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PHYTOPHTHORA ROOT AND CROWN ROT OF PEPPER IN EGYPT

[61]

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ABSTRACT

Root and crown rot of pepper plants, caused by *Phytophthora capsici*, was first detected in Egypt in Late 1997. The disease was recorded on pepper grown in plastic greenhouse at El-Salhia region. During 1998-2000, it was also recorded in pepper nurseries and protected and outdoor cultivations in fields at Dakahlia, Sharkia, Kalyobia and Giza governorates. Disease incidence did not exceed 7.0%. Symptoms include wilting of foliage, dark green to black discoloured lesion on the crown followed by a soft wet rot and complete rot of the root of even large plants. The fungus was isolated from diseased tissue of the crown and roots the on Masago's Phytophthora selective medium and identified as *P. capsici*. Isolates of *P. capsici* varied for their virulence on pepper plant from highly virulent to less virulent. No oospores were formed when these isolates were paired together in all different combination or in aged single culture (heterothallic). All *P. capsici* isolates were sensitive to the fungicide, metalaxyl. All pepper cultivars and hybrids tested were highly susceptible to the disease. Ridomyl and Privicur N applied as preventive or curative soil drench treatment were the most effective fungicides and significantly reduced disease incidence and severity in the greenhouse. Treatment of pepper transplants with *Pseudomonas fluorescens* (Pf5) or *Trichoderma harzianum* (Th1) effectively reduced progress of *P. capsici* infection on pepper plants grown in artifially infested soil. Both Pf5 and Th1 strains increased shoot and root weights of pepper plants in sterilized soil. It is concluded that, this disease may become a potential constraint to pepper cultivation in clay-loam soil where the crop is irrigated extensively.

Key words: Pepper, *Phytophtora capsici*, Incidence, Control.

INTRODUCTION

Pepper (*Capsicum annum* L.) has became one of the most important vegetable crops, during the last ten years, in Egypt. Pepper plants are grown in three different growing seasons in Egypt, either under protected cultivation or in open fields, where furrow or drip irrigation is used. Several soil borne fungal pathogens i.e *Fusarium* spp., *Pythium* spp. and *Rhizoctonia solani* were reported to cause

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serious damage in diverse production areas in Egypt (**Harfoush, 1970; Abada, 1994 and Abd El-Kader, 1999**).

Pythophtora root and crown rot of pepper caused by *Phytopthora capsici* leonian is a severe disease on peppers, tomatoes and cucurbits, worldwide (**Ristaino, 1991; Hwang and Kim, 1995 and Erwin and Ribeiro, 1996**), where soil moisture is excessive during the growing season. In the autumn of 1997 and again in the early summer seasons, our attention was drawn to a wide spread wilt of entire pepper plants in local greenhouse at El-Salhia region. Affected plants had been grown from transplants produced in seedling trays with non-sterilized peatmoss-vermiculite mixture as substrate. However, disease control by the fungicide benomyl was ineffective. *Phytophthora capsici* was consistently associated with these symptoms. Since then, disease survey was done during 1998-2000 in several pepper nurseries, greenhouses and fields at Sharkya, Dakahlia, Kalyobia and Giza.

Although the disease, currently, is not limiting to pepper production in Egypt, and increase in the use of drip irrigation in vegetable production areas could exacerbate disease problems, therefore effective controls need to be developed.

Considerable research has been directed toward development of control measures for *P. capsici* because its devasting effect on production of pepper (**Ristaino and Johnston, 1999**). Attempts to control *P. capsici* by for example, pre-soil fumigation and by the use of resistant cultivars have shown little success (**Hwang and Kim, 1995**). The principle methods for controlling *P. capsici* include cultural practices and the use of fungicides (**Ristaino and Johnston, 1999**). Several fungicides such as metalaxyl, propamocarb and mefenoxam have been used in several countries (**Hwang and Kim, 1995 and Matheron and Prochas, 2000**) to control Phytophthora root, crown and fruit rot of pepper. However, timing of fungicide application seems to be important for effective control (**Matheron and Prochas, 2000**). Although, the fungicide Mefenoxam (Trade name: Ridomyl Gold) was used widely in pepper for the first time in 1997 in USA, resistance of *P. capsici* to mefenoxam was reported (**Parra and Ristaino, 1998**). In recent years, various antagonistic microorganisms such as *Trichoderma* species. *Bacillus subtilis* and fluorescent Pseudomonads were used to control *P. capsici* on pepper (**Lee *et al* 1999; Sharifi-Tahrani and Omati, 1999 and Sid Ahmed *et al* 1999**).

The objectives of this study were to investigate the nature of Phytophthora root and crown rot disease on pepper in Egypt, and device control measure.

MATERIAL AND METHODS

Isolation and identification of *P. capsici*

Isolation was made from seedlings or mature plants that showed typical symptoms of root and crown rot (**Hwang and Kim, 1995**). Symptomatic pepper plants were collected from nurseries and several greenhouses and fields in different pepper growing locations in four governorates (Sharkia, Dakahlya, Kalyobia and Giza), during 1998-2000. Diseased tissues were surface-sterilized with 70% ethyl alcohol for 5-10 sec., rinsed with sterile distilled water, and blotted on sterile paper towels. Small pieces of tissue from the margins of actively ex-

panding lesions were excised and plated on Masago's Phytophthora- selective medium (**Masago *et al* 1977**). Plates were warped with Parafilm and incubated at 25°C for 3 to 7 days in the dark and observed for growth of *P. capsici*. Developed colonies were transferred to V-8 agar plates and subcultures were established from single sporangium and maintained on corn meal agar (CMA) or V-8 agar slants at 15°C. The isolates were identified as *P. capscisi* based on the taxonomic key of **Stamps *et al* (1990) & Erwin and Ribeiro (1996)**.

Inoculum production

Two types of *P. capsici* inocula were produced as described by **Larkin *et al* (1995)** as zoospores or mycelial propagules consisted of hyphae and sporangia of the fungus. All isolates were grown on V-8 agar at 25°C for 7 days **(Mitchell and Kannwischer-Mitchell, 1992)** prior to production of both types of inoculum.

(a) For zoospore production: V-8 agar cultures were cut into pieces, flooded with sterile distilled water and incubated under fluorescent light at 25°C for 72 hr. Zoospore release was induced by chilling cultures at 5°C for one hr and then incubating at 25°C for 60 min. Zoospore suspension were filtered through eight layers of cheesecloth to remove hyphal and sporangial debries. Zoospore concentrations was counted using a hemacytometer and added to soil in a water suspension.

(b) For production of mycelial propagules inoculum: Cultures - colonized agar pieces were added to 500 cm^3 of vermiculite and 250 ml of V-8 broth (800 ml of water, 200 ml clarified V-8 juice and 2 g $CaCO_3$) in autoclaved 1-liter jars and incubated in the dark at 25°C for 4 weeks. Appropriate amounts of the V-8-vermiculite inoculum were added to soil on a weight per volume to achieve the particular inoculum level desired (10 cm^3/kg soil).

Comparative pathogenity of isolates

Five isolates of *P. capsici* (Pc1, Pc2, Pc3, Pc4 and Pc5 were tested for pathogenicity either on seedlings or mature pepper plant cv. California Wonder.

1. Seeds were sown in multipot seedling trays containing steam sterilized potting mixture (peatmoss and vermiculite, 1:1 v/v) which infested by pipitting 1.0 ml of a 10^4/ml zoospore suspension on the surface of each single pot. After inoculation, the trys were kept under greenhouse condition for 35 days and irrigated regularly. The incidence of seedling damping-off and survival seedlings were recorded.
2. Healthy pepper plants, six-weeks old, were planted in plastic pots (20 cm diameter), containing clay-loam soil one plant per pot and 10 replicates were used. A 10 ml of 10^4/ml zoospore suspension of each isolates were placed on the surface of each pot. Thereafter the pots were irrigated regularly and kept under greenhouse condition. Beginning 5 days after inoculation, disease incidence and severity was evaluated periodically, as described by **Ristaino (1991)**. Disease severity on shoots was evaluated using a scale of 0-4, in which 0= no symptoms; 1= wilting of plant, without stem lesion; 2= wilting and stem lesion without girdling; 3= girdled plant stem; 4= dead plant. Meanwhile, infection by *P. capsici* was confirmed

by reisolating the fungus from diseased plants on Masago's selective medium.

Production of oospores

The ability of *P. capsici* isolates to produce oospores in paired or single culture was studied. All five isolates were paired with themselves in all different combinations. Agar disks (5 mm diam) of each isolate were placed 4 cm apart from other isolate on clarified V-8 agar medium (CV-8). The plates were incubated at 25°C in the dark for 14 days. These plates were examined microscopically to observe the presence of oospores. Meanwhile, single culture of each isolate were grown on CV-8 agar medium for 40 days at 25°C, and examined for oospore formation.

Sensitivity to the fungicide metalaxyl

Growth of five *P. capsici* isolates on V-8 agar medium amended with varying levels of metalaxyl was studied. Metalaxyl (97.35%) was kindly obtained from Dr. Y. Yokomizo (Synginta, Tokyo, Japan). The range of concentrations (μg/ml) used were 0.1, 1, 10 and 100. Agar disks (5 mm) from 4 days old *P. capsici* mycellium were placed in the center of fungicide amended V-8 agar plates and incubated at 25°C for 6 days. Fungal radial growth was measured and the percentage of inhibition of radial growth on fungicide amended medium compared with that on unamended control was determined.

Susceptibility of pepper cultivars and hybrids to *P. capsici*

Eight pepper cultivars and hybrids i.e. California Wonder, Yolo Wonder, Gedeon, Glax, Magna, Balady, Enheim and Orly, were evaluated for susceptibility to root and crown rot disease caused by *P. capsici*. Isolate Pc 5, highly virulent, was used throughout the study. Plant of each cultivar or hybrid, 6 weeks old, were transplanted in pots (25 cm diameter) containing autoclave-sterilized soil, which previously infested with a V-8 vermiculite based inoculum at the rate of 10 cm^3/kg soil, two days before transplanting. The plants were grown in the greenhouse during early summer season and irrigated regularly. The incidence of root rot and wilt severity was recorded periodically up to 6 weeks after transplanting.

Effect of fungicides on disease development

Three fungicides, commonly used to control oomycetes pathogens, were used in this study: Metalaxyl (Ridomil 25 WP), fosetyl-AL (Aliette 80WDG) and Propamocarp-HCL (Privicur N 72.2 SL) at rates of 25, 100, 2000 μg/ml, respectively, as soil drench treatment. This experiment was done in plastic boxes (45 X 30 X 25 cm deep). Boxes were only three-fourth filled with autoclave- sterilized clay-loam soil. Inoculum of *P. capsici* isolate (Pc5) on V-8-vermiculite medium was applied to soil in each box at rate of 50 cm^3/Box, 2 days before planting. A 800 ml aqueous suspension of each fungicide were drenched on soil in each replicate box, either 3 days before soil infestation with pathogen (preventive treatment) or 5 days after infestation (curative treatment). Control treatment was treated with water only. A control treatment consisting of non-ifested soil was also established. Pepper seedlings 6

weeks old, was planted into the plastic boxes with 4 plants per box, and four boxes for each treatment. Plants were maintained in the greenhouse for up to 10 weeks. Data was collected when plants wilted permanently due to disease development and disease incidence and severity were calculated, as described above.

Biological control

Three isolates: *Trichoderma harzianum* (Th-1), *Bacillus subtilis* (B1) and *Pseudomonas fluorescens* (Pf5) with antagonistic potential, *in vitro*, to *P. capsici* (Data not shown) were selected from the Culture Collection of Department of Plant Pathology, Faculty of Agriculture, Ain Shams University. These isolates were examined for their biological control capacity for root and crown rot of pepper under controlled conditions in the greenhouse. Clay pots (25 cm diam) containing autoclave-sterilized clay-loam soil were artificially inoculated with a V-8-vermiculite based inoculum of *P. capsici* (Pc5) at rate of 10 cm^3/kg soil. After 2 days, six weeks old pepper plants cv. California wonder were treated by immersion in conidial suspension ($2X10^6$ conidia/ml) of *T. harzianum* (Th-5) or in bacterial suspensions ($1X10^8$ cfu/ml) of BI and Pf5 for 5 min. Furthermore, a 10 ml of each bioagents suspension were added over the crown of each pepper plant, immediately after transplanting. Control treatments were treated with water. A control non-infested soil treated with each bioagent was also established. There were 10 pots, with two plants per pot, for each treatment. Disease incidence and severity were assessed periodically as previously described. Meanwhile, dry weight of roots and shoots of pepper plants were determined after drying tissues at 80°C for 24 hr.

Statistical analysis

All experiments were set up in a complete randomized design. Data were subjected to analysis of variance (ANOVA) using the Statistical Analysis System (**SAS Institute, Inc., 1996**). Means were separated by Duncan's multiple range test at P= 0.05 level.

RESULTS AND DISCUSSION

Symptomatology

Disease symptoms observed in nursery, field and greenhouse are described. Pepper seedlings can be killed in nursery. On small plants, the root turned brown and rotted and/or the crown was shriveled by black colored lesion and collapsed within few days. In the field, the infected plants were stunted permanently or grown very little. The foliage of infected plants gradually wilted and died without noticeable change of color. On older plants, the disease was characterized by dark green to black discolored lesion close to the soil surface may sometimes extend to 10 cm above the surface, under favorable conditions, followed by a soft wet rot which dry later to brown color. The lower tap roots and root hairs became brown and rotted. Discoloration of the vascular systems was observed sometimes in the area above and below the crown canker, however, no pathogen was isolated from vascular tissues. The crop was finished three months earlier in heavly infected plants in the greenhouse.

Disease incidence

In the initial investigation conducted in 1997, three commercial greenhouses for pepper production at El-Salhia region was checked for plants exhibited symptoms of root and crown rot. Typical Phytophthora root rot symptoms was detected only on one greenhouse where affected plants had been grown from transplants produced in multi-celled plug trays in which a peat based mixture was used as the propagative medium. Approximately 18% of plants were affected greatly; stunting of the plants was associated with extensive rooting of rots and collapsing of basel stem tissues. In the subsequent survey conducted between 1998-2000, few diseased plants in a field at Kasasin (Sharkia), Mit Ghamr (Dakahlia) and Gezirt El-Dahab (Giza) showed symptoms of Phytophthora root-rot. The highest disease incidence (7.0%) was in nurseries and fields at Tukh and Kaha (Kalyobia) and occurred in October and appeared in epiphytotic form in open fields during months of March and April. Meanwhile a few scattared diseased plants by *P. capsici* were found in pepper greenhouse at Gezirt El-Dahab (Giza), during season of 2000, where other root-rot pathogens i.e. *Rhizoctonia solani*, *Pythium* spp. and *Fusarium* spp. were predominant.

Isolation and Identification of the pathogen

Phytophthora capsici was consistently isolated from edges of stem lesions and rotted-rots of diseased pepper plants on Masago's selective medium. Five isolates from different areas, designated Pc1, Pc2, Pc3, Pc4 and Pc5, were established in pure culture on V-8 or CMA media. When the fungus grown on V-8, agar all isolates produced white, smooth and more uniform growth with formation of few arial hyphae (Fig. 1A). All isolates produced papillate sporangia that were oval to lemoniform in shap with tapering base and long pedicel (Fig. 1 B). Sporangia dimension (length X width) among isolates ranged from 39.5 to 56.3 X 18.4 to 32.6 µm. All isolates were caducous (produced sporangia that were deciduous in water). Mean pedicel length among isolates varied from 38.5 to 87.8 µm. No chlamydospores were found either in aged cultures or submerged hyphae. All isolates grew on CMA medium at temperature ranging from 15 to 35°C with optimum growth at 25-32°C (Data not shown).

Production of oospores

No oospores were formed when these isolates were paired in all different combination. However, none of these isolates produced oospores in single culture after incubation for 40 days on CV-8 agar medium. Therefore, all five isolates tested were considered to be of one mating type only.

Pathogenicity tests

The pathogenic potential of five isolates of *P. capsici* was tested twice on pepper. In the greenhouse experiments with artificial inoculation, symptoms developed rapidely either as pre or post-emergence damping-off. When plants (6 week old) were transplanted in infested soil, symptoms developed rapidly on leaves, stems and roots (Fig. 1C & D). *P. capsici* was reisolated from inoculated

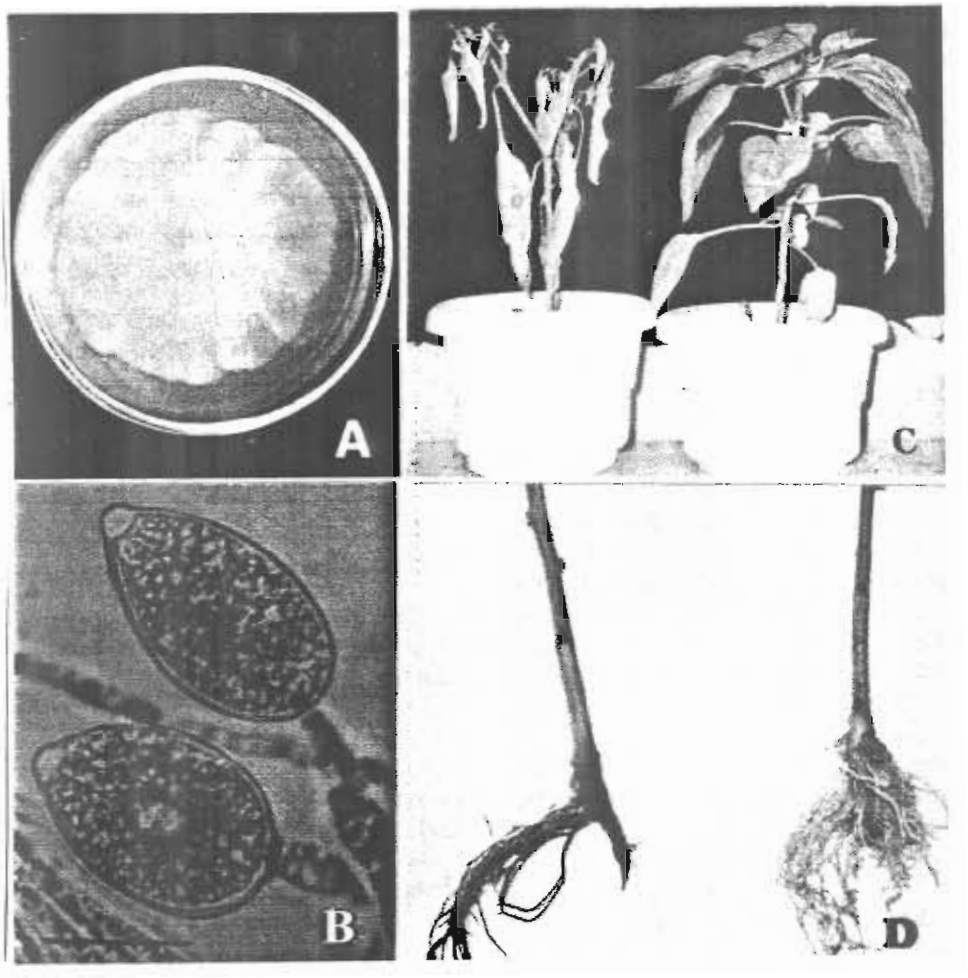

Fig. 1. A) Growth behavior of *Phytophthora capsici* isolate Pc5 grown on V-8 agar medium for 5 days at 25°C. Note the smooth uniform growth with few aerial hyphae. B) Oval to lemon-shaped sporangia of *P. capsici* with tapering base and pedicel; scale bare is 30 µm, C) *Phytophthora* root symptoms on diseased pepper plants. Diseased plant (left) with wilting of foliage compared with healthy plant (right). D) Root of diseased plant (left) showing severe rot and distinctive brownish to black lesion on the stem base extending upward compared with healthy plant root (right)

plants and with these re-isolates, the same disease symptoms were reproduced. Results in Table (1) show that all *P. capsici* isolate tested were capable of attacking pepper seedlings and plants. Isolates Pc3 and Pc5 were highly virulent and caused the highest percentage of seedling damping-off, 77.5 and 83.75%, respectively and also the highest disease severity on pepper plants, 2 and 4 weeks after transplanting. Isolate Pc1 and Pc2 were moderately virulent, while isolate Pc4 was less virulent.

Sensitivity to metalaxyl

The inhibitory effect of metalaxyl on radial growth of five isolates of *P. capsici* is shown in Fig. (2). The isolates differed in their sensitivity to metalaxyl. A lower concentration (0.1 μg/ml) was active in reducing the radial growth of these isolates, but with different degrees. However, metalaxyl at concentration of 1 μg/ml was inhibitory to all tested isolates giving more than 50% reduction in growth. Mycelial growth was inhibited completely (100%) at 10 and 100 μg/ml.

Cultivar susceptibility to *P. capsici*

Eight commercially available pepper cultivars and hybrids included in this study i.e. Calofornia Wonder, Yolo Wonder, Gedeon, Glax, Magna, Eneheim, Orly and Balady were highly susceptible to *P. capsici* isolate (Pc5) with no differences among them (data not shown in Table).

Disease suppression by fungicides

The effect of three fungicides as soil drench treatment, on severity of Phytophthora root and crown rot were examined in greenhouse trials. Results in Table (2) indicate that the three fungicides have significantly reduced disease incidence and severity. Ridomyl was the most effective fungicide when used as preventive treatment, 3 days before soil infestation with pathogen and reduced disease incidense by 93% compared with non treated plants, followed by Privicur N (86%). However, when these fungicides were used, 5 days after soil infestation, privicor N was the most effective curative treatment and reduced disease incidence by 73%. Meanwhile, disease severity was also reduced on fungicide-treated plants compared with non-treated control (Table 2).

Biological control

The effect of three selected antagonistic microorganisms to suppress Phytophthora root-rot of pepper was studied under greenhouse conditions. Data in Fig. (3) indicate that incidence and severity of Phytophthora root rot of pepper was suppressed by all antagonists used. When 100% mortality of plants was recorded in the control after 20 days from transplanting in *P. capsici* infested soil, all the three antagonists reduced disease incidence at varying levels. Neverthelss, disease progress was significantly different on Trichoderma- treated plants compared with other treatments. *T. harzianum* (Th-1) was the most effective treatment and reduced disease incidence by 65%, meanwhile, disease severity was also greatly reduced. *Pseudomonas fluorescens* (Pf5) treatment reduced disease incidence by 55%, while *B. subtilis* was the less effective (Fig. 3). However, shoot and root dry weight were greatly

Table 1. Pathogenicity of *Phytophthora capsici* isolates to pepper in sowing ped or after transplanting in pot experiment in the greenhouse

Isolate	Sowing bed [a]		Survival [c]	After transplanting [b]	
	Damping-off			Disease severity [d]	
	Pre-emergence	Post-emergence		2W	4W
Pc1	28.75 b [e]	36.25 a	35.00 b	1.3 b	2.5 b
Pc2	36.25 b	31.25 a	32.50 b	2.0 b	3.0ab
Pc3	67.50 a	10.00 b	22.50 c	2.3 a	3.2 a
Pc4	18.75 b	8.75 b	72.50 b	1.0 b	2.1 b
Pc5	71.25 a	12.50 b	16.25 c	3.1 a	3.8 a
None	5.00 c	0.00 c	95.0 a	0.0	0.0

a) Surface-disinfested seeds were sown in seedling trays containing peatmoss-vermiculite mixture infested with zoospore suspension (10^4/ml) of *P. capsici* per pot.
b) Healthy plants, 6 weeks old, were transplanted in pots containing clay soil infested with V8-vermiculite inoculum of *P. capsici* (10 cm^3/kg soil).
c) Recorded up to 35 days after sowing.
d) Disease severity was rated, 2 or 4 weeks after transplanting, based on a scale of 0=no symptoms – 4= plant dead as described by **Ristaino (1991).**
e) Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test at P = 0.05.

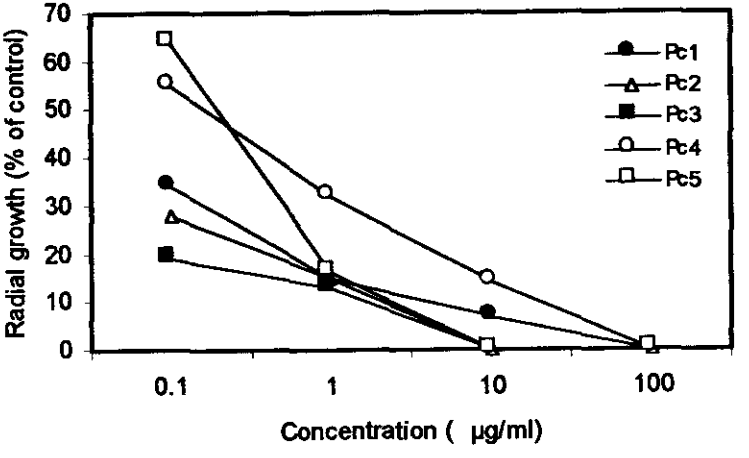

Fig. 2. Effect of the fungicide metalaxyl on radial growth of five isolates of *P. capsici* on V-8 agar medium

Table 2. Effect of fungicide treatment and timing on incidence and severity of Phytophthora root and crown rot of pepper under greenhouse conditions

Fungicide	Rate µ/ml	Preventive [a]		Curative [b]	
		% Disease incidence	Disease severity [c]	% Disease incidence	Disease severity [c]
Ridomyl	25	6.25cc [d]	0.2 c	37.75 b	1.5 b
Privicur N	100	12.50 c	0.4 c	25.00 c	0.5 c
Alliette	2000	37.75 b	1.3 b	50.00 b	1.7 b
Non-treated	-	93.75 a	3.7 a	93.75 a	3.7 a

a) Fungicides were applied, 3 days before inoculation of *P. capsici*.
b) Fungicides were applied, 5 days after inoculation of *P. capsici*.
c) Severity ratings are based on scale of 0 = no symptoms, 4= plant did as described by **Ristaino (1991)**.
d) Each value is the mean of 16 replicate plants. Numbers in each column followed by the same letter are not significantly different (P= 0.05) according to Duncan's multiple range test.

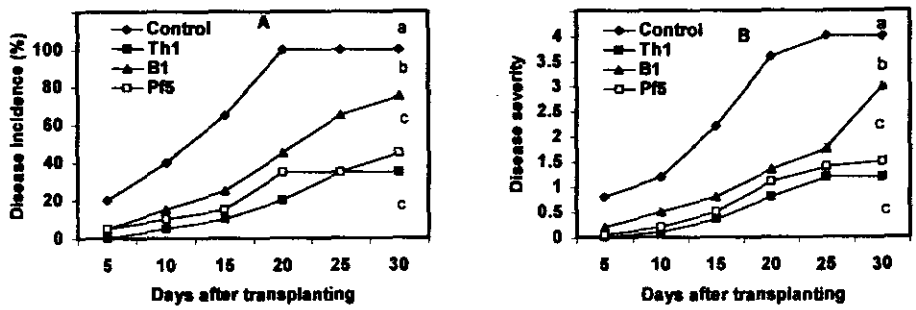

Fig. 3. Effect of three antagonistic microorganisms, *Trichoderma harzianum* (Th-1), *Bacillus subtilis* (B1), *Pseudomonas flourescens* (Pf5) on the incidence (A) and severity over time (B) of Phytophthora root rot on pepper plants grown in pots containing infested clay-loam soil. Disease severity was rated on a scale of 0-4.

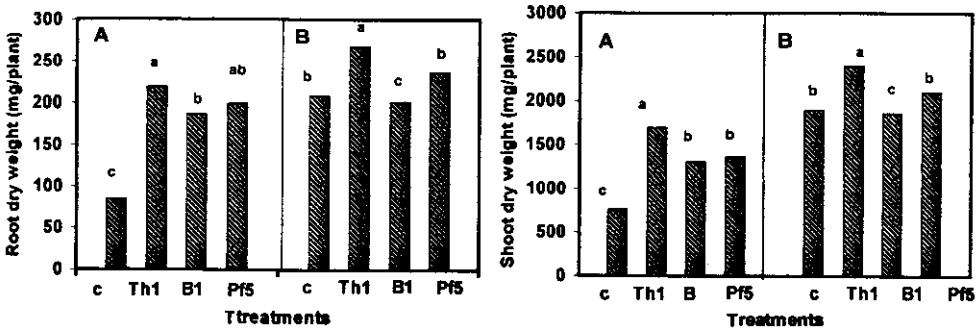

Fig. 4. Effect of three bioagents treatments, *T. harzianum* (Th-1), *B. subtilis* (B1), *Pseudomonas fluorescens* (Pf5) on root and shoot dry weight of pepper plants grown in pots containing either infested (A) or non-infested (B) soil with *P. capsici*. The columns headed by the same letter are not significantly different according to Duncan's multiple range test ($P \leq 0.05$)

increased in response to bioagent treatment in pathogen infested soil compared with non treated plants. Studies on growth response to three antagonistic in sterilized non-infested soil showed that root and shoot dry weight were increased greatly by *T. harzianum* and *P. fluorescens* treatments, respectively (Fig. 4). Meanwhile *B. subtilis* has no significant effect on plant growth.

DISCUSSION

This study report the incidence of Phytophthora root and crown rot of pepper in Egypt. Dead plants with typical symptoms were observed in late 1997 in pepper greenhouse at El-Salhia region. Isolation from diseased tissues on Masago's Phytophtora selective medium revealed the presence of *P. capsici*. Koch's postulates were performed for the fungus and proved that *P. capsici* was the causal of the disease. Further survey during 1998-2000 revealed that the pathogen caused serious losses in pepper nurseries and fields at Tokh district (Kalyobia), however, disease incidence was sporadic and limited in fields at Dakahlia, Sharkia, and Giza; only few plants showing typical symptoms of Phytophthora infection were obtained. Based on classical taxonomic approaches described by **Stamps *et al* (1990) and Erwin and Ribeiro (1996)**, all obtained *Phytophthora* isolates were identified as *P. capsici*. To our know edge, this is the first report of this pathogen on crops in Egypt. Root rot and wilt diseases are apparently occurred wherever pepper grown in Egypt. Several pathogenic fungi were isolated from root-rotted and wilted pepper plants in Egypt which included mainly *Rhizoctonia solani, Pythium* spp.,

Fusarium solani and *Fusarium oxysporum* **(Harfoush, 1970; Abada, 1994 and Abd El-Kader, 1999)**. Although, *P. capsici* could infect tomato also, **Fahim *et al* (1986) and Satour *et al* (1986)** have reported the incidence of *P. parasitica* on tomato in Egypt. The source of *P. capsici* on pepper in Egypt is unknown. These results suggest that it has been newly introduced to Egypt; possibily on recently imported seeds. The fungus can survive on and in seeds **(Sherf and Mac Nab, 1986)**. The fungus has a wide host range including pepper, cucurbits and tomato **(Satour & Butler, 1967 and Erwin & Ribeiro, 1996)**.

In the present study, it was observed that plants with severe disease was occurred in fields composed mostly of heavy clay soil, with poor drainage. Disease was also occurred in greenhouse plants which drip-irrigated more frequently. These observations are consistent with results of **Ristaino (1991) and Café-Filho & Duniway (1995)**. Diseases caused by species of *Phytophthora* generally increase with irrigation **(Duniway, 1983)**. Therefore, extending intervals between irrigation would help to manage *P. capsici* and to optimize the use of water resources without compromising commercial yield **(Café-Filho and Duniway, 1995)**.

In inoculation experiments, symptoms development and growth reduction were most severe in clay-loam soil under greenhouse conditions. The symptoms were typical of those described by **Sherf & Mac Nab, (1986) and Hwang & Kim (1995)**. In this study, *P. capsici* caused pre-and post-emergence damping-off when seeds were sown in infested soil mixture. Sudden wilt of entire plants was first observed few days after transplanting of plants in infested soil, which is caused by rotting of the stem near the soil surface **(Hwang and Kim, 1995)**. Variation in virulence of isolates of *P. capsici*, in this study, are in agreement with **Ristaino, (1990)**. Distinct pathogenic strains of *P. capsici* have been identified among diverse isolates from tomato, cururbits and pepper **(Polach and Webster, 1972)**.

In this study, all five *P. capsici* isolates were unable to form oospores when paired together in all different combinations, thus they considered to belong of one mating type only. *Phytophthora capsici* is a heterothalic fungus with two mating types, designated A1 and A2, are needed for sexual reproduction to form oospores **(Erwin and Ribeiro, 1996)**. Because tester strains of known mating type isolates were not available, the mating type of these isolates remain to be determined. Although, certain isolates of *P. capsici* produced a few homothalic oospores in single culture on V8 agar **(Ristaino, 1990)**, none of the isolate examined in the present study had produced such oospores. Oospores of *P. capsici* play an active role in the infection process **(Bowers & Mitchell, 1991 and Larkin *et al* 1995)**.

Control of the disease would be best achieved with resistant cultivars. All commercially available pepper cultivars and hybrids included in the experiments were susceptible to *P. capsici*. Selection of cultivars that are genetically resistant and planting in soil that is well drained are the most effective method of control **(Erwin and Ribeiro, 1996)**. Numerous attempts have been made to find sources of resistance to *P. capsici* in pepper; yet few resistant cultivars are deployed commercially **(Reifschneider *et al* 1992**

and Café-Filho & Duniway, 1995). Unforutnately, some of these cultivars did not possess sufficient horticultural characteristics to be accepted by the majority of the growers (Ristaino and Johnston, 1999).

Biological control and fungicides worked well in the experiments of this study when used as preventive treatments. In effect, this would require the controlling method to be applied at the same time at seed sowing in the nursery or propagation medium or at transplanting in the field. However, three fungicides used in this study showed different effects when used as preventive or curaive treatments against *P. capsici*. Metalaxyl and Privicor N were highly effective, as soil drench treatment, in reducing disease incidence and severity on pepper. Despite its effetiveness, resistance to metalaxyl by *P. capsici* had developed (Oh & Kim, 1992 and Pennesi *et al* 1998), and has caused considerable difficulties in the continuous use of this fungicide. However, all *P. capsici* isolates tested in the present study were sensitive to metalaxyl. Recently, the manufacturer replaced metalaxyl with mefenoxam (trade name: Ridomyl Gold), however, insensitivity to mefenoxam has been also reported from field isolates of *P. capsici* on bell pepper (Para & Ristaino, 1998 and Lamour & Hausbeck, 2000). However, the fature of these compounds is uncertain and a number of compounds with action against Oomycete pathogens are being evaluated as alternative (Ristaino and Johnston, 1999).

The results revealed the effectiveness of *Pseudomonas fluorescens* (Pf5) and *Trichoderma harzianum* (Th-1) for suppression of root rot incidence and severity on pepper. Both strains effectively reduced disease progress in artifically infested soil; and also stimulated plant growth in sterilized-non infested soil. Successful biological control of *P. capsici* on pepper has been reported (Lee *et al* 1999 and Sid Ahmed *et al* 1999 & 2000). Promotion of plant growth by rhizobacteria and fungi has been reported (Harris *et al* 1994 and Sid Ahmed *et al* 1999). Several possible mechanisms have been suggested to explain this phenomenon including production of plant hormones and vitamines, and increased uptake and translocation of minerals (Windham *et al* 1986 and Kleifled & Chet, 1992). Additional work is in progress in order to demonstrate the biocontrol efficacy of these isolates under commercial greenhouse conditions.

The results of this study demonstrated that Phytophthora root and crown rot is a serious additional threat to pepper production in Egypt. There is no available resistant cultivars and many regestered fungicides to control root-rot and wilt diseases in vegetable production are ineffective against Oomycete pathogens. Thus, selection for *Phytophthora* may be possible. It is a notifiable disease and efforts should be made to eliminate it before it becomes established. Much research should be directed toward development of integrated management strategy for soil-borne pathogens of pepper.

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مرض عفن الجذور والتاج الفيتوفثورى على الفلفل فى مصر

[٦١]

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يعتبر مرض عفن الجذور والتاج المتسبب عن الفطر فيتوفثورا كابسيسى من أخطر أمراض الفلفل فى مناطق عديدة فى العالم . يلقى هذا البحث الضوء على مدى وجود المرض فى زراعات الفلفل فى مصر سواء فى المشاتل أو الحقول المفتوحة أو الزراعات المحمية حيث لوحظ المرض أولا فى نوفمبر ١٩٩٧ فى إحدى الصوب بمنطقة الصالحية مسببا خسائر كبيرة لمحصول الفلفل ، وفى الفترة ١٩٩٨ الى ٢٠٠٠ لوحظ وجود المرض فى زراعات الفلفل بالقليوبية والدقهلية والشرقية والجيزة بنسب متفاوته لم تتعدى ٧% .

تتميز أعراض المرض بظهور ذبول عام على النباتات الكبيرة مع تساقط أوراقها مع وجود عفن طرى لونه رمادى مخضر الى بنى مسود على قاعدة الساق قرب سطح التربة غالبا والتى يحيط بها مؤديا لموت النبات وعند اقتلاع النبات من التربة يلاحظ تعفن للجذور والشعيرات الجذرية ويصبح لونها بنيا .

تم عزل الفطر الممرض من أنسجة سيقان وجذور الفلفل المصابه على بيئة متخصصة للفيتوفثورا (بيئة ماساجو) وحيث عرفت العزلات الناتجة بناء على صفاتها المورفولوجية والمرضية وإعتمادا على المراجع التقسيمية المتخصصة بأنها الفطر فيتوفثورا كابسيسى . أظهرت خمسة عزلات مختبرة تفاوتا فى قدرتها الامراضية على نباتات الفلفل من شديدة المرضية الى أقل مرضية . لم تكون أى من العزلات الخمسة جراثيما بيضية سواء فى المزارع النقية أو عندما تم تزاوجها معا على بيئة V-8 وهو مايؤكد أنها تتبع طرزا تزاوجيا واحدا للفطر . كانت جميع العزلات حساسة للمبيد الفطرى ميتالاكسيل . كانت جميع أصناف وهجن الفلفل الثمانية المختبرة شديدة القابلية للاصابة بالفطر الممرض . كانت مبيدات الريدوميل والبريفيكيور فعاله فى اختزال

شدة المرض سواء عند استخدامها وقائيا قبل العدوى أو علاجيا بعد العدوى بالفطر الممرض فى الصوبة . أظهرت بكتريا السيدوموناس فلورسينس (Pf5) وكذلك عزلة الفطر تريكوديرما هارزيانم (Th1) كفاءة عالية فى اختزال تقدم الاصابة بالفطر وشدة المرض على النباتات المعاملة بطريقة نقع الشتلات وغمر التربة عند الشتل ، كما أدت المعاملة أيضا الى زيادة الوزن الجاف للمجموع الخضرى والجذرى لنباتات الفلفل النامية فى تربة معقمة خالية من الممرض .

توضح الدراسة أن الفطر فيتوفثورا كابسيسى قد أصبح يمثل مشكلة فى زراعات الفلفل فى بعض المناطق فى مصر خاصة فى الزراعات المحمية حيث تناسب ظروف الزراعات المحمية انتشار المرض ونظرا لعدم وجود أصناف مقاومة للفطر المسبب للمرض فانه يجب إجراء مزيد من الدراسة لوضع استراتيجية متكاملة لمكافحة هذا الممرض الخطير ضمن برامج مكافحة مسببات أمراض أعفان الجذور والذبول الأخرى فى الفلفل تحت نظم الزراعة المختلفة فى مصر .

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