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CONTROL OF FUNGAL PEPPER ROOT ROT DISEASE

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ABSTRACT: *All diseased plant materials that collected from five governorates in Egypt were subjected to isolate the causal pathogens. Many soil fungal pathogens were isolated i.e. Fusarium solani, F. oxysporum, F. semitectum, F. aveniceaum, Macrophomina phaseolina, Rhizoctonia solani ,Pythium spp., Alternaria spp. and others. The most frequent pathogenic fungus that isolated from all diseased materials that collected from the five governorates was Macrophomina phaseolina, followed by R. solani, whereas the least isolated fungus was Alternaria spp, followed by Pythium spp. Fusarium solani* (five isolates), *Fusarium aveniceaum* (three *isolates), Fusarium oxysporum (five isolates), Fusarium semitectum (four isolates), Rhizoctonia solani (five isolates), Macrophomina phaseolina (five isolates) were chosen for pathogenicity tests against the commercially grown pepper genotype "Orangery" was tested under greenhouse conditions .Five tested isolates of each isolated fungi were pathogenic to pepper plants. These fungal isolates differed significantly in their virulence. To control of these pathogens, soil solarization, calcium salts, antioxidants, biological control agents as well as fungicides were applied to achieve to the best method for disease control. All mentioned control methods were effective with various degrees.*

Key Words: *Pepper, Fungal root rot, Fusarium, Rhizoctonia, Macrophomina, Disease control, Solarization, Calcium salts, Antioxidants, Biocontrol and Fungicides.*

INTRODUCTION

Root rot diseases of pepper are economically very important and responsible of loss in yield due to disease infection. Survey of the common and frequent isolates of soil borne pathogens attacking pepper plants seems to be very important in the Egyptian soils. Using different methods to control the pathogens such as soil solarization, calcium salts, antioxidants, fungicides *in vivo* and biological control agents against the pathogens. *Alternaria alternate, Fusarium oxysporum, F. moniliforme, F. proliferatum, F. solani, Macrophomina phaseolina, Rhizoctonia solani* and *Pythium aphanidermatum* were predominant in pepper plants showing root rot symptoms (Mushtaq and Hashmi, 1997). Incidence of soft rot of bell pepper

was caused by *Fusarium semitectum* and *F. equiseti* in pathogenicity (Arti-Shukla *et al.*, (2000). Saleem *et al.*, (1997) declared that, *Phytophthora capsici, Fusarium oxysporum, F. solani, F. semitectum, Rhizoctonia solani, Macrophomina phaseolina, Alternatria alternate, Cladosporium* sp., *Rhizopus* sp. and *Aspergillus* spp., were isolated from root and collar rot of chillies (*Capsicum annuum).* Abdou *et al.*, (2004) mentioned that, Salicylic acid as seed treatment affected incidence of wilt and root rot incited by *Fusarium oxysporum* f.sp.sesame, *Macrophomina phaseolina, Theilaviopsis basicola* and *Mucor haemalis.* All treatments of antioxidants against the (*F.solani, F.oxysporumf.sp.cucumerinum, F. clamydosporum, F. equesti, Rhizoctonia solani, M. phaseolina* and *Pythium ultimum*) were great controlled the disease infection and recorded the least D.I., and survival plants were maximized and their values were higher in all treatments in comparing to control treatment (Abdou, 2007). The most toxic fungicides as it stopped growth of *F. solani, M. phaseolina, Botryodiplodia theobromae, S. rolfsii* and *R. solani* at 1 – 5 ppm, followed by Benlate at (10 – 800 ppm), Vitavax-T (25 – 200 ppm) and Rizolex-T (200 – 800 ppm) (El-Habbaa *et al.*, 2002). Abdou (2007) found that, the concentration of Kema- Z were minimized disease infection with all tested pathogenic fungi, the most effect was noticed by 100 ppm on *F. clamydosporum*, 200 ppm on *F. solani* and 300 ppm in *M. phaseolina*. Bandyoadhyaya *et al.*, (2002) indicated the genus *Trichoderma* is being extensively used as biological control agent against plant pathogens as well as their antagonistic potential against *Fusarium oxysporum*, *Rhizoctonia solani* and *Macrophomina phaseolina. The aim of this work was to evaluate different methods to control the pathogens such as soil solarization, calcium salts, fungicides in vivo and biological control agents and, antioxidants against the disease incidence.*

MATERIALS AND METHODS

1- Isolation of the causal organisms and bioagents:

Naturally infected plants showing root rot symptoms and / or damped-off seedlings were collected from different pepper growing areas in Egypt, i.e., Minufiya governorate (Shibin El-Kom, Quesna, Berkat El-Sabie, Minuf, Ashmon, Tala and El-Sadat) Behaira governorate (El-Tahrir), Qaluobiya governorate (Banha), Kafr El-Sheikh governorate (Sakha) & Giza. These materials were subjected for isolation of the causal pathogens and biological agents; the isolated fungi were then purified using the hyphal tip or single spore technique and then transferred to slants of PDA, and incubated at 25°C for 5 days. The pure cultures of the growing fungi of the causal organisms and the associated fungi and bioagents were then examined microscopically and identified at Agriculture Botany Department, Faculty of Agriculture, Minufiya University according to Domsch *et al.* (1980), Rifai (1969) and Bissett (1991).. Frequency % of the isolated fungi from root rotted pepper

plants; collected from different pepper growing areas in different governorates in Egypt; were calculated and tabulated.

2- Pathogenicity tests:

From 856 fungal isolates that obtained from diseased pepper materials collected from different 10 districts belong to five governorates, 27 fungal isolates represent all districts and governorates were chosen for pathogenicity tests (according to isolation frequency) against the susceptible pepper genotype Orangery. These fungi were *Fusarium solani* (5 isolates), *Macrophomina phaseolina* (5isolates) ,*Fusarium aveniceaum* (3 isolates), *Fusarium oxysporum* (5 isolates), *Fusarium semitectum* (4 isolates), *Rhizoctonia solani* (5 isolates).

3- Control of root rots pathogens:

a- Soil solarization:

The inoculated pots with three selective aggressive isolalates i.e., [*F. solani* isolate (1), *R. solani* (5) and *M. phaseolina* isolate (3)] were divided to 5 groups; the first group was covered with one layer (100 Mm) of polyethylene transparent sheets, the second group was covered with red polyethylene sheets, the third group was covered with green polyethylene sheets, also the fourth group was covered with black polyethylene sheets and the fifth group was left without covering to sunlight. These trials were done during hot summer days for one month. Each pot sowed with six seedlings of genotype "Orangery". . Disease index and survival plants were recorded; data was tabulated and statistically analyzed.

b- Calcium salts:

Four calcium salts i.e., Calcium sulphate, Ca chloride, Ca phosphate and Ca carbonate were applied, under greenhouse conditions. 200 and 400 ppm solutions were treated as soil drenches individually, as irrigation treatments every 15 days intervals. The same three isolates were applied in pots and sawed as mentioned before. Disease index and survival plants were recorded.

c- Fungicides:

Soil drenching with fungicides under greenhouse conditions with three fungicides solutions at rate 10, 100, 500 and 1000 ppm; two weeks intervals; i.e., Rizolex, Topsin M-70 and Mooncut were used for controlling the same three pathogenic isolates individually. Disease index and survival plants were recorded as mentioned before.

d- Biological control and antioxidants:

Three isolates of *Trichoderma* spp, i.e. *T. harzianum2&5 and one isolate of T. viride* and four antioxidants were used for disease control, i.e. Salicylic

acid, Sodium benzoate, Benzoic acid, Ascorbic acid, at (100, 200 ppm) against four isolates of each of *R .solani* and *M. phaseolina* and four isolates of *Fusarium* spp., i.e. one isolate of each of *F. solani*, *F. oxysporum*, *F. semitectum* and *F. aveniceaum* were used for *in vivo* greenhouse experiments. Combinations of the pathogenic fungi were made in pots contains the antagonist fungi. Then all pots were watered and left for seven days. Six seedlings of pepper Orangery Rz F1 hybrid cultivar (the most susceptible cultivar) were sown in each pot. Pots were irrigated five times with antioxidant solutions two weeks intervals. Disease index and survival plants were recorded as mentioned before.

RESULTS AND DISCUSSION:

Data in Table (1) indicated that, the most frequent pathogenic fungus that isolated from all diseased materials that collected from the five governorates was *Macrophomina phaseolina* that isolated with 227 isolates comprised 26.52% from all isolated fungi (856 isolates), followed by *R. solani* (210 isolates with 24.53%), whereas the least isolated fungus was *Alternaria* spp., that revealed 3 times only (00.35%), followed by *Pythium* spp. (45 isolates and 5.26%). The maximum number of isolates was recorded by *R. solani* that isolates with 60 isolates from materials of Minufiya governorate, followed by *M. phaseolina* with 53 isolates in the same governorate. Generally, there were great and significant differences between governorates in the isolated fungi and percentages of them.

These results are in agreement with those obtained by Raut *et al.* (1990), Flectcher (2004), Marchoux *et al.* (2000), Pershina (2001) and Pomar *et al.* (2001) Velasquez-Valle *et al.* (2001) explained the symptomatology associated with pepper root rots included defoliation colour change and curling of foliage, damage to reproductive organs, early and irregular ripening, root-rot, necrotic rootlets, These results in accordance with those obtained by Zapata *et al.*(2001), Sanogo (2003) and Gonzalez *et al.* (2004).

Table (1): Frequency of fungi isolated from root rotted pepper plants collected from different governorates in Egypt during 2005 and 2006 seasons

Governorate / Fungus	Minufiya		Behaira		Giza		Kafr El-Shikh		Kaluobiya		Total	
	№	%	№	%	№	%	№	%	№	%	№	%
F.solani	40	17.69	09	06.67	16	09.41	05	06.07	11	07.48	081	09.41
F.oxysporum	32	14.16	06	04.44	20	11.76	17	10.43	22	14.96	097	11.26
F.semitectum	29	12.03	00	00.00	42	24.70	30	18.40	00	00.00	101	11.73
F. aveniceaum	22	09.73	30	22.22	00	00.00	16	09.81	20	13.60	088	10.22
M. phaseolina	53	23.45	40	29.63	50	29.41	44	26.99	40	27.21	227	26.36
Pythium spp	00	00.00	20	41.81	11	06.47	00	00.00	14	09.52	045	05.23
R. solani	60	26.55	30	22.22	30	17.65	50	30.67	40	27.21	210	24.97
Alternaria spp	02	00.88	00	00.00	01	00.59	00	00.00	00	00.00	003	00.35
Trichoderma spp	00	00.00	00	00.00	00	00.00	00	00.00	00	00.00	000	00.00
Others	03	01.33	00	00.00	00	00.00	01	00.61	00	00.00	004	00.46
Total	241	-	135	-	170	-	163	-	147	-	856	-

Data in Table (2) indicated that soil solarization great affected root rot disease incidence of pepper plants. Disease index (D.I) was at lower value in pots which inoculated with the three aggressive pathogenic fungi, *F. solani* isolate (1), *R. solani* isolate (5) and *M. phaseolina* isolate (3), and covered by black sheet (12.5, 4.17 and 15.28% D.I, respectively), followed by green sheet (18.05, 9.94 and 23.61% D.I, respectively). Significant differences were noticed between all percentages of disease index. Survival plants were recorded the least number in pots which were treated by *M. phaseolina* and were covered by transparent sheet, which recorded (88.89% survival plants)

followed by number in pots which were treated by the same fungi and were covered by red sheet (94.44% survival plants). The rest pots which were treated by *F. solani* and *R. solani* and were covered by four sheets that mentioned before recorded (100% survival plants).Non-significant differences were noticed between percentages of survival plants.

Soil solarization is a non chemical soil disinfestations method which harnesses solar energy for heating the soil and have along-term in disease control and enhancement of plant growth and yield. Covering of inoculated pots using plastic sheets decreased all disease parameters in comparing to control (none covered) treatment. Soil solarization by covering pots with transparent polyethylene sheets for 15 days greatly reduced the population of soil borne pathogens at 0 – 20 cm depth and these results suggest a new approach to disease control by the application of summer irrigation in hot arid regions (Lodha, 1994). Similar results were reported by Ahmed *et al.* (1995), Lodha *et al.* (1997), Katan (1998), Ahmed *et al.* (2000) and Bazanboor (2010). Solarization during 30 days reached on average 49°C as maximum temperature, about 10°C higher than the non-solarized treatments, and led to a significant reduction in inoculum of *M. phaseolina* (Ndiaye, 2007).

Table (2): Effect of soil solarization on root rot incidence of pepper genotype Orangery incited by one aggressive isolate of *F. solani*, *R. solani* and *M. phaseolina* under greenhouse conditions.

Treatments	Fungal isolates					
	F.solani (1)		*R.solani* (5)		*M.phaseolina* (3)	
	Disease Index (DI)& Survival plants(SP)					
	D.I	S.P	D.I	S.P	D.I	S.P
Transparent Sheet	33.61^{b}	100.00^{a}	18.05^{b}	100.00^{a}	27.78^{b}	88.89^{c}
Red Sheet	20.83^{c}	100.00^{a}	13.89^{c}	100.00^{a}	$25.00b^{c}$	$94.44a^{b}$
Green Sheet	18.05^{d}	100.00^{a}	09.94^{d}	100.00^{a}	23.61^{c}	100.00^{a}
Black Sheet	12.50^{e}	100.00^{a}	04.17^{e}	100.00^{a}	15.28^{d}	100.00^{a}
Mean	18.75	100.00	11.51	100.00	22.92	95.83
Control (Non-Covered)	56.94^{a}	77.78^{b}	58.33^{a}	72.22^{b}	52.78^{a}	77.78^{d}
P value (Sig.) ≤	00.05*					

Means within classification followed by differ letter are differ significantly at 0.05 level (LSD Test).* *P* value (Sig.) ≤ 0.05 *, NS = Non-Significant

Data in Table (3) illustrated that calcium salts in both tested concentrations were affected disease severity index. All D.I were decreased in comparing to control treatment (infested), and also showed that survival plants of pepper infested with the aggressive pathogenic fungi *F. solani* isolate (1), *R. solani* isolate (5) and isolate (3) of *M. phaseolina* was increased by application of Calcium salts in both tested concentrations in comparing to control (infested) treatment. Significant differences were noticed between all calcium salts in D.I and survival plants. The highest D.I was recorded by Calcium carbonate in 200 ppm which recorded (38.89% D.I), while the least

D.I was recorded by calcium carbonate in (400 ppm) concentration (20.83% D.I), followed by Calcium phosphate in (400 ppm) concentration (22.22% D.I). The best calcium salt treatment which was used in controlling *F. solani* was calcium phosphate in (400 ppm) concentration. *R. solani* and *M. phaseolina* were controlled by Calcium salts treatments in both applied concentrations in comparing to control. The best calcium salt treatment which was used in controlling *R. solani* and *M. phaseolina* was calcium carbonate in (400 ppm) concentration. The obtained results are in agreement with those obtained by Campanella and Nigro (2002), El-Bana *et al.* (2006) and Chang *et al.* (2007).

Table (3): Effect of four Calcium salts on root rot incidence of pepper genotype Orangery incited by one aggressive isolate of *F. solani*, *R.solani* and *M. phaseolina* under greenhouse conditions.

Calcium salts	Conc. (ppm)	Fungal isolates					
		F.solani (1)		*R.solani* (5)		*M.phaseoline* (3)	
		Disease Index (DI)& Survival plants(SP)					
		D.I	S.P	D.I	S.P	D.I	S.P
Calcium Sulphate	200	33.33^{b}	100.00^{a}	26.39^{ef}	94.44^{b}	25.00^{cd}	94.44^{b}
	400	26.39^{d}	88.89^{c}	25.00^{f}	88.89^{c}	25.00^{cd}	94.44^{b}
Calcium Chloride	200	18.05^{f}	100.00^{a}	27.78^{de}	94.44^{b}	26.39^{c}	88.89^{c}
	400	20.83^{e}	100.00^{a}	30.55^{c}	88.89^{c}	29.15^{b}	88.89^{c}
Calcium Phosphate	200	29.15^{c}	88.89^{c}	29.15^{cd}	88.89^{c}	26.39^{c}	88.89^{c}
	400	15.28^{f}	100.00^{a}	22.22^{g}	100.00^{a}	20.83^{e}	100.00^{a}
Calcium Carbonate	200	25.00^{d}	94.44^{b}	38.89^{b}	88.89^{c}	23.61^{d}	100.00^{a}
	400	20.83^{e}	100.00^{a}	20.83^{g}	100.00^{a}	15.28^{f}	100.00^{a}
Mean		23.61	96.53	27.60	81.25	23.96	94.44
Control (infested)		54.17^{a}	72.22^{d}	59.72^{a}	72.22^{d}	51.39^{a}	83.33^{a}
P value (Sig.) ≤		00.05 *					

Means within classification followed by differ letter are differ significantly at 0.05 level (LSD Test). * *P* value (Sig.) ≤ 0.05 *, NS = Non-Significant.

Data in Table (4) illustrated that the effect of Rizolex fungicide on D.I was very clear by raising its concentrations. It recorded (26.39 and 12.5% D.I in infested pots drenched by 500 and 100 ppm, respectively). The most effect was noticed by Rizolex fungicide, followed by Topsin M-70 which recorded (29.15 and 15.28% D.I) in infested pots drenched by (500 and 100 ppm, respectively). Regarding to survival plants, data in Table (4) pointed out that all concentrations of Rizolex fungicide (10, 100, 500 and 1000 ppm) increased survival plants that recorded (77.78, 77.78, 88.8 9 and 100% survival plants, respectively), followed by Topsin-M which recorded at (100, 500 and 1000 ppm) (77.78, 88.89 and 100% survival plants). Significant differences were noticed between all percentages of survival plants. Rizolex-T followed by Topsin-M were the most effective fungicides in inhibiting the disease incidence of *F. solani*and *R. solani* and *M. phaseolina*. Similar results were obtained by using many various fungicides by many investigators (El-Habba *et al.* (2002) and Abdou (2007).

Table (4): Effect of three fungicides on root rot incidence of pepper genotype Orangery incited by one aggressive isolate of *F. solani*, *R. solani* and *M. phaseolina* under greenhouse conditions.

Fungicides	Conc. (ppm)	Fungal isolates					
		F.solani (1)		*R.solani* (5)		*M.phaseolina* (3)	
		Disease Index (DI)& Survival plants(SP)					
		D.I	S.P	D.I	S.P	D.I	S.P
Rizolex-T	10	58.33^{a}	72.22^{e}	56.94^{b}	77.78^{d}	48.61^{b}	72.22^{f}
	100	54.17^{b}	72.22^{e}	56.94^{b}	77.78^{d}	37.50^{d}	94.44^{b}
	500	25.00^{e}	94.44^{b}	26.39^{e}	88.89^{b}	22.22^{e}	94.44^{b}
	1000	09.94^{g}	100.00^{a}	12.50^{g}	100.00^{a}	13.89^{f}	100.00^{a}
Topsin-M	10	58.33^{a}	72.22^{e}	59.72^{a}	72.22^{e}	52.78^{a}	77.78^{e}
	100	56.94^{a}	77.78^{d}	56.94^{b}	77.78^{d}	48.61^{b}	72.22^{f}
	500	27.78^{d}	94.44^{b}	29.15^{d}	88.89^{b}	43.05^{c}	88.89^{c}
	1000	15.28^{f}	100.00^{a}	15.28^{f}	100.00^{a}	22.22^{e}	94.44^{b}
Mooncut	10	56.94^{a}	77.78^{d}	59.72^{a}	72.22^{e}	52.78^{a}	77.78^{e}
	100	56.94^{a}	77.78^{d}	58.33^{ab}	72.22^{e}	52.78^{a}	77.78^{e}
	500	52.78^{b}	77.78^{d}	56.94^{b}	77.78^{d}	48.61^{b}	72.22^{f}
	1000	45.83^{c}	88.89^{c}	51.39^{c}	83.33^{c}	47.22^{b}	83.33^{d}
Mean		43.19	83.80	45.02	82.41	40.86	83.30
Control (infested)		54.17^{b}	72.22^{e}	58.33^{ab}	72.22^{e}	51.39^{a}	83.33^{d}
P value (Sig.) ≤		00.05*					

Means within classification followed by differ letter are differ significantly at 0.05 level (LSD Test).* *P* value (Sig.) ≤ 0.05 *, NS = Non-Significant.

Data in Table (5-a) indicated that biocontrol agents + antioxidants were most effective in controlling pepper root rot pathogens in the integrated control under greenhouse conditions. Disease index (D.I) was clear minimized very much in comparing to control treatment. *T. harzianum* 2 + Sodium benzoate, *T. harzianum* 5 + (Sodium benzoate and Benzoic acid) and *T. viride* + (Sodium benzoate and Benzoic acid) were recorded the best control of *F. solani* (4.17% D.I), followed by *T. harzianum* 2 + Benzoic acid (5.55% D.I). The highest diseas index was recorded by *T. harzianum* 5 and *T. viride* + Ascorbic acid (19.44% D.I). Control treatments in the integrated control trials were improved survival plants (SP)% in comparing to control treatment in all tested pathogens it means that control treatments minimized disease incidence and maximized survival plants as shown in Table (5-a). All control treatments gave (100% survival plants).

Data in Table (5-a) also showed that *T. harzianum* 5 + Sodium benzoate was recorded the best control of *F. oxysporum* (4.17% D.I), whereas the highest D.I was recorded by *T. viride* + Ascorbic acid (20.83% D.I), followed by *T. harzianum* 2 + Salisylic acid and *T. harzianum* 5 + Ascorbic acid (19.44% D.I). All control treatment gave (100% survival plants). *T. harzianum* (2, 5) and *T. viride* + Sodium benzoate were recorded the best control of *F. semitectum* (5.55% D.I), while the highest D.I was recorded by *T. viride* + Ascorbic acid (22.22% D.I).

Table (5-a): Integrated control of pepper root rot pathogens (*Fusarium* spp.) using biological agents and antioxidant by soil drenching under greenhouse conditions.

Bioagent	Fungus	*F.solani*		*F.oxysporum*		*F.semitectum*		*F.aveniceaum*	
	Param.	D.I%	S.P%	D.I%	S.P%	D.I%	S.P%	D.I%	S.P%
T. harzianum 2	Salisylic acid	18.05^{b}	100 ^{a}	19.44^{bc}	100 ^{a}	19.44^{c}	100 ^{a}	18.05^{c}	100 ^{a}
	Sodium benzoate	4.17^{e}	100 ^{a}	5.55^{ef}	100 ^{a}	5.55^{d}	100 ^{a}	5.55^{f}	100 ^{a}
	Benzoic acid	5.55^{e}	100 ^{a}	6.94^{e}	100 ^{a}	6.94^{d}	100 ^{a}	9.94^{e}	100 ^{a}
	Ascorbic acid	15.28^{c}	100 ^{a}	18.05^{c}	100 ^{a}	18.05^{c}	100 ^{a}	18.05^{c}	100 ^{a}
T. harzianum 5	Salisylic acid	12.5^{d}	100 ^{a}	18.05^{c}	100 ^{a}	18.05^{c}	100 ^{a}	19.44^{bc}	100 ^{a}
	Sodium benzoate	4.17^{e}	100 ^{a}	4.17^{f}	100 ^{a}	5.55^{d}	100 ^{a}	4.17^{f}	100 ^{a}
	Benzoic acid	4.17^{e}	100 ^{a}	5.55^{ef}	100 ^{a}	6.94^{d}	100 ^{a}	5.55^{f}	100 ^{a}
	Ascorbic acid	19.44^{b}	100 ^{a}	19.44^{bc}	100 ^{a}	18.05^{c}	100 ^{a}	13.89^{d}	100 ^{a}
T. viride	Salisylic acid	13.89^{cd}	100 ^{a}	13.89^{d}	100 ^{a}	18.05^{c}	100 ^{a}	15.28^{d}	100 ^{a}
	Sodium benzoate	4.17^{e}	100 ^{a}	5.55^{ef}	100 ^{a}	5.55^{d}	100 ^{a}	4.17^{f}	100 ^{a}
	Benzoic acid	4.17^{e}	100 ^{a}	5.55^{ef}	100 ^{a}	6.94^{d}	100 ^{a}	4.17^{f}	100 ^{a}
	Ascorbic acid	19.44^{b}	100 ^{a}	20.83^{b}	100 ^{a}	22.22^{b}	100 ^{a}	20.83^{b}	100 ^{a}
Control		54.17^{a}	72.22^{b}	52.78^{a}	77.78^{b}	54.17^{a}	72.22 ^{b}	47.22^{a}	83.33^{b}
P Value (Sig.) ≤		0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *

Means within classification followed by differ letter are differ significantly at 0.05 level (LSD Test).
*** *P* value (Sig.) ≤ 0.05 *, NS = Non-Significant.**

All control treatments gave (100% survival plants). Data also pointed out that *T. harzianum* 5 + Sodium benzoate and *T. viride* + (Sodium benzoate and Benzoic acid) were recorded the best control of *F. aveniceaum* (4.17% D.I), while the highest D.I was recorded by *T. viride* + Ascorbic acid (20.83% D.I).All control treatments gave (100% survival plants).

Data in table (5-b) indicated that *T. harzianum* 2 + (Sodium benzoate and Benzoic acid) and *T. harzianum* 5 + Benzoic acid were recorded the best control of *R. solani* 1 (4.17% D.I), whereas the highest D.I was given by *T. viride* + Ascorbic and (23.61% D.I). All control treatments gave (100% survival plants) except *T. viride* + Ascorbic acid which gave (94.44% survival plants. *T. harzianum* 5 and *T. viride* + Sodium benzoate were recorded the best control of *R. solani* 2 (4.17% D.I), while the highest D.I was recorded by *T. harzianum* 5 + Salisylic acid and *T. viride* + Ascorbic acid (19.44% D.I).All control treatments gave (100% survival plants).

Data in Table (5-b) also showed that *T. harzianum* 2 + Benzoic acid, *T. harzianum* 5 + (Sodium benzoate and Benzoic acid) and *T. viride* + Sodium benzoate were recorded the best control of *R. solani* 3, whereas the highest D.I was recorded by *T. harzianum* 2 + Salisylic acid, *T. harzianum* 5 + Ascorbic acid and *T. viride* + Ascorbic acid (13.89% D.I).All control treatments gave (100% survival plants).*T. harzianum* 2 + (Sodium benzoate and Benzoic acid) *T. harzianum* 5 + (Sodium benzoate) and *T. viride* + (Benzoic acid) were the best control of *R. solani* 4 (4.17% D.I), while the highest D.I was recorded by *T. viride* + Salisylic acid (16.67% D.I). All control treatments gave (100% survival plants).

Data in Table (5-c) indicated that *T. harzianum* 5 + (Sodium benzoate and Benzoic acid) and *T. viride* + (Sodium benzoate) were the best control treatment of *M. phaseolina* 1 (4.17% D.I), followed by *T. harzianum* 2 + (Sodium benzoate and Benzoic acid) which recorded (5.55% D.I). The highest D.I was recorded by *T. harzianum* 2 + Ascorbic acid (19.44% D.I). All control treatments gave (100% survival plants).Data also showed that *T. harzianum* (2, 5) + Benzoic acid and *T. viride* + (Sodium benzoate and Benzoic acid) was the best control treatment of *M. phaseolina* 2 which recorded (4.17% D.I), followed by *T. harzianum* (2, 5) + Sodium benzoate (5.55% D.I), while the highest D.I was recorded by *T. harzianum* 2 + Ascorbic acid and *T. harzianum* 5 + Salisylic acid (19.44% D.I). All control treatments recorded (100% survival plants).*T. harzianum* 2, 5 + (Sodium benzoate and Benzoic acid) and *T. viride* + (Benzoic acid) which recorded (4.17% D.I) were the best control treatment of *M. phaseolina* 3, while the highest + D.I was recorded by *T. harzianum* 2 + Salisylic acid (18.05% D.I). All control treatments gave (100% survival plants).

Table (5-b): Integrated control of pepper root rot pathogens (*Rhizoctonia solani*) using biological agents and antioxidant by soil drenching under greenhouse conditions .

Bioagent	Fungus	*R. solani 1*		*R. solani 2*		*R. solani 3*		*R. solani 4*	
	Param.	D.I%	S.P%	D.I%	S.P%	D.I%	S.P%	D.I%	S.P%
T.harzianum 2	Salisylic acid	12.5^{d}	100^{a}	15.82^{c}	100^{a}	13.89^{b}	100^{a}	13.89^{c}	100^{a}
	Sodium benzoate	4.17^{f}	100^{a}	5.55^{ef}	100^{a}	6.94^{e}	100^{a}	4.17^{f}	100^{a}
	Benzoic acid	4.17^{f}	100^{a}	6.94^{e}	100^{a}	5.55^{ef}	100^{a}	4.17^{f}	100^{a}
	Ascorbic acid	13.89^{d}	100^{a}	15.28^{cd}	100^{a}	12.5^{bc}	100^{a}	13.89^{c}	100^{a}
T.harzianum 5	Salisylic acid	18.05^{c}	100^{a}	19.44^{b}	100^{a}	11.11^{cd}	100^{a}	9.72^{d}	100^{a}
	Sodium benzoate	5.55^{ef}	100^{a}	4.17^{f}	100^{a}	4.17^{f}	100^{a}	4.17^{f}	100^{a}
	Benzoic acid	4.17^{f}	100^{a}	5.55^{ef}	100^{a}	4.17^{f}	100^{a}	6.94^{e}	100^{a}
	Ascorbic acid	13.89^{d}	100^{a}	13.89^{d}	100^{a}	13.89^{b}	100^{a}	13.89^{c}	100^{a}
T. viride	Salisylic acid	16.67^{c}	100^{a}	18.05^{b}	100^{a}	9.72^{d}	100^{a}	16.67^{b}	100^{a}
	Sodium benzoate	5.55^{ef}	100^{a}	4.17^{f}	100^{a}	4.17^{f}	100^{a}	5.55^{ef}	100^{a}
	Benzoic acid	6.94^{e}	100^{a}	5.55^{ef}	100^{a}	5.55^{ef}	100^{a}	4.17^{f}	100^{a}
	Ascorbic acid	23.61^{b}	94.44^{b}	19.44^{b}	100^{a}	13.89^{b}	100^{a}	13.89^{c}	100^{a}
Control		58.33^{a}	72.22^{c}	56.94^{a}	77.78^{b}	52.78^{a}	77.78^{b}	52.78^{a}	77.78^{b}
P Value (Sig.) ≤		0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05*

Means within classification followed by differ letter are differ significantly at 0.05 level (LSD Test).

* *P* value (Sig.) ≤ 0.05 *, NS = Non-Significant.

Table (5-c): Integrated control of pepper root rot pathogens (*Macrophomina phaseolina*) using biological agents and antioxidant by soil drenching under greenhouse conditions.

Bioagent	Fungus	*M. phaseolina 1*		*M. phaseolina 2*		*M. phaseolina 3*		*M. phaseolina 4*	
	Param.	D.I%	S.P%	D.I%	S.P%	D.I%	S.P%	D.I%	S.P%
T.harzianum 2	Salisylic acid	15.28^{c}	100^{a}	18.05^{b}	100^{a}	18.05^{b}	100^{a}	16.67^{c}	100^{a}
	Sodium benzoate	5.55^{de}	100^{a}	5.55^{d}	100^{a}	4.17^{d}	100^{a}	5.55^{d}	100^{a}
	Benzoic acid	5.55^{de}	100^{a}	4.17^{d}	100^{a}	4.17^{d}	100^{a}	4.17^{d}	100^{a}
	Ascorbic acid	19.44^{b}	100^{a}	19.44^{b}	100^{a}	16.67^{bc}	100^{a}	18.05^{bc}	100^{a}
T.harzianum 5	Salisylic acid	18.05^{b}	100^{a}	19.44^{b}	100^{a}	16.67^{bc}	100^{a}	19.44^{b}	100^{a}
	Sodium benzoate	4.17^{e}	100^{a}	5.55^{d}	100^{a}	4.17^{d}	100^{a}	4.17^{d}	100^{a}
	Benzoic acid	4.17^{e}	100^{a}	4.17^{d}	100^{a}	4.17^{d}	100^{a}	4.17^{d}	100^{a}
	Ascorbic acid	18.05^{b}	100^{a}	18.05^{b}	100^{a}	15.28^{c}	100^{a}	18.05^{bc}	100^{a}
T. viride	Salisylic acid	13.89^{c}	100^{a}	18.05^{b}	100^{a}	15.28^{c}	100^{a}	18.05^{bc}	100^{a}
	Sodium benzoate	4.17^{e}	100^{a}	4.17^{d}	100^{a}	5.55^{d}	100^{a}	4.17^{d}	100^{a}
	Benzoic acid	6.94^{d}	100^{a}	4.17^{d}	100^{a}	4.17^{d}	100^{a}	4.17^{d}	100^{a}
	Ascorbic acid	15.28^{c}	100^{a}	15.28^{c}	100^{a}	15.28^{c}	100^{a}	16.67^{c}	100^{a}
Control		48.61^{a}	72.22^{b}	47.22^{a}	83.33^{b}	48.61^{a}	72.22^{b}	51.39^{a}	83.33^{b}
P Value (Sig.) ≤		0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *	0.05 *

Means within classification followed by differ letter are differ significantly at 0.05 level (LSD Test). * *P* value (Sig.) ≤ 0.05 *, NS = Non-Significant.

Data in Table (5-c) also showed that *T. harzianum* 2 + (Benzoic acid) and *T. harzianum* 5, *T. viride* + (Sodium benzoate and Benzoic acid) which gave (4.17% D.I) were the best control treatment of *M. phaseolina* 4, whereas the highest D.I was *T. harzianum* 5 + Salisylic acid (19.44% D.I).All control treatments recorded (100% survival plants).

Combination of T. harzianum 2 or 5 or T. viride and four antioxidant compounds i.e., Salicylic acid, Sodium benzoate, Benzoic acid and Ascorbic acid 200 ppm concentrations was very effective for controlling root rot disease incidence especially sodium benzoate + T. harzianum 5. The obtained results are in agreement with those, i.e., Lodha (1994), Ahmed *et al.* (1995), Lodha *et al.* (1997), Cububeta *et al.* (1999), Abdel-Aziz (1999), Ahmed *et al.* (2000), Campanella and Nigro (2002), Abdel-Rahim (2007) and Bazanboor (2010). . Soil drenching by Sodium benzoate and Benzoic acid in 200 ppm concentration was the best antioxidant treatment that recorded the least Disease index and the highest number of survival plants. Similar results were reported by, Galal *et al.* (2000), Galal *et al.* (2001), Galal *et al.* (2002), Abdou *et al.* (2004), El-Sagheer and Hassan (2006), Abdel rahim (2007) and Abdou (2007).

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مقاومة مرض عفن الجذور الفطري في الفلفل

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الملخص العربي

تم جمع نباتات فلفل مصابة بمرض عفن الجذور على أصناف متعددة منزرعة فى العديد من الحقول التجارية بمراكز عديدة تتبع خمسة محافظات خلال موسمي الزراعة ٢٠٠٥ – ٢٠٠٦ . كانت الفطريات المعزولة والتي تم تنقيتها وتعريفها هى فيوزاريم سولانى ، فيوزاريم اوكسيسبورم، فيوزاريم سيميتكتم ، فيوزاريم أفينيكم ، ماكروفومينا فاسيولينا ، ريزوكتونيا سولانى ، وأنواع من الألترناريا وكذلك أنواع من فطر التضاد الحيوي تريكوديرما والتي تم عزلها من ريزوسفير نباتات سليمة من نفس مناطق الحصر . في اختبارات العدوى بواسطة الفطريات المعزولة على نباتات الفلفل الحساسة للإصابة (صنف أورانجيرى) ، كانت فطريات الفيوزاريم الأربعة والريزوكتونيا والماكروفومينا قادرة على إحداث الإصابة بعفن الجذور في الفلفل بنسب عالية من المعامل المرضى . في تجارب مقاومة المرض كان لمعاملات التشميس (تغطية الأصص المعدية بالبلاستيك مختلف الألوان) تأثيرا فعال على مقاومة حدوث مرض عفن الجذور في الفلفل، وكانت أفضل المعاملات تغطية الأصص بالأفرخ البلاستيك الأسود متبوعا بالبلاستيك الأخضر. وكان الفطر الأكثر تأثرا هو فطر الريزوكتونيا سولانى ، ثم يليه فطر الفيوزاريم سولانى .كانت مقاومة مرض عفن جذور الفلفل باستخدام أربعة أملاح من الكالسيوم بتركيزين عالية التأثير في مقاومة حدوث المرض، وذلك بالمقارنة بالنباتات المنزرعة في أصص معدية (كنترول)، وفى نفس الوقت فقد ازدادت أعداد النباتات الحية عند المعاملة بكلا التركيزين من أملاح الكالسيوم. وكان محلول بنزوات الصوديوم وحمض البنزويك بتركيز ٢٠٠ جزء في

المليون هو الأكثر فعالية بين مضادات الأكسدة حيث قلل معدل حدوث المرض مما نتج عنه زيادة في عدد النباتات الحية .كان مبيد ريزولكس ــ ت أفضل المبيدات الفطرية في تثبيط مرض عفن الجذور في الفلفل والحادث عند العدوى بالفيوزاريم سولانى والريزوكتونيا سولانى والماكروفومينا فاسيولينا ، يليه المبيد توبسين ــ م. كان للمعاملة بواسطة كائنات التضاد الحيوي ومضادات الأكسدة مجتمعة في محاولة لإحداث مقاومة متكاملة تأثيرا جيد في التحكم في حدوث المرض على نباتات الفلفل. وكانت أفضل المعاملات بنزوات الصوديوم بتركيز ٢٠٠ جزء في المليون + تريكوديرما هارزيانم عزلة ٥ .