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Original Research Article

Bio–Compost Field application to control major soil borne fungal diseases and improvement growth and yield of potato (*Solanum tuberosum* L.) plants

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Abstract

Black scurf and dry rot diseases caused by *Rhizoctonia solani* and *Fusarium sambucinum* are the most limiting factors for potato production. In laboratory trials, *Trichoderma harzianum* isolate 3 and *T.viride* isolate 1 showed highly antagonistic effect against all tested pathogenic isolates of *R. solani* and *F. sambucinum*. All bio compost extracts inhibited linear growth of R. *solani* and *F.sambucinum*, bio compost 3 at 50% concentration provided highest reduction in linear growth. Drenching soil with tested bio composts before sowing potato tuber significantly reduce Fusarium dry rot and Rhizoctonia Black scurf diseases during two cultivation seasons. Bio-compost 3 followed by bio compost 1 and 2 were the most effective soil treatments in control of both diseases during two seasons. Moreover, such treatments resulted highest records of plant growth parameter as well as quantity and quality of potato tuber yield. The highest records of potato total tuber yield, nutritional values, and total carbohydrates were observed in bio compost 3 followed by bio compost 1 and bio compost 2 soil treatments if compared with compost 4 and control treatments during 1st and 2nd seasons. It could be stated that, field application of composted agricultural wastes fortified with bio control agents could be suggested as easily soil biologically soil treatment for controlling fungal soil borne pathogens of potato especially under organic farming system.

Key words: Bio compost, Biological control, Fusarium dry rot, Potato, Rhizoctonis black scurf

INTRODUCTION

Potatoes (*Solanum tuberosum* L.) are widely cultivated and could contribute to reducing worldwide food shortages. Soil borne diseases are still a major threat to potato cultivation in Egypt. Several very important potato pathogens in Egypt originate from soil borne inoculums. Potato plants are susceptible to devastation by various diseases such as Black scurf caused by *Rhizoctonia solania* and dry rot caused by *Fusarium sambucinum* (Frank *et al*., 1979; Agrios, 1997 and Peters *et al*., 2008).The soil borne fungal pathogen *Rhizoctonia solani* Kühn (teleomorph: *Thanatephorus cucumeris* (Frank) Donk) pathogenic to potato is ubiquitous in potato production worldwide (Banville *et al*., 1996).The pathogen can cause lesions (canker) on below-ground plant tissues, and produces sclerotic on daughter tubers (black scurf). Both diseases reduce marketable tuber yields. In the same time Rhizoctonia solani infected plant lets may develop crown root , root rot ,or stem canker which often leads to wilting and plant death in the sever cases. Similarly Fusarium dry rot of seed tubers can reduce establishment by killing the developing potato spouts. Also, both diseases can greatly affect tuber quality and therefore, can severely reduce its market value (Scholte, 1989 and Sadfi *et al*., 2002). Control of soil borne pathogens such as *R. solani* and *F. sambucinum* is difficult because these pathogens survive for many years as sclerotia in soil or as mycelim in organic matter under several environmental conditions (El-Kot, 2008) .Control of Rhizoctonia and Fusarium diseases has commonly relied on culture practices and on the use of fungicidal treatments (Ivanyuk and Aleksandeow, 1996 and Rauf *et al*., 2007). However, cultures practices alone are not efficient and at the present time. Chemical control was massively applied, however, for the increasing public concern over the fungicides usage (Ekhlas *et al*., 2006).

In the recent years alternative control methods are strongly desired for sustainable agricultural, where organic amendments play an important role an environmentally friendly and sustainable alternative to protect plants against soil borne pathogens .The use of organic agricultural wastes in this respect can be an advantageous both in soil fertility, recycling of agricultural residues and could provide a powerful tool for management of plant diseases. Compost and /or composts fortified with bio control agent (bio-compost) were applied as soil amendments to reduce pathogens propagates density and protected plants from soil borne plant pathogens (Huang, 1991; Yogen *et al.,* 2006 and Khalil and El-Maghrabia, 2010).

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; Prasad and Ragashwaran, 1999; Godwin and Arinze, 2000; Liu and Huany, 2000 and El-Kot, 2008). Sugar can bagasse degraded by *Trichaderma* spp was used as soil amendment to improve growth and yield of many crops. Amendment of compost with *Trichoderma harzianum* was reported to accelerate agricultural wastes composting and improved its diseases –suppressive effect (Mitra and Nandi, 1994; Nemec *et al.,* 1996; Ravelo *et al*., 2000; El-Mohamedy, 2004; El-Mohamedy *et al.,* 2006, 2010 and 2012).

The present study was designed to investigate the potential of manipulating soil with bio composts made from composted agricultural wastes that fortified with *Trichodrema harzianum* and /or *T. viride* in control of Rhizoctonia back scurf and Fusarium dry rot diseases of potato as well as the beneficial effect of such treatments of growth and tuber yield was investigated under organic farming system.

MATERIALS AND METHODS

Plant material and pathogenic isolates

Different pathogenic isolates of *Rhizoctonia solani and Fusarium sambucinum were* isolated from diseased potato tubers samples collected from different fields located at Nubaria region, Behera Governorate, Egypt in previously studies. Three aggressiveness isolates of each R*. solani and F. sambucinum* were used in the present study. Potato seeds cv. Diamond were used for cultivation under field conditions.

Antagonistic of *Trichoderma spp.* against *R. solani* and *F. sambucinum* in vitro

The antagonistic ability of *Trichoderma harzianum* and *T. viride* was tested against *F. sambucinum* and *R. solani* the causal pathogens of dry rot and black scurf diseases of potato respectively, using Dual culture technique (Ferreria *et al.,*1991). A 5-mm disk of *T. harzianum* growth culture was placed onto the PDA, 10 mm from the edge of the Petri dish. Another disk of the same diameter of *F. sambucinum* fungal growth culture was placed on the opposite side of the dish at the same distance. The control treatment was inoculated with a culture disk of either pathogenic or antagonistic culture alone at the same conditions. All inoculated Petri dishes were incubated at 25±2^{o}C and the fungal growth diameter away from and towards the antagonist agent was measured after the pathogenic fungal growth in the control treatment had reached the edge of the Petri dish. The radial growth of the all treatments was measured after 8 days of incubation periods and the percentage of reduction in fungal growth was calculated.

Effect of bio-compost extracts (bio-composts tea) on pathogens growth in vitro

A modified technique from Szczech (1999) and Bernal-Vicente *et al*. (2008) was applied to measure the inhibitory effect of the compost extracts on linear growth of *F. sambucinum* and *R. solani* growth. Compost extracts were prepared by mixed different samples of tested bio-composts with tap water at a 1:2 ratio (w/v) and extracted at 25ºC for 48 h. After incubation, the mixtures were filtered through cheesecloth and the clean extracts were sterilized by autoclaving. PDA media were prepared with low water content and after autoclaving they were filled with the filtered extracts in concentrations of 0, 10, 20, 30, 40 and 50 %. Discs (5 mm) of 7-day-old of each *F. sambucinum* and *R. solani* mycelium were placed in the center of each plate, which were then incubated at 27ºC for one week .The radial growth of the all treatments was measured after 8 days of incubation periods and the percentage of reduction in fungal growth was calculated.

Bio composts Preparation

Three available agricultural residues, *i.e*. sugarcane bagasse (industrial wastes of sugarcane), rice straw and soybean straw were used as raw materials for compost formulation according to the rapid composting method described by Cuevas (1993) and El-Mohamedy (2004).

A mixture of sugarcane bagasse + rice straw + soybean straw was ground to small pieces, then, 8.0g ammonium sulphate, 20.0g super phosphate, 20.0g potassium sulphate were added to each 1 kg of ground mixture (400 mL/1kg) and mixed thoroughly the packed into polyethylene bags. All polyethylene bags were autoclaved for 1 hr at 121°C and left at room temperature 25C for 14 days. The bags contained composted agricultural wastes were divided into four types of composts as follow:

Bio compost 1: compost inoculated with 50 mL/Kg spore suspension 3x106 spore/mL of *Trichoderma harzianum* isolate 3(Th3).

Bio compost 2: compost inoculated with 50 mL/Kg spore suspension 3x106 spore/mL of *T. viride* isolate 1 (Tv1).

Bio compost 3: compost inoculated with 25 mL/Kg spore suspension 3x106 spore/mL of each *T. harzianum* Th3 and *T. viride* Tv1.

Compost 4: compost of sugarcane bagasse + rice straw + soybean straw without inoculated by bio agent. All inoculated and uninsulated bags were incubated for 14 days at room temperature (25-27°C). Then composted agricultures wastes that fortified with bio agents (*T. harzianum* and *T.viride)* were used as bio compost for direct incorporation into the field soil.

Management of Rhizoctonia black scurf (RBS) and Fusarium dry rot (FDR) diseases under field conditions

The efficiency of manipulation soil with different formulations of bio composts to control soil borne pathogens, i.e., *Rhizoctonia solani* and *Fusarium sambucinum* the causal agents of RBS and FDR diseases of potato, respectively were studied during two winter growing seasons 2013and 2014. Field experiment consisted of plots 42 m^2 (3x14m) in area with three replicates for each treatment as well as control. Each plot comprised of 3 lines with 60 cm between holes. Potato tuber cv. Diamond was planted in the private farm with history of RBS and FDR diseases of potato at Nobaria providence, Beheria Governorate, Egypt. Whole potato tuber were sown (one tuber /hole) in two winter growing seasons 2013and 2014. The experiment was carried out using a randomized complete block design with four replicates and five treatments as follow: T1 = Bio compost 1 (Compost fortified with *T. harzainum* isolate 3 -TH3). T2 = Bio compost 2 (Compost fortified with *T. viride* isolate 1-TV1). T3 = Bio compost 3 (Compost fortified with *T.harzianum* isolate 3 -TH3 + *T. viride* isolate 1-TV1). T4 = Compost 4 (composted agricultural wastes of sugar bagasse, soybean and rice straw without inoculated with any bio agents). T5 = Control (non soil treatment). Compost and bio composts soil treatments were applied at the rate of 750 g / m^2 in the top of 20 cm of the soil surface during soil preparation 10 days before potato planting.

Assessment of Rhizoctonia black scurf (RBS) and Fusarium dry rot (FDR) Diseases

Plants were evaluated throughout 60 days for stem and tuber diseases signs (stem lesion, canker, girdling, pruning, and stolen pruning). A plant is considered infected with Rhizoctonia black scurf (RBS) when one or more than of these signs appeared. Incidence of these was expressed in percentage by dividing infected plants on the total plant emergence. The severity of the RBS disease was determined on a zero to 5 scale, with zero indicate no signs, 1 - small lesions (0.2cm long), 2- medium lesion (0.2cm long), 3 - canker (0.3cm long), 4 - girdling of stem and 5- pruning of stem (Frank *et al*., 1979). Fusarium dry rot (FDR) was determined as percentage of infected tuber in a 200-tuber sample.

Plant growth measurements

A sample of 10 plants was randomly taken at flowering stage (60 days after sowing date), from each experimental plot for determining growth characters of potato plant, as follows: Plant height from soil surface to the highest point of the plant, number of leaves and branches per plant as well as fresh and dry weight of leaves, branches and whole plant.

Total bulbs yield parameters

At harvesting stage (90 days after sowing), total yield from each plot were harvested. The following data were recorded: number of tubers per plant, number of tubers per m^2, weight of tubers per plant (g), weight of tubers (ton\fed.), fresh weight of tuber (g) and tuber size (cm^3) as well as fresh and dry weight of tuber (g) was also calculated.

Nutritive value of tubers

A random sample of 10 tubers at harvested were taken and the following data were recorded: N percentage in tuber was determined according to the method of Pregl (1945). In addition, protein percentages in tuber were calculated by multiplying nitrogen content by 6.25. Potassium was assayed using flame spectrophotometer according to Allen *et al.* (1984). Phosphorous was extracted and measured spectrophotometer according to

Table 1. Fungal growth reduction (%) of *R. solani* and *F.sambucinum* affected by Trichoderma spp. on PDA medium in *vitro*.

	R. solani		***F. sambucinum***	
***Trichoderma spp* isolate**	**Linear growth (mm)**	**Reduction %**	**Linear growth (mm)**	**Reduction %**
T. harzianum Th1	22b	75.5	29b	67.8
T. harzianum Th2	18c	80.0	24bc	73.3
T. harzianum Th3	10d	88.8	14c	84.4
T. viride Tv1	13d	85.5	18c	80.0
T. viride Tv2	25b	72.2	28b	68.8
T. viride Tv3	22b	75.5	26b	71.1
Control	90a	0.0	90a	0.0

Means followed by the same letter are not significantly different at P ≤ 0.05.

Jackson (1965). As well as Fe, Mn, Zn and Cu (ppm) were determined using flame ionization atomic absorption spectrophotometer model 1100 B according to the method of Chapman and Pratt (1978). In addition, total tuber carbohydrate was determined according to the method of Dubois, *et al* (1960).

Statistical Analysis

All data obtained were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran (1982) and Tukey test for multiple comparisons among means was utilized (Neler *et al*., 1985).

RESULTS AND DISCUSSION

Antagonistic activity of *Trichoderma spp*. against *R. solani* and *F.sambucinum* in vitro

The antagonistic ability of three isolates of each *T. harzainum and T. viride* against *R. solani* and *F. sambucinum* on PDA medium was recorded in Table (1).

All isolates of *Trichoderma* spp. have antagonistic effect against *R. solani* and *F.sambucinum* with different degrees of inhibition.

T. harzainum isolates cause reduction in linear growth *R.solani* by 75 .5-88.8% and *F. sambucinum* by 67.8-84.4%. Meanwhile, *T. viride* isolates cause reduction in linear growth of the same pathogens by 72.2-85.5% of *R.solani* and by 68.8-80.0% of *F. sambucinum.T. harzainum* isolate(Th3) and *T.viride* isolate (Tv1) caused highest reduction in linear growth (88.8 % and 85.5%) of *R. solani* and (84.4% and 80.0%) of *F. sambucinum*.

In general *T. harzainum* inhibited the linear growth of all tested pathogens by overcoming their growth in Peri-dishes. Similar results were reported by many investigators (Andersen *et al.* 2003; Khalil and Al-Mughrabia, 2010; Sadfi *et al*., 2002). The inhibition in the growth of the fungal pathogens could be attributed to antibiosis, hyperparasitism or production of chitinase and *ß*-1,3 glucanase enzymes which degrade the cell wall leading to lyses of mycelium of the pathogen (Windhan *et al.,* 1986 and Ahmed and Baker, 1987). Therefore, these tow bio control isolates Th3 and Tv1 were selected as bio-inoculant for preparation different types of bio composts formulation used in this study.

Effect of bio-composts extracts on *R. solani* and *F.sambucinum* growth in vitro

All tested concentrations of the bio-composts extracts inhibited the in *vitro* the linear growth of *R. solani* and *F.sambucinum* when compared with control treatment. The inhibitory effect increased by increasing concentration of bio-compost extracts.

Extract of bio compost 3 (compost fortified with *T.harzianum* isolate 3 and *T. viridi* isolate 1) provided highest reduction records in linear growth of *R. solani* and *F. sambucinum* compared with the other extracts, reducing mycelia growth of the two pathogens by up to 88.8 % and 75.5% respectively at 50% concentration Table (2). Bio-compost 1 and 2 extracts at 50% concentration showed considerable effect, provided inhibitory effect reach to 70.0 and 65.5% of *R. solani,* 65.5 and 61.1% of *F. sambucinum.* Extracts of compost 1, 2 and 3 at 30 % concentration showed less inhibitory effect, as the reduction of linear growth reach up to 38.8% of R. *solani* and 33.3% of *F.sambucinum* .Meanwhile, bio-compost 4 showed inhibitory effect reach to 26.6% and 16.6 % at 30% concentration. These results are harmony with recorded by many investigators (Yogen *et al.,* 2006 and Khalil and El-Maghrabia, 2010), they noted that compost could provide natural biological control for some plant diseases. Its water extracts (compost tea) has been proposed as substitutes for synthetic fungicides.

The suppressiveness on linear growth of the tested pathogens shown by compost extracts is a combination of various factors, such as competition for nutrients, antibiosis, and production of lytic enzymes outside the

Table 2. Percentage of reduction in fungal growth of *R. solani* and *F.sambucinum* by different bio -compost extracts (compost tea) on PDA medium in *vitro*.

Compost type	Pathogen	Concentration									
		10%		20%		30%		40%		50%	
		LG	R%	LG	R%	LG	R%	LG	R%	LG	R%
Bio-compost 1	*R. solani*	84b	6.6	72c	20.0	60c	33.3	42ef	53.3	27e	70.0
	F.sambucinum	85b	5.5	80b	11.1	70b	22.2	48e	46.6	31d	65.5
Bio-compost 2	*R. solani*	86b	4.4	74c	17.7	64c	28.8	45e	50.0	31d	65.5
	F.sambucinum	86b	4.4	76b	15.5	72b	20.0	60c	33.3	35d	61.1
Bio-compost 3	*R. solani*	81b	10.0	72c	20.0	55d	38.8	40f	55.5	10f	88.8
	F.sambucinum	85b	6.5	70c	22.2	60cd	33.3	44f	43.3	22e	75.5
Compost 4	*R. solani*	86b	4.4	80b	11.1	66c	26.6	55d	37.8	45c	50.0
	F.sambucinum	88a	2.2	88a	13.3	65c	16.6	65b	27.7	50b	44.4
Control	*R. solani*	90a	0.0	90a	0.0	90a	0.0	90a	0.0	90a	0.0

Bio-compost 1= Compost fortified with Th3 isolate, Bio-compost 2= Compost fortified with Tv1 isolate, Bio-compost 3= Compost fortified with Th3 isolate + Tv1 isolate, Compost 4= composted agricultural wastes
Means followed by the same letter are not significantly different at P ≤ 0.05.

cells and of low molecular weight molecules, which are capable of degrading the fungus wall (Diánez *et al*., 2006).

Management of Black Scurf and Dry Rot Diseases in Field Conditions

Influence on Rhizoctonia black scurf and Fusarium dry rot diseases incidence

The experiments were carried out under field conditions to evaluate the effect of different bio-composts as biologically soil treatments on management of black scurf and Fusarium dry rot of potato under naturally infested soil at private farm at Nobaria province, Beharia Governorate during winter cultivations 2013/2014 seasons.

Manipulating soil by different bio composts as biologically soil treatments significantly reduced the diseases incidence of black scurf and dry rot on potato. The highest records of reduction were provided by bio-compost 3 followed by bio- compost 1 treatments, meanwhile bio-compost 2 show considerable effect if compared with compost 4 and control treatments during two seasons. Drenching soil before potato sowing with bio-compost 3 reduced black scurf disease incidence and severity by 70.6%; 74.4 and 75.0% and 62.5%; 65.0% respectively. While bio compost 1 and bio compost 2 provided considerable control of black scurf disease, they reduced black scurf disease incidence and severity by 63.1%; 66.9 and 57.5, 60.3% during the same seasons respectively. Compost 4 (non fortified with bio agent) soil treatment showed lowest records of reduction in disease incidence (42.4 and 44.6%) and severity (43.0 and 39.0%) during two seasons. Results in Table(3) also clearly show that all tested bio composts soil treatments has highly effect on decreasing of Fusarium dry rot incidence than black scurf disease. Bio-compost 3 soil treatment provided highest records in reduction Fusarium dry rot of on potato tubers (82.3 and 83.8%) followed by bio compost 1 (68.8 and 74.1%) compared with 41.1% and 48.3% of compost 4 during two seasons, respectively. Meanwhile, bio compost 2 provided considerable reduction (55.8% and 61.2%) during the same seasons if compared with compost 4 and control soil treatments.

In this respect, our results are agreement with providing by many researchers (Hari and Smosekhar, 1998; Prasad and Ragashwaran, 1999; Godwin and Arinze, 2000; Liu and Huany, 2000; El-Mohamedy, 2004). They 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. El-Mohamedy *et al*., found that amended soil around stems of diseased mandarin trees by bio compost (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*. was highly decreased, where population density of *Trichoderma spp* were increased in rhizosphere soil of treated trees by bio compost (BCAW). Several researchers have already proved bio compost soil amendment to suppress soil borne disease on many economic crops. 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. Therefore, these methods introduced efficient disease control and incensing yield of many crops (Huang, 1991; Voland and Epstein, 1994; Ceuster and Harry, 1999; Davis *et al*., 1996; Lazarovites, 2001; El-Mohamedy, 2004; 2006 and 2012). Soil amendment with agricultural wastes alone or in combination with bio-

Table 3. Influence of soil treatment with different bio composts formulations on incidence of black scurf and dry rot diseases of potato plants under field conditions.

Soil treatment	black scurf				Fusarium dry rot		
	Disease Infection	Reduction %	Disease severity	Reduction %	Number of infected tuber	Disease Incidence	Reduction %
First season							
Bio-compost 1	11.8c	63.1	10.2c	57.5	14c	6.0c	68.8
Bio-compost 2	14.0c	56.2	12.0c	50.0	15c	7.5c	55.8
Bio-compost 3	9.4d	70.6	9.0d	62.5	6d	3.0d	82.3
Compost 4	18.4b	42.4	15.8b	34.0	20a	10b	41.1
Control	32.0a	0.0	24.0a	0.0	34a	17.0a	0.0
Second season							
Bio-compost 1	9.2c	66.9	8.4c	60.3	8d	4.0c	74.1
Bio-compost 2	11.8c	57.5	10.0c	52.8	12c	6.0c	61.2
Bio-compost 3	7.2d	74.1	7.4d	65.0	5d	2.5d	83.8
Compost 4	15.4b	44.6	12.8b	39.6	16b	8.0b	48.3
Control	27.8a	0.0	21.2a	0.0	31a	15.5a	0.0

Bio-compost 1= Compost fortified with Th3 isolate, Bio-compost 2= Compost fortified with Tv1 isolate
Bio-compost 3= Compost fortified with Th3 isolate + Tv1 isolate, Compost 4= composted agricultural wastes.
Means followed by the same letter are not significantly different at $P \leq 0.05$.

control agents was recommended for controlling soil borne pathogens and increasing the yield of many crops. Elad *et al.,* noted that stem rot of groundnut reduced by up to 83 % when *T. harzianum* formulation in wheat bran-sand soil mixture was added to soil (30 g/kg soil).

Control of root rot pathogens through amended soil with organic materials formulated with bio-control agents may be attributed to: 1) increasing the activity of indigenous micro flora resulting suppression of pathogens population on through competition or specific inhibition. 2) Releasing degradation compounds such carbon dioxides, ammonia, nitrites, saponine or enzymes which are generally toxic to the pathogens. 3) inducing plant defense mechanisms. 4) Cellulose and glucanese are prevalent to high concentration in soil as a result of biodegradation of cellulose and lignin (Tsao and Oster, 1981; Windham *et al.,* 1986; Mitra and Nandi, 1994; Liu and Huang, 2001). In this respect *Trichoderma* spp. are formulated and marketed as biological control agents (BCAs) for numerous plant pathogens, including *R. solani* (Whipps and Lumsden, 2000).

Influence on potato Growth characters

It is interesting to note that drenching soil before sowing potato seeds with bio compost treatments was very important in reducing both black scurf and dry rot diseases under field conditions, and improving the final tubers yield of potato.

Influence of soil treatment with different bio composts formulations gained a significant effect on the most potato plant growth parameters compared to the control treatment (Table 4). Whereas, in both cultivation seasons , all bio composts and compost soil treatments resulted the best plant vigor, *i.e.* the tallest plant, heaviest number of leaves and branches per plant, fresh and dry weight of leaves, branches and whole plant . Bio-compost 3 followed by bio compost 1 and 2 were the most effective soil treatments as the highest records of plant growth parameter maintained above were observed if compared with those recorded with control treatment. However, potato plants sowing in soil amended with compost 4 show least records of plant vigor's parameters .These findings were true in both two seasons.

The obtained data are in good accordance with those which previously reported by (Sarhan *et al*., 2011; Adavi and Tadayoun, 2014) they noted that tuber size, number of tuber per plant, tuber yield, and starch yield were significantly higher in inoculated plants by bio fertilizer than in non-inoculated plants. Therefore, bio fertilizer could be considered as a suitable substitute for chemical phosphorus fertilizer in organic agricultural systems. It is also could be noted that, the superiority of potato plant growth that obtained by bio composts soil treatments might be attributed to increased photosynthetic activity and increased production and accumulation of carbohydrate. As bio composts soil treatments may be provide organic acids that help dissolve soil nutrients and make them available for the plants.

Organic fertilizers, such as compost or bio compost provide slow release fertilizer growth, yield and nutrients values of potato plants if compared to chemical fertilizer (Shafeek *et al*., 2001), play a key role in water uptake (Marulanda *et al*., 2007), increased antioxidant activity

Table 4. Influence of soil treatment with different bio composts formulations on tuber on growth characters of potato plants during two seasons.

Treatments	Plant length (cm)	No. of		Fresh weight (g)			Dry weight (g)		
		leaves	branches	leave	branches	Total	leave	branches	Total
First season									
Bio-compost 3	53.53	43.33	10.33	158.33	168.47	321.37	17.47	19.63	36.57
Bio-compost 1	53.07	42.33	8.33	156.53	158.57	316.90	16.80	19.10	36.43
Bio-compost 2	49.43	41.67	8.00	153.37	156.50	312.50	16.50	17.53	33.87
Compost 4	47.70	39.00	7.67	152.90	152.97	309.87	16.20	17.37	33.73
control	44.10	36.67	7.00	136.47	141.13	277.60	16.07	16.47	32.53
LSD 5%	1.81	N.S.	1.18	3.28	2.24	3.34	N.S.	1.32	1.71
Second season									
Bio-compost 3	68.13	72.33	12.00	298.13	130.13	428.27	23.93	20.77	44.70
Bio-compost 1	60.63	68.33	10.33	296.27	122.30	418.57	23.23	18.53	41.77
Bio-compost 2	59.07	67.33	10.33	276.63	120.57	396.70	21.83	17.70	39.53
Compost 4	58.53	64.67	9.67	274.37	119.97	394.93	21.13	16.23	37.37
control	53.77	61.33	9.00	255.63	116.10	371.73	19.43	14.23	33.67
LSD 5%	2.09	2.09	0.64	9.41	3.12	10.86	0.73	1.11	1.38

Bio-compost 1= Compost fortified with Th3 isolate, Bio-compost 2= Compost fortified with Tv1 isolate, Bio-compost 3= Compost fortified with Th3 isolate + Tv1 isolate, Compost 4= composted agricultural wastes.

(Marulanda *et al.,* 2007), altered a quaporin expression (Uehlein *et al*., 2007), osmotic adjustment (Wu and Xia, 2006), hormone relations (Estrada-Luna and Davies, 2003), bio control of pathogens (Ozgonen *et al*., 2001), soil fertility, plant nutrition, enhancing the uptake, and translocation of mineral nutrients (mainly P, N, S, K, Ca, Fe, Cu, and Zn) from soil to host plants (Ceccarelli *et al.,* 2010).

The application of *Trichoderma* spp. has been associated with reduced *R. solani* diseases on crops including bean, cotton, tomato, beet and potato (Grosch *et al*., 2006 and Verma *et al*., 2007). Moreover, diverse *Trichoderma* spp. has been associated with increased crop productivity in species such as tobacco, tomato and radish (Gravel *et al*., 2007 and Hoyos- Carvajal *et al*., 2009; Hermosa et al., 2012). Growth promotion by the application of *Trichoderma* spp. has not been extensively studied in potato, although there are reports of other plant-associated microorganisms promoting potato plant growth (Kumar *et al*., 2013).

Influence on Total tuber yield and its components:

Concerning to the effect of different bio composts formulations (compost fortified with TH_3 isolate + TV_1 isolate) on the total yield and its components of potato plant, the resulted data showed that all bio compost soil treatments had an enhancement in tuber yield parameters and its components if compared with control treatment Tables (5 and 6) . Results in Table(5) show that all tested soil treatments cause an increasing in the average of tuber yield /plant and calculated tuber yield /feddan (4200m). The highest records of potato total tuber yield were observed in bio compost 3 (13.42 and 20.11 ton\fed) followed by bio compost 1 (12.56 and 16.95 ton\fed) and bio compost 2 (12.54 and 16.64 ton\fed) soil treatments, if compared with 11.75 and 15.76; 11.43 and 12.79 ton\fed in compost 4 and control treatments during1st and 2nd seasons respectively. The highest records of number of tubers /plant, number of tuber m^2, weight of tuber\plant, tuber size as well as fresh and dry weight of tuber were also observed in plants sowing in soil treated by bio compost 3-soil treatment. Meanwhile, the least records of the same parameters of tuber yield were recorded with compost 4 and control treatments.

Generally, it could be abstracted that, the application of the bio compost 3 was the best favorable effect on the total yield of potato tubers. In addition, it could be stated that, the bio-compost 3 gained an enhancement plant productively if compared to the control treatment. The higher total tubers yield of potato obtained from using the bio-compost 3 may be due to increasing potato plant growth characters and reduction in diseases incidence (Table 3 and 4). Many workers applied compost particularly with bio agents for vegetable plants and their results supported the obtained data (Shafeek *et al.,* 2001, Ceccarelli *et al.,* 2010, Sarhan *et al.,* 2011 and Adavi and Tadayoun, 2014). *Trichoderma* spp. have also been shown to promote plant root development, which is often associated with increased plant yield and biomass (Harman *et al*., 2004). The yield increase measured in the present study may have resulted either from suppression of Rhizoctonia black scurf and Fusarium dry rot diseases , or from direct interactions between the bio compost soil treatments and the potato plants, for example from hormone regulation or nutrient acquisition (Hermosa *et al*., 2012); or possibly from a combination of both these effects.

Table 5. Influence of soil treatment with different bio composts formulations on total yield and its components of potato plants during two seasons.

Treatments	Parameter of potato tuber yield						
	No. tuber \ plant	No. tuber \ m^2	Wt. tuber \ plant (g)	Wt. total tuber Yield (ton\fed)	Fresh Wt. tuber (g)	Dry Wt. Tuber (g)	Tuber size cm^2
First season							
Bio-compost 3	12.0	46.0	1373.5	13.42	126.03	23.13	128.67
Bio-compost 1	11.3	44.3	1293.8	12.56	117.13	20.47	128.33
Bio-compost 2	10.3	43.7	1145.8	12.54	112.07	18.97	125.67
Compost 4	9.7	39.0	1042.4	11.75	109.30	18.47	121.00
control	9.3	36.7	956.3	11.43	105.30	16.50	116.33
LSD at 5%	1.0	3.03	94.7	0.76	3.479	1.29	3.756
Second season							
Bio-compost 3	11.3	48.0	1400.5	20.11	119.73	19.90	170.33
Bio-compost 1	10.7	44.7	1248.4	16.95	115.80	19.27	160.33
Bio-compost 2	10.3	43.0	1238.8	16.64	115.30	17.87	160.00
Compost 4	10.3	42.2	1127.6	15.76	113.27	16.27	154.00
control	9.0	35.7	915.9	12.79	106.63	15.07	129.00
LSD at 5%	0.45	1.03	72.08	1.43	3.97	0.72	3.29

Bio-compost 1= Compost fortified with Th3 isolate, Bio-compost 2= Compost fortified with Tv1 isolate.
Bio-compost 3= Compost fortified with Th3 isolate + Tv1 isolate, Compost 4= composted agricultural wastes.

Table 6. Influence of soil treatment with different bio composts formulations on total chemical tuber contents of potato plants during two seasons.

Treatments	Chemical tuber contents %				Chemical tuber contents ppm				Total Carbo-hydrate
	N	Protein	P	K	Fe	Mn	Zn	Cu	
First season									
Bio-compost 3	1.54	9.63	0.37	2.59	303.667	53.33	50.00	13.97	74.40
Bio-compost 1	1.52	9.53	0.31	2.57	282.333	48.00	45.67	13.00	72.17
Bio-compost 2	1.31	8.17	0.27	2.48	278.000	47.67	43.67	12.67	71.87
Compost 4	1.23	7.70	0.25	2.44	268.000	41.33	39.67	11.73	71.77
Control	1.05	6.53	0.25	2.42	256.333	34.67	39.33	11.30	66.37
LSD at 5%	0.09	0.53	0.02	0.06	7.436	4.69	1.99	0.67	0.72
Second season									
Bio-compost 3	1.34	8.43	0.15	2.79	300.667	46.00	46.67	13.50	74.700
Bio-compost 1	1.29	8.10	0.12	2.67	277.000	44.33	43.33	12.40	70.500
Bio-compost 2	1.19	7.43	0.11	2.59	276.333	41.33	42.33	11.93	70.300
Compost 4	1.16	7.23	0.10	2.52	274.000	39.67	41.67	11.60	67.533
Control	0.90	5.67	0.08	2.07	257.667	34.33	40.33	11.37	63.900
LSD at 5%	0.10	0.66	0.03	0.33	11.405	5.28	2.62	0.98	4.253

Bio-compost 1= Compost fortified with Th3 isolate, Bio-compost 2= Compost fortified with Tv1 isolate,
Bio-compost 3= Compost fortified with Th3 isolate + Tv1 isolate, Compost 4= composted agricultural wastes.

The obtained data are in good accordance with those which previously reported by (Sarhan *et al*., 2011 and Adavi and Tadayoun, 2014) they noted that tuber size, number of tuber per plant, tuber yield, and starch yield were significantly higher in inoculated plants by bio fertilizer than in non-inoculated plants. Similar results have cleared that the suppression of black scurf, scab and Verticillium wilt of potato as a result of soil amendment with organic manure (Matsuzaki *et al.,* 1998; Davis *et al*., 1996; Ivanyuk and Aleksandeow, 1996). Sugar can bagasse degraded by *Trichaderma* spp was used as soil amendment to improve growth and yield of pea, cowpea, potato and citrus (Mitra and Nandi, 1994 and El-Mohamedy et al., 2010).

In newly cultivated soil organic material is frequently recommended to prevent the increase of pathogens inoculums and this was attributed to the unfavorable condition that produces by organic and bio compost soil amendments. Moreover, such soil treatments enhance toxicity and antagonistic ability of bio control agents against soil borne plant pathogens. These probably contributed to the higher nutrient contents, which reflect on enhancement of plant growth vigor's and quality of tuber yield (Matsuzaki *et al*., 1998. Ekhlas *et al*., 2006; El-Mohamedy, 2004; El-Mohamedy *et al*., 2006, 2010 and 2012).

Influence on tuber total chemical contents

The application of bio-compost 3 for potato tuber chemical contents (Table 6) resulted more the percentage of nutritional values, i.e., protein, N , P and K as well as the contents of micronutrients expressed as Fe, Mn , Zn and Cu and total carbohydrates in tube tissues if compared with the no supplied plants.

Moreover, potatoes plants, which sowed in soil treated with bio compost 3, bio compost 1 and 2 soil treatments resulted the best tuber chemical properties as in a comparison with that of compost 4 and control treatments during two cultivations seasons. These results were similar in the two experiments of 2013 and 2014. It could be concluded that, soil treated with bio compost 3 had an enhancement in the chemical constituents of potato tubers. This might be attributed to the role of each compost or bio composts formulations in plant metabolism, which reflected on the total tubers yield and its chemical properties. Many authors studied the response of vegetable plants to the application of compost and bio composts formulations and their reports are in good accordance with that which written here (Shafeek *et al*., 2001; David *et al.,* 2007, Sarhan, 2008, Sarhan, 2011 and Adavi and Tadayoun, 2014).

CONCLUSION

In the present study, *Trichoderma harzainum* and *T. viride* were screened for Fusarium dry rot and Rhizoctonia black scurf diseases suppression and improved growth and tuber yield of potato plants under field condition. *T harzainum* and *T. viride* showed potential as a bio control agents against *R. salami* and *F.sambucinum*. Furthermore, this research has demonstrated that biologically soil treatment with composted agricultural fortified with such bio control agents (bio compost 1, 2 ,and 3) resulted in suppressive both Fusarium dry rot and Rhizoctonia black scurf diseases and increased potato plant growth ,quantity and quality of tuber yield during two seasons . Further research will be conducted to assess the potential of bio compost as a commercial product for biological control of soil borne pathogens under organic farming system.

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