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Management of dry root rot disease of mandarin (*Citrus reticulate* Blanco) through biocomposted agricultural wastes

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The effects of soil drenching with biocomposted agricultural wastes (BCAW) , *Trichoderma harzianum* (spore suspension 5x10^6 cfu/ml) and Topsin-M 70% were evaluated for controlling dry root rot caused by *Fusarium solani* of mandarin (*Citrus reticulate* Blanco) under green house and field conditions. Manipulation of soil with biocompost (composted of sugarcane bagasse, rice straw and soybean straw inoculated with spore suspension 5x10^6 cfu/ml of *T. harzianum* isolate NB10) , *T. harzianum* (spore suspension 5x10^6 cfu / ml) and Topsin M 70% successfully controlled *F. solani* the main pathogen of dry root rot disease on mandarin. Complete reduction of the *F. solani* linear growth was recorded at 100 ppm of Topsin M and *T. harzianum* . In greenhouse, the highest reduction in Fusarium dry root rot disease on mandarin seedlings was obtained with biocompost (BCAW) at 10% (w/w) and Topsin-M (1 g/L) . Moreover, such treatments caused highest reduction in population density of *Fusarium solani* in rhizosphere soil of treated seedlings , but *Trichoderma* population were highly increased. Under Field condition which were amended soil around stems of diseased mandarin trees by biocompost (BCAW) and Topsin-M (1 g/L) treatments as twice applications per season resulted in recovering great number of diseased trees and decreased the disease severity on others. Population density of *Fusarium* spp. were highly decreased, where population density of *Trichoderma* spp were increased in rhizosphere soil of treated trees by biocompost (BCAW) . The highest increased in fruit yield was recorded on mandarin trees treated with bio-compost and Topsin M treatments as twice soil applications. It could be suggested that using soil amendments by biocompost (composed agricultural wastes colonized by *T. harzianum*) alone or in combined with a reduced rates of Topsin M 70 % (fungicide) can be successfully used to replace traditional fungicides and avoid environmental pollution.

Key words: Citrus Root rot, *Fusarium solani*, Biocompost .

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Introduction

Dry root rot disease of citrus caused by *Fusarium solani* (Mart.) is one of the most serious diseases attacked mandarin trees especially that cultivated in new reclaimed lands in Egypt, it has been estimated to affect 11.6% of mandarin trees and caused 39.6% loss in fruit yield (El- Mohamedy, 1998) . Such disease of citrus was reported to attack all citrus varieties (Conzulex *et al.,* 1997; El-Mohamedy, 1998; Catara and Polizzi, 1999). *F. solani* induce tow syndrome of root rot on citrus. Firstly , dry root rot is confined to the crown and scaffold roots and the second, feeder and fibrous root rots are associated with gradual decline of the canopy, leaf curl (witting), defoliation, dieback, fibrous roots turn soft and appears water soaked, slough their cortex easily by hand (Kore and Mane, 1992; Praksasmย *et al.* 1992; Verma *et al.* 1999).Control of this disease depends mainly on fungicides application (El-Mohamedy, 1998 and Verma *et al.* 1999). Meanwhile, fungicides are always desirable due to high coast, probability of development of resistant strains and potential hazards to the environment. Among the recent recommended trials for controlling soil borne pathogens other than fungicides, biological and soil amendment means individually or in combination were recommended. Such means comprise elimination of pathogens density in the soil and maintaining soil condition, favorable for root development and enhancement the competitive ability of bio agents against pathogens. There fore, these methods introduced efficient disease control and incensing yield of many crops (Huang, 1991; Tumey and Meng, 1994; Fang and Tsao, 1995; Walker and Morry, 1999; May and Kimati, 1999; Ceuster *et.al.*1999). Using agricultural wastes, domestic food wastes or some grains as substrates for *T. harzianum* growth formulation and directly delivery in soil for controlling soil borne pathogens on some crops were recorded (Hari and smosekhar, 1998; Godwin and Arinze, 2000; Liu and Huany, 2000; Prasad and Ragashwaran, 1999; El-Mohamedy *et al*., 2006). Sugar can bagasse degraded by *Trichaderma* spp was used as soil amendment to improve growth and yield of rice and pea (Mitra and Nandi, 1994). Nemec *et al.* (1996) noted that amended planting mixes with formulation of commercial bio control agents such as *T. harzianum, Bacillus subtilis, Gliocladium virens* and *Stroptomyces* spp reduced root rot and crown rot diseases on tomato, ball pepper, celery and citrus. The purpose of this research was to evaluate the efficiency of amended soil with biocomposed agricultural wastes colonized by *T. harzianum* on control of Fusarium dry root rot disease on mandarin as well as on population density of both the pathogen (*Fusarium solani)* and bioagent (*T. harzianum)* in rhizosphere soil. An attempt has been made to convert sugarcane bagasse, rice straw and soybean straw into a biomanure for land application using *T. harzianum*.

Materials and methods

Fungal isolates

Fusarium solani (Mart) Appal & Wr. Emeed. Snyd & Hans was previously isolated from naturally infected roots of citrus trees affected by root rot disease. This isolate was recorded to cause root rot on different citrus rootstocks in previous studies (El-Mohamedy, 1998). *Trichoderma harzianum* (Rifai) was previously isolated from rhizosphere soil of citrus trees by Dep. Plant. Pathology, NRC, Cairo, Egypt.

Effect of T. harzianum and Topsin M 70% on F. solani in vitro

Antagonistic ability of *T. harzianum* against *F. solani* was carried out on PDA medium using duel culture technique (Ferreira *et al.* 1991) Five Peteri dishes were used as replicates for each treatment. All plates were incubated at 25 ^{o}C for 5 and 10 days.Antagonistic ability was expressed as percent of reduction in linear growth of *F.solani* over the Reduction in linear growth of *F. solani* was calculated.

Serial quantities of Topsin- M 70% were added to conical flasks containing melted PDA medium to obtain final concentrations of 0.0, 25, 50, 100, 200, and 400 ppm and mixed gently and then dispensed in sterilized Petri dishes (10 cm diameter). Plates were individually inoculated at the centre with equal disks (5 mm diameter) of 10 day old culture of *F. solani* and incubated at 25°C. The overage linear growth of fungi was calculated after 7 days. Each treatment was represented by 5 replicates.

The spores of *Fusarium solani* obtained from the 10-days-old cultures on PDA medium were collected, suspended in distilled sterile water, and mixed with appropriate aliquots of stock aqueous suspension/solutions of Topsin M 70% to obtain a density of 5 x 10^5 spores/ml and the concentrations of Topsin M. Three drops (about 50µl) of each treatment were then placed on microscopic slide , kept at 20°C in moisten filter paper placed in Petri dishes for 28 h. The germination percentages of conidia (50 conidia for each treatment) were measured using an Olympus Cx40 microscope. The conidium's was considered germinated when the germ-tube length was at least equal to the conidial diameter. The experiment was replicated four times.

Preparation of biocomposted agricultural wastes (BCAW)

Agricultural wastes such as Sugarcane bagasse, rice straw and soybean straw were ground to powder, mixture of 250 g of each waste powder was mixed with sand soil (4:1) in polyethylene bags, then 2.0 g ammonium sulphate ,5.0 g super phosphate , 5.0 g potassium sulphate and 400 ml water per 1000 g powder were added to each bag. All bags were sterilized for 1 hr in autoclave at 121C. The mixture in a half of these bags were inoculated by spore suspension of *T. harzianum* 3 x 10^6 spore / mL (this mixture represented as biocompose) and the other left as cheek treatment control (this mixture represented as compost). All bags were incubated at 25^{o}C for 21 days at room temperature, then used as biocomposted agricultural wastes (BCAW) (composed agricltrural wastes colonized by *T. harzianum*) or composted agricultural wastes (CAW) for direct application into the soil.

Greenhouse experiments

The experiments were carried out to evaluate the efficacy of different soil amendments (BCAW or CAW) as well as Tosin-M (fungicide) treatments to control *Fusarium* dry root rot on mandarin seedlings, inoculum density of *Fusarium* and *Trichoderma* in rhizosphere soil of treated seedlings.

Plastic pots (20 cm diam.) containing sand loam soil (2:1) were infested by *F. solani* according to El-Mohamedy (1998) were used. Mandarin cv. Baladi seedlings (3 years old) grafted on sour orange rootstock were inoculated by the same pathogen and replanting in infested soil according to Strauss and Labuschagen (1995). Five seedlings were used as replicates for each treatment.

The following treatments were evaluated as biocomposted agricultural wastes (BCAW) colonized by *T. harzianum*) at the rate 10 % (w/w) of soil infested soil. Composted agricultural wastes (CAW) at the rate 10 % (w/w) of soil infested soil, *T. harzianum* at the rate 5% (v/w) of infested soil, fungicide (Topsin-M 70%) 1.0 g /L, control (non treated infested soil).

After 15 days from soil infestation, all mandarin seedlings were replanting. All soil treatments were applied at replanting time of seedlings as one application, and 30 days from replanting seedling as second application. The number of diseased seedlings was recorded and development of disease symptoms (severity) on seedlings was determined and rated on scale from 0-4 rates (0 = healthy plants 4 = dead plants) according to Morgan and Timmer (1984) and El-Mohamedy (1998). Percentages of the disease infection and severity after 90 days from replanting of the seedlings were recorded and calculated.

Field experiments

The experiments were carried out at Nobaria province (Behiera Governorate) during 2008 and 2009 seasons in two Privet orchards of mandarin (10-year old cv. Baladi grafted on sour orange rootstock) with the history of root rot disease. The following soil treatments were used:- BCAW 1 kg/tree, CAW 1 kg/tree, Topsin M 70 % 20 g/tree and control (non-treated pathogen).

One hundred and twenty diseased mandarin trees showing typical symptoms of *Fusarium* dry root rot disease were selected. 10 diseased trees with different rates of disease severity (1, 2 and 3) were used as replicates for each treatment as well as control treatment. All soil treatments were applied to soil around mean stem of tree twice per season, first, in spring (March) and the second in summer (July). After 60 and 90 days from the adding second application a number of recovered trees and the development of disease severity on diseased trees were recorded. The percentages of disease severity were calculated.

Count of *Fusarium* and *Trichoderma* propagules in rhizosphere soil. Plate count technique (Allen, 1961), using Peptone PCNB agar medium (Nash and Snyder, 1962) and PDA medium supplement with 250 ppm chloromycetin (Papavizes and Lumsden, 1982) was used to determine total counts of *Fusarium* and *Trichoderma* in rhizosphere soil of mandarin seedlings or trees respectively. Five plates were used as replicates for each treatment. Total count of each fungus was expressed as cell forming units (cfu) per gram dry soil.

Effect of soil amendment treatments on mandarin yield: all fruits of each tree in each treatment were picked and weighted, the average of fruit yield per tree as well as per Faddan was calculated. A number of 50 fruit from each treatment were weighted and the average weight of fruit was determined.

Statistical analysis: tukey test for multiple comparision among means was utilized (Neler *et al*., 1985).

Results

Effect of T. harzianum and Topsin M on F. solani in vitro

The inhibitory effect of different concentrations of Topsin-M and *T. harzainum* against linear growth and spore germination of *F. solani* were tested. Results showed that increasing fungicide concentration caused strongly decrease on both linear growth and spore germination of *F.solani* as shown in Table 1. The linear growth and spore germination of *F. solani* were completely inhibited at 200 ppm of Topsin M. *T. harzainum* was highly antagonistic to *F.*

solani as complete reduction (100%) of the growth of *F. solani* recorded after eight days of incubation .

Table 1. Percentage reduction (%) of linear growth and spore germination of *F. solani* as affected by Topsin-M 70% and *T .harzianum* PDA medium

Treatment		**Linear growth (mm) reduction %**	**Spore germination reduction %**
Tosin -M 70% (fungicide)	25 ppm	0.0	0.0
	50 ppm	15.0	22
	100 ppm	60.0	74
	200 ppm	100	100
	400 ppm	100	100
T .harzianum		100	100
Control		0.0	0.0

Greenhouse experiments

The effects of amended artificially infested soil (in greenhouse) with different soil amendments as well as fungicide treatment on percentage of infection and severity of *Fusarium* dry root rot on mandarin seedlings was studied. Population density of *Furarium* and *Trichoderma* propagules counts in rhizusphere soil was also determined.

Result showed that both disease infection and severity of mandarin seedlings in all tested soil treatments were significantly reduced when compared with control as shown in Table 2. *Fusarium* root rot disease on mandarin seedlings was highly significant reduced when BCAW and Topsin-M treatments were delivered into artificially infested soil as twice application compared with control (untreated infested soil). As the percentages of disease infection and severity were 32 and 44 % and 15 and 28 % compared with 100 and 84% of control treatment respectively. Meanwhile, CAW and *T. harzianum* treatments gave a considerable disease control compared with control treatment especially with twice application.

Results indicated that all tested soil treatments were significantly reduced the population total counts of *F. solani* compared with control as shown in Table 3. BCAW and Topsin-M treatments showed a high significant reduction in population density of *F. solani* in rhizosphere soil of treated seedlings. These counts were 1.3 and 2.2 x 10^5 cfu/g dry soil compared with 3.1 x 10^5 cfu/g soil of control treatment. Meanwhile, when these treatments were applied as one application the total counts were 3.1 and 3.0 x 10^5 cfu/g dry soil of the same pathogen.

Twice soil applications of BCAW, CAW and Topsin-M treatments were highly effective in controlling *Fusarium* root rot disease on mandarin seedling in green house experiments. Moreover, they decreased population density of *Fusarium* and caused increasing in population density of *Trichoderma* around roots of seedlings. So, these treatments were chosen for controlling the disease on mandarin trees under field conditions.

Table 2. Effect of different soil treatments on *Fusarium* dry root rot incidence (%) on mandarin seedlings planting in artificially infested soil in greenhouse

Soil treatment	No. of application	Fusarium dry root rot incidence			
		Disease severity %	Reduction %	Disease severity %	Reduction %
BCAW (10% w/w) (1)	One	66 c (2)	34	38 e	54.7
T. harzainum (10% v/w)		88 b	22	60 cd	28.6
CAW (10% w/w)		88 b	22	71 b	15.5
Topsin –M 70% (1 g/L)		88 b	22	55 d	34.5
BCAW (10% w/w)	Two	32 d	68	15 h	82.1
T. harzainum (10% v/w)		66 c	34	44 e	47.6
CAW (10% w/w)		88 b	22	60 cd	28.6
Topsin –M 70% (1 g/L)		44 c	56	28 f	66.7
Control		100 a	0.0	84 a	0.0

BCAW : bio composed agricultural wastes CAW : composed agricultural wastes
Figures with the same letters are not significant different (P =0.05)

Table 3. Effect of different soil treatments on total counts of *Fusarium* and *Trichoderma* propagules in rhizosphere soil of mandarin seedlings planting in artificially infested soil in greenhouse

Soil treatment	No. of application	Fusarium propagules cfu x 10^5/g dry soil	Trichoderma propagules cfu x 10^4/g dry soil
BCAW (10% w/w)(1)	One	3.1b	5.9 b
T. harzainum (10% v/w)		3.3 a	4.4 c
CAW (10% w/w)		3.5 a	0.0 d
Topsin –M 70% (1 g/L)		3.6 a	0.0 d
BCAW (10% w/w)	Two	1.3 d	6.4 a
T. harzainum (10% v/w)		3.1 b	4.6 c
CAW (10% w/w)		3.3 a	4.2 c
Topsin –M 70% (1 g/L)		2.2 c	0.0 d
Control		3.6 a	0.0 d

BCAW: bio composed agricultural wastes CAW : composed agricultural wastes
Figures with the same letters are not significant different (P =0.05)

Field experiments

The experiments were carried out under field conditions to evaluate the effect of different soil treatments before on recovering naturally infested mandarin trees with *Fusarium* root rot disease. Population total counts of Fusarium and *Trichaderma* propagules counts in rhizosphere soil and also fruit yield of trees were estimated.

Result showed that all soil treatments reduced both the number of infected trees and percentages of disease severity on these trees as shown in Table 4. There are no significant differences between all tested treatments and control (untreated diseased trees). The severity of disease on these trees was reduced after 60 days from soil application. Meanwhile, after 120 days from amended soil with BCAW, CAW and Topsin-M resulted in recovering 4, 7 and 6 trees and reduced disease severity from 84.4 % of control treatment to 16.1, 27.5 and 41.0% of the same treatments respectively.

Table 4. *Fusarium* dry root rot development on mandarin trees as affected by different soil treatments under field conditions during 2008 and 2009 seasons

Soil treatment	Season	Fusarium dry root rot devilment					
		No. of diseased trees after application			Disease severity (%) after application		
		0 day	60 day	120 day	0 day	60 day	120 day
BCAW (10% w/w)[1]	2008	10 a [2]	7 b	4 c	50 b	34.0 c	16.1 d
CAW (10% w/w)		10 a	8 b	6 c	50 b	48.2 b	41.0 b
Topsin –M 70% (1 g/L)		10 a	10 a	7b	50 b	36.6 c	27.5 c
Control		10 a	10 a	10 a	50 b	73.4 a	84.8 a
BCAW (10% w/w)		12 a	6.0 b	4c	60 a	32.0 c	15.0 c
CAW (10% w/w)	2009	12 a	9 b	5 c	60 a	42.0 b	30.0 b
Topsin –M 70% (1 g/L)		12 a	12 a	8 b	60 a	35.0 c	25.0 b
Control		12 a	12 a	12 a	60 a	75.0 a	85 a

1- BCAW : bio composed agricultural wastes CAW : composed agricultural wastes
2- Figures with the same letters are not significant different (P =0.05)

Table 5. *Fusarium* and *Trichoderm* propagules counts in rhizosphere soil of infested mandarin trees affected by different soil amendment treatments under field conditions during 2008 and 2009 seasons

Soil treatment	Season	Fusarium propagules count (cfu x 10^3) / g dry soil			Trichoderma propagules count (cfu x 10^3) / g dry soil		
		0 day	60 day	120 day	0 day	60 day	120 day
BCAW (10% w/w)(1)	2008	7.5 a(2)	4.8 c	6.8 c	1.7 ab	8.7 a	9.0 a
CAW (10% w/w)		7.2 a	6.3 bb	7.5 b	1.5 b	2.2 c	2.4 c
Topsin –M 70% (1 g/L)		7.5 a	5.1 c	5.1 d	2.0 a	4.6 b	5.5 b
Control (diseased tree)		7.5 a	10.6 a	12.5 a	1.8 ab	3.1 c	3.2 c
BCAW (10% w/w)		5.5 c	4.3 c	4.0 c	1.8 b	9.0 a	12.5 a
CAW (10% w/w)	2009	6.0 b	5.6 b	5.2 b	2.0 a	2.5 b	2.7 b
Topsin –M 70% (1 g/L)		6.5 b	6.0 b	5.5 b	1.5 b	2.2 b	2.0 b
Control (diseased tree)		8.5 a	12.0 a	13.0 a	2.0 a	3.0 b	3.0 b

1-BCAW : bio composed agricultural wastes CAW : composed agricultural wastes
2- Figures with the same letters are not significant different (P =0.05)

Result indicated that all soil treatments were significantly reduced the number of *Fusarium* propagules counts in rhizosphere soil of treated trees, while it increased in untreated diseased trees (control) as shown in Table 5. BCAW and Topsin-M treatments show highly effective in inhibition of *Fusarium* activity (density) around roots of trees followed by CAW treatment. BCAW, CAW and Topsin-M treatments reduced the counts of *Fusarium* propagules counts from 12.5 x 10^3 cfu / g soil (untreated diseased trees) to 8.6, 7.5 and 5.1 x 10^3 cfu / g soil respectively. Moreover, these treatments cause increasing in population density of *Trichoderma* spp around roots of treated trees except in the case of Topsin-M treatment. As the total propagules count of *Trichoderm* spp in rhizosphere soil of treated trees with BCAW or CAW were 9.0 and 5.5 x 10^3 cfu / g dry soil compared with 3.2 and 2.4 x 10^3 cfu / g dry soil with untreated control and Topsin-M treatments respectively.

It showed that averages of fruit yield per tree and fruit weight were increased due to amended soil of diseased trees with BCAW, CAW and Topsin-M treatments during 2008and 2009seasons as shown in Table 6. These values were 67.4, 64.2, 40.0 kg/tree and 154 ,140, 121 g/fruit respectively compared with 30.0 kg/tree and 85 g/fruit of untreated diseased trees (control). Total fruit yield per / feddan was increased by 131.9, 117.0 and 68.1% due to amended soil of infected trees with the same treatments, respectively during 2008 season. The same trend of results was recoded during the second season 2009.

Table 6. Effect of different soil treatments on fruit yield of mandarin trees affected by *Fusarium* root rot disease under field conditions during 2008 and 2009 seasons

Soil treatment	Season	Average fruit tree (kg)	Average fruit weight (g)	Fruit Yield	
				Ton / Feddan	% Increase over control (diseased tree)
BCAW (10% w/w)[1]	2008	67.3 a[2]	154.0 a	10.9 a	131.9
CAW (10% w/w)		50.0 c	121.0 c	7.9 c	68.1
Topsin –M 70% (1 g/L)		64.2 b	140.0 b	10.2 b	117.0
Control (diseased tree)		30.0 d	93.0 d	4.7 d	—
Control (Healthy tree)		70.6b	167bc	11.3b	—
BCAW (10% w/w)		70.5 a	162.0 a	12 .0 a	126
CAW (10% w/w)	2009	54.0 c	134.0 c	8.2 c	54.7
Topsin –M 70% (1 g/L)		62.0 b	146.0 b	11.2 b	111.3
Control (diseased tree)		35.0 d	100.0 d	5.3 d	—
Control (Healthy tree)		70.6b	167bc	11.3b	—

1-BCAW : bio composed agricultural wastes CAW : composed agricultural wastes
2- Figures with the same letters are not significant different (P =0.05)

Discussion

Fusarium root rot disease caused by *Fusarium solani* (Mart.) is one of the most serious diseases attacked mandarin trees especially that cultivated in new reclaimed lands in the desert (El-Mohamedy, 1998). Control such disease has been greatly concerned in Egypt, especially after an increasing of citrus cultivation in these lands. The same tern of results are in agreement with El Mohamedy (1998, 2004), as they indicated that *T. harzainum* alone or in combination with fungicides have been used in combination of chemical-biological integrated control programs against several soilborne plant pathogens. Elad *et al*. (1980) found that the mechanisms of the antagonism of *T. harzainum* against different pathogens may be due to mycoparasitism, competition and antibiosis.

Trichoderma spp. formulations on wheat bran, CMC, sorghum grains, agricultural wastes and domestic food wastes were used and delivery for bio control into soil and soil amendments for controlling soil borne pathogens on some crops were investigated and recorded by many researchers (Mitra and Nandi, 1994; Sawant *et al*.1995; Nemec *et al*.1996; Prasad and Ragashwaran, 1999; Liu and Huany, 2000; Godwin and Arinze, 2000).

In greenhouse experiments, amended artificially infested soil with BCAW (composted agricultural wastes colonized by *T. harzianum*), CAW, Topsin-M (1 g/L) or spore suspension of *T. harzianum* treatments caused significant reduction in percentages in infection and severity of *Fusarium* dry root rot disease on mandarin seedling compared with control (untreated seedlings). Twice soil application with BCAW, *T. harzianum* and Topsin-M treatments were highly effective treatments in controlling the disease. Moreover, population density of propagules counts of *Fusarium* were highly decreased, where population density of *Trichoderma* propagules were highly increased in rhizosphere soil of seedling treaded with BCAW and CAW. The reduction in both disease infection and severity on seedlings may be attributed to the highly decreased in population density of the pathogen in the soil and increased the activity of *T. harzianum* propagules in the soil. Moreover the antagonistic ability of the bioagent against the pathogen and its enzymatic activity (chitinase and cellulase) were highly increased due to growing the bio agent on sugarcane bagasse (El-Mohamedy, 2004). *Trichoderma* spp. enhanced the growth and induced systemic resistance of plants (Klopper *et al.*1981; Windham *et al.*1986).

Control of root rot disease pathogens through amended soil by organic materials or agricultural wastes alone or in combined with biocontrol agents may be attributed to increase the activity of the indigenous microflora resulting suppression of pathogens population through competition or specific inhibition, and to release degradation compounds such carbon dioxide, ammonia, nitrites, saponins or enzymes which are generally toxic to the pathogens, to induce plant defense mechanisms and for cellulase and glucanase reactions are prevalent to high concentration as a result of the breakdown of cellulase and lignin by microorganisms in the soil (Kloepper *et al*. 1981; Tsao and Oster, 1981; Tumey and Menge, 1994; Wang, 1999;Walker and Morry, 1999; Liu and Huang, 2000).

In field experiments, the soil around stems of naturally infected mandarin trees with *Fusarium* dry root rot disease were amended with BCAW, CAW or Topsin-M treatments as twice application per season. Such treatments resulted in recovering some of diseased trees and reduced disease severity on the others. The best soil treatments in controlling the disease were BCAW followed by Topsin-M. These treatments reduced the number of infected mandarin trees, disease severity on diseased trees and also caused high reduction in population density of *Fusarium* spp in rhizosphere soil of treated trees compared with control (non treated diseased trees). Moreover, population density of *Trichoderma* propagules counts were highly increased in rhizosphere soil of trees that treated with the same treatments. These results are relatively in accordance with results recorded by Fang and Tsao (1995); Sawand *et al.* (1995) and Tewari and Mukhadhyay (2001); Sawant *et al*. (1995) fount that *Phytopthora* root rot of mandarin trees was significantly reduced when the soil of the trees were drenched with Ridoml and amended with *Trichoderma* spp. grown on coffee waste. In addition, these treatments cause an increasing in fruit weight, fruit yield per tree and also total yield per feddan. Increasing fruit yield of mandarin trees may be due to the high number of recovered diseased trees, enhanced in the growth of treated trees due to inhibition of pathogen (*Fusarium*) activity and increasing population density of bioagent (*Trichoderma*) in rhizosphere soil. ,restricted the development of feeder roots providing a healthy and vigorous trees capable of producing maximum yield .Amended soil with agricultural wastes inoculated by different biocontrol agents were recoded to improve plant growth and increased their yield (Tumey and Meng, 1994; Mitra and Nandi, 1994; Nemec *et al*. 1996).

It could be suggested that supplemented agricultural wastes with bio control agents such *Trichoderma* spp. then added to the soil as soil amendments or biofertilizer for controlling soilborne pathogens can be successfully used under field conditions replacing traditional fungicide treatments and avoid environmental pollution.

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