cultures were incubated at 25 ± 2 °C and radial growth of mycelia was measured after 6 days. Fungicidal effect of the plant extracts was measured and MIC and MFC were determined then compared with fungicidal effect of the reference fungicide under a totally random design with four replications.

GC/GC-MS analysis of the effective plant extracts

The effective plant extracts of *T. vulgaris* and *Zingiber officinale* were analyzed through Gas Chromatography and Mass Spectroscopy (GC-MS) Varian model, 450 equipped with a flame ionization detector and quantization was carried out by the area normalization method neglecting response factors. The analysis was carried out using a VF-5MS capillary column (30 m x 0.25 mm; 0.25 µm film thickness). The operating conditions were as follow: injection and detector temperature, 250 and 300 °C respectively; split ratio, 1 : 50; carrier gas, Helium with flow rate (1.0 ml/min). Oven temperature program was 50 – 300 °C at the rate of 7 °C/min. Mass spectrometer conditions were: ionization potential, 70 eV; mass range from m/z, 40 – 400 amu; electron multiplier energy, 2000 V. The components of plant extracts were identified by comparison of their relative retention times and the mass spectra with those authentic reference compound shown in the literature (Adams, 2007) and by computer matching of their MS spectra with Wiley and Nist 8 mass spectral library.

Statistical analysis

All experiments were conducted in four replicates for each treatment and the data were reported as mean ± SE (standard error). The data were also analyzed statistically using One-way analysis of variance (ANOVA) and differences among the means were determined for significance at P ≤ 0.05 (by SPSS, 16.1 Chicago, USA).

RESULTS

Botanical and common name of the plants used and the extract percentage yield of the selected

plant species are illustrated in Table 1. Five plants belonging to five different families were studied to evaluate their antifungal activities against tomato phytopathogenic fungi. Methanolic extracts of five plant species were studied and evaluated for their antifungal activities against tomato phytopathogenic fungi (*F. oxysporum*, *P.*

aphanideratum and *R. solani*). Of these, 3 plant extracts at 10 mg/ml were effective in suppressing the mycelial growth of tomato phytopathogenic fungi compared to non-treated control. *T. vulgaris* extract was the most effective in suppressing the mycelial growth of phytopathogenic fungi followed by *Z. officinale* and *S. persica* (Table 1, 2). The

Table 1. The ethnobotanical data of the plant parts employed and extract percentage yield.

Plant species	Family	Common name	Plant part used [@]	Extract yield (%)
<i>Lantanta camara</i>	Verbenaceae	Lantanas	L	7.68
<i>Salvadora persica</i>	Salvadoraceae	Arak	B	10.72
<i>Thymus vulgaris</i>	Lamiaceae	Thyme	L	11.05
<i>Zingiber officinale</i>	Zingiberaceae	Ginger	R	4.20
<i>Ziziphus spina-christi</i>	Rhamnaceae	Seder	L	9.43

[@]Plant parts used: L, leaves; B, bark; R, rhizome

Table 2. Antifungal screening test of some methanolic plant extracts (10mg/ml) against tomato phytopathogenic fungi

Plant species	Mean diameter of mycelial growth (mm)			Percentage of mycelial growth inhibition		
	<i>F. o</i>	<i>P. a</i>	<i>R. s</i>	<i>F. o</i>	<i>Pa</i>	<i>R. s</i>
<i>Lantanta camara</i>	47.8* ± 0.085	0.00 ± 0.00	69.5* ± 0.065	28.12	100.0	16.56
<i>Salvadora persica</i>	56.8* ± 0.085	18.8* ± 0.085	36.3* ± 0.085	14.69	77.83	56.43
<i>Thymus vulgaris</i>	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	100.0	100.0	100.0
<i>Zingiber officinale</i>	18.5* ± 0.029	0.00 ± 0.00	0.00 ± 0.00	72.18	100.0	100.01
<i>Ziziphus spina-christi</i>	69.3* ± 0.063	85.8* ± 0.048	82.3* ± 0.063	0.00	0.00	0.00
Control	66.5* ± 0.065	84.8* ± 0.063	82.0* ± 0.041	0.00	0.00	0.00

F. o: *Fusarium oxysporum*; *P. a*: *Pythium aphanidermatum*; *R. s*: *Rhizoctonia solani*

Values in the same column followed by asterisk (*) are significantly different at (P=0.05)

Data are means (n=4) ± standard error of four replicates

Table 3. Effect of different concentrations of reference fungicide (Carbendazim) on mycelial growth of tomato phytopathogenic fungi

Carbendazim Conc. (ppm)	Mean diameter of mycelial growth (mm)			Percentage of mycelial growth inhibition		
	<i>F. o</i>	<i>P. a</i>	<i>R. s</i>	<i>F. o</i>	<i>Pa</i>	<i>R. s</i>
0.00	86.8* ± 0.075	89.5* ± 0.05	84.8* ± 0.085	0.00	0.00	0.00
2.00	68.5* ± 0.132	52.8* ± 0.165	63.3* ± 0.103	21.08	41.01	25.35
4.00	37.3* ± 0.125	0.00 ± 0.00	28.5* ± 0.132	57.03	100.0	66.39
8.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	100.0	100.0	100.0
16.0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	100.0	100.0	100.0

F. o: *Fusarium oxysporum*; *P. a*: *Pythium aphanidermatum*; *R. s*: *Rhizoctonia solani*

Values in the same column followed by asterisk (*) are significantly different at (P=0.05)

Data are means (n=4) ± standard error of four replicates

Table 4. Effect of different concentrations of the effective plant extracts on mycelial growth of tomato phytopathogenic fungi

Plant extracts	Conc. mg/ml	Mean diameter of mycelial growth (mm)			Percentage of mycelial growth inhibition		
		<i>F. o</i>	<i>P. a</i>	<i>R. s</i>	<i>F. o</i>	<i>P.a</i>	<i>R. s</i>
<i>Thymus vulgaris</i>	0.00	69.3* ± 0.125	83.8* ± 0.111	76.8* ± 0.165	0.00	0.00	0.00
	2.00	48.3* ± 0.189	39.3* ± 0.149	44.3* ± 0.111	30.30	53.1	42.32
	4.00	21.5* ± 0.119	11.8* ± 0.103	15.3* ± 0.075	68.98	85.92	80.10
	8.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	100.0	100.0	100.0
	16.0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	100.0	100.0	100.0
<i>Zingiber officinale</i>	0.00	76.5* ± 0.156	87.5* ± 0.126	81.5* ± 0.266	0.00	0.00	0.00
	2.00	65.3* ± 0.180	53.5* ± 0.065	46.5* ± 0.096	14.64	38.86	42.95
	4.00	41.3* ± 0.103	32.3* ± 0.125	21.8* ± 0.138	46.01	63.09	73.25
	8.00	25.6* ± 0.103	0.00 ± 0.00	0.00 ± 0.00	66.53	100.0	100.0
	16.0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	100.0	100.0	100.0

F. o: *Fusarium oxysporum*; *P. a*: *Pythium aphanidermatum*; *R. s*: *Rhizoctonia solani*
 Values in the same column followed by asterisk (*) are significantly different at (P = 0.05)
 Data are means (n= 4) ± standard error of four replicates

Table 5. Phytochemical composition of the most effective plant extracts and their relative contents (%)

Compound	Plant extracts			
	<i>Thymus vulgaris</i>		<i>Zingiber officinale</i>	
	RI	%	RI	%
α-Thujane	8.135	2.31	-	-
α-Terpinolene	8.631	5.94	-	-
β-Olimene	9.742	4.73	-	-
Bornyl acetate	11.020	6.12	-	-
Piperitine oxide	11.631	2.13	-	-
α-Gurjunene	12.473	1.72	-	-
ρ-Cimene	13.027	10.13	-	-
Borneol	15.321	3.27	-	-
Carvacol	21.173	0.90	-	-
Thymol	22.430	38.73	-	-
Carvacrol	23.251	19.31	-	-
Bisabolene	26.651	3.71	-	-
α-Curcumene	-	-	21.230	7.32
Zingiberene	-	-	21.475	7.41
α-Farnesene	-	-	21.587	1.07
Cedrene	-	-	22.004	8.39
±Nerolidol	-	-	22.580	2.71
β-Guaiene	-	-	23.943	1.86
β-Eudesmol	-	-	24.341	4.37
β-Cedren-9-α-ol	-	-	24.888	6.71
α-Bisabolene epoxide	-	-	26.626	7.64
Longipinocarvol	-	-	27.454	5.34
Gingerol	-	-	33.250	46.85

RI: Retention time

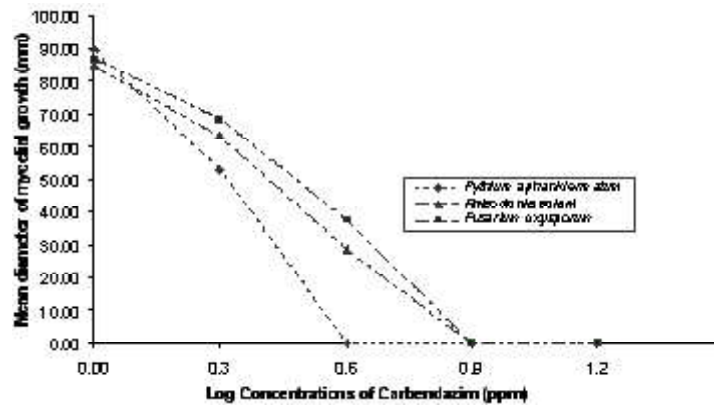


Fig. 1. Effect of different concentrations of Carbendazim on colony radial growth of the tomato phytopathogenic fungi

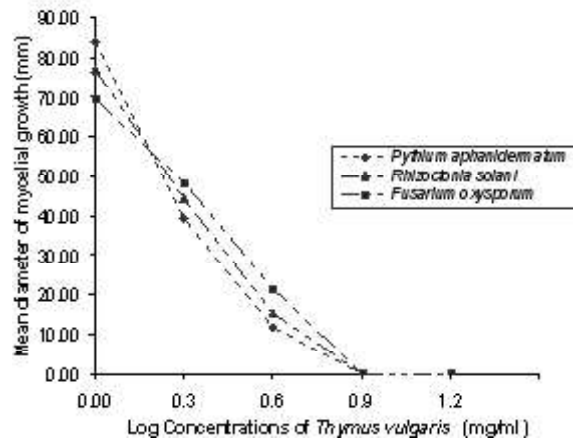


Fig. 2(a). Effect of different concentrations of *Thymus vulgaris* on colony radial growth of the tomato phytopathogenic fungi

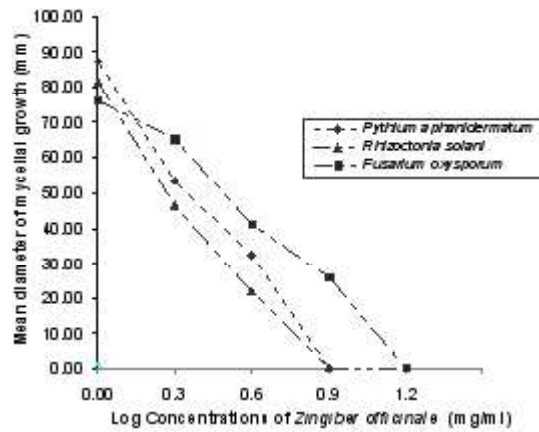


Fig. 2(b). Effect of different concentrations of *Zingiber officinale* on colony radial growth of the tomato phytopathogenic fungi

methanolic extract of *T. vulgaris* showed complete suppression on mycelial growth of the three phytopathogenic fungi at (10 mg/ml) followed by *Z. officinale* which appear to be effective against *P. aphanidermatum* and *R. solani* suppressing completely their mycelial growth whereas *F. oxysporum* was less sensitive as its mycelial growth was inhibited to 72.18% at the same concentration.

Although, *S. persica* extract was found to be slightly effective against *F. oxysporum* inhibiting its mycelial growth to 14.69%, it was strongly effective against *P. aphanidermatum* and *R. solani* suppressing their mycelial growth with 77.83 and 56.43% respectively. In contrast, *L. camara* and *Z. spina-christi* extracts were not effective against tomato phytopathogenic fungi except mycelial growth of *P. aphanidermatum* which was completely inhibited at 10 mg/ml of *L. camara* extract.

The MIC and MFC of the most effective plant extracts (*T. vulgaris* and *Z. officinale*) in comparison with carbendazim as a reference fungicide were employed by poisoned food technique to assess their fungicidal and fungistatic properties. As illustrated in Table, 3 Carbendazim shows a various capabilities to suppress tomato phytopathogenic fungi on solid medium. *P. aphanidermatum* was more sensitive to carbendazim and its mycelial growth was completely inhibited at 4 ppm while *F. oxysporum* and *R. solani* were less sensitive and their mycelial growth were inhibited to 57.03 and 66.39% respectively at the same concentration.

The concentration effect of carbendazim is presented in Fig. 1 where the inhibitory effect started at 2 ppm and increased in proportion to carbendazim concentration reached to maximum in final concentration of 8 ppm. Carbendazim was strongly effective against *P. aphanidermatum* with MIC of 2 ppm and MFC of 4 ppm while it showed fungistatic activity against *F. oxysporum* and *R. solani* with MIC 4 ppm and MFC of 8 ppm. On the other hand, *T. vulgaris* and *Z. officinale* extracts showed antifungal activities against the tomato phytopathogenic fungi and their inhibitory effect was increased in proportion to their concentrations and reached to maximum at 8 mg/ml except *F. oxysporum* which was inhibited to 66.53% with *Z. officinale* extract at the same concentration and

completely inhibited at 16 mg/ml. These inhibitions were reported to be significant for the most effective plant extracts (*T. vulgaris* and *Z. officinale*) at the level of 0.05 (ANOVA)

T. vulgaris and *Z. officinale* extracts were strongly active and showed fungicidal and fungistatic activities against the tested phytopathogenic fungi with MIC of 4 mg/ml and MFC of 8 mg/ml except *F. oxysporum* which was less sensitive and its minimal fungicidal concentration reached to 16 mg/ml of *Z. officinale* extract (Table, 4). The concentration effect of the most effective plant extracts (*T. vulgaris* and *Z. officinale*) on mycelial growth is shown by plotting their logarithm concentration against mycelial growth of the phytopathogenic fungi (Fig. 2a-b). Growth inhibitions of phytopathogenic fungi were observed and increased with concentration reached to maximum at 8 mg/ml except for *F. oxysporum* which was completely inhibited at 16 mg/ml of *Z. officinale* extract.

The main constituents of the effective plant extracts (*T. vulgaris* and *Z. officinale*) identified by GC- MS spectrometric analysis are summarized in Table 5, according to their retention indices (RI) and percentage composition. *T. vulgaris* extract was composed by thymol (38.73%), carvacrol (19.31%), β -cimene (10.13%) and α -terpinolene (5.94%) while *Z. officinale* was mainly composed by Gingerol (46.85%), cedrene (8.39%), zingiberene (7.41%) and α -curcumene (7.32%) respectively.

DISCUSSION

The control of seedlings damping-off diseases of tomato is mainly based on the application of chemical fungicides, crop rotation and the use of pathogen-resistant varieties. However, fungicide application has resulted in the accumulation of residual toxicity in soil and vegetables, increase environmental pollution and alter the biological balance in the soil by decimating non-target and beneficial microorganisms. Adverse effects of chemical fungicides on the environment and human health are burning issues and there is a need to search for a new fungicides eco-friendly in nature. Five methanolic plant extracts were screened *in vitro* at 10 mg/ml to evaluate them to control tomato phytopathogenic fungi (*Pythium*

aphanidermatum, *Rhizoctonia solani* and *Fusarium oxysporum*). Assays showed that, three plant extract provided a significant inhibition of mycelial growth of the phytopathogenic fungi and their sensitivity to a given plant extract varied greatly. *T. vulgaris* extract showed complete suppression on colony growth of *F. oxysporum*, *P. aphanidermatum* and *R. solani* followed by extract of *Z. officinale* which appear to be effective against *P. aphanidermatum* and *R. solani* and less effective against *F. oxysporum*. These results are in accordance with that of Ramanathan *et al.*, 2004 and Jung *et al.*, 2003. On the other hand, *S. persica* extract was found to be effective against *P. aphanidrematum* and *R. solani* inhibiting their mycelial growth to 77.83% and 56.43% and slightly inhibited mycelial growth of *F. oxysporum* to 14.69 respectively. Although, *L. camara* was found to be effective in controlling *P. aphanidermatum* at 10 mg/ml, it was ineffective in controlling the other tested fungal species and higher concentrations more than 10 mg/ml were required to be effective. A variation on fungitoxicity of the concerned plant extracts against phytopathogenic fungi may be due to considerable variations in their constituents and variation in fungal species itself (Manoranjithan *et al.*, 2001 and Narayana Bhat and Shukla, 2001). The study of MIC and MFC of the fungitoxicants compared with reference fungicide are necessary to evaluate their efficacy in suppressing mycelial growth of the phytopathogenic fungi. *T. vulgaris* extract was strongly active against the tomato phytopathogenic fungi and its MIC with MFC were comparatively lower than that of *Z. officinale*. However, carbendazim 98% fungicide was the most effective fungitoxicant suppressing growth of phytopathogenic fungi than extracts of *T. vulgaris* and *Z. officinale* as mycelial growth of the three phytopathogenic fungi were completely inhibited at 8 ppm while a huge concentration reached to 8 mg/ml was required for plant extracts to attain the same effect. GC/MS analysis of the effective plant extracts showed that phenolic compounds as thymol, carvacrol, β -cimene and α -terpinolene present in *T. vulgaris* extract as well as other phenolic compounds such as Gingerol, cedrene, zingiberene and α -curcumene present in *Z. officinale* extract play the vital role in growth inhibition of phytopathogenic fungi. Gingerol, cedrene and zingiberene were determined as the

most effective antimicrobial component in *Z. officinale* extract (Mostafa *et al.*, 2011) while thymol and carvacrol were determined as the effective antimicrobial compounds in *T. vulgaris* extract (Al-Rahmah *et al.*, 2011 and Boyraz & Ozcan, 2006). Some researchers have suggested that antimicrobial components of the plant extracts cross the cell membrane interacting with the enzymes and proteins of the membrane, so producing a flux of protons towards the cell exterior which induces change in the cell and ultimately their death (Pane *et al.*, 2011 and Omidbeygi *et al.*, 2007). Other researcher attributed the inhibitory effect of these plant extracts to hydrophobicity characters of these plant extracts and their components. This enables them to partition in the lipids of the fungal cell wall membrane and mitochondria disturbing their structure and rendering them more permeable. Leaking of ions and other cell contents can then occur causing cell death (Burt, 2004). The present study indicated that application of plant extracts as biocontrol agents was found to be effective in controlling tomato damping-off diseases and *T. vulgaris* and *Z. officinale* extracts may be an attractive alternative for the use of natural product to control tomato phytopathogenic fungi avoiding chemical fungicide application.

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