Int. J. Phytopathol. 03 (01) 2014. 33-40

Available Online at ESci Journals
International Journal of Phytopathology
ISSN: 2312-9344 (Online), 2313-1241 (Print)
http://www.escijournals.net/phytopath

ENHANCEMENT OF GROWTH PARAMETERS AND YIELD COMPONENTS IN EGGPLANT USING ANTAGONISM OF TRICHODERMA SPP. AGAINST FUSARIUM WILT DISEASE

[a]Montaser F. Abdel-Monaim*, [b]Mohsen A. Abdel-Gaid, [a]Sahar A. Zayan, [c]Dalia M.T. Nassef

[a] *Plant Pathology Research Institute, Agriculture Research Center, Giza, Egypt.*
[b] *Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.*
[c] *Horticulture Department, Faculty of Agriculture, Assiut University, Assiut, Egypt.*

A B S T R A C T

Eggplant is one of the important economic vegetable crop which is attacked by several serious diseases such as wilt. *Fusarium oxysporum* f. sp. *melongenae* was isolated from a naturally occurring epidemic of wilt in eggplant plants grown in New Valley governorate. In this study, the antagonistic activity of five *Trichoderma* species (*Trichoderma spirale, T. hamatum, T. polysoprium, T. harzianum* and *T. viride*) against *F. oxysporium* f. sp. *melongenae* was evaluated using dual culture technique. *T. viride* (isolate TVM-5) and *T. hamatum* (isolate THM-2) showed the highest antagonistic activity, while *T. spirale* (TSM-1) was the lowest one. In pot experiment, the obtained data showed that all *Trichoderma* species reduced significantly area under wilt progress curve caused by *F. oxysporum* f. sp. *melongenae*. *Trichoderma viride* and *T. hamatum* recorded the highest reduction of area under wilt progress curve (AUWPC) (244.0 and 325.33 AUWPC as compared to 1125.33 in control treatment, respectively). Under field conditions results showed that, these treatments significantly reduced AUWPC and increased all tested plant growth parameters (Plant height, No. of branches plant^{-1}) and fruit yield components (number of fruits plant-1, fruits yield plant-1, fruit weight, No of fruit Kg-1, fruit length, fruit diameters and fruits yield fed.-1) compared with control during growing seasons (2011-2012 and 2012-2013). *Trichoderma viride* and *T. hamatum* were the best biocontrol agents as manifested by the significant reduction in both disease severity and increase plant growth parameters and fruit yield components.

Keywords: *Eggplant, Trichoderma species, wilt disease, plant growth parameters, biological control*.

INTRODUCTION

The Eggplant, Aubergine or Brinjal (*Solanum melongena* L.), of the family Solanaceae, is grown in the subtropical and tropical regions of the world. It is one of the most common, highly productive and popular vegetable crops grown in Egypt. It is quite popular as the poor man's crop (Gargi Chakravarty and Kalita, 2012). The unripe fruit of eggplant is primarily used as a cooking vegetable for the various dishes in many countries in the world. The eggplant is also reported to possess medicinal properties. Various plant parts are used for curing ailments such as diabetes, cholera, bronchitis, dysuria, dysentery, otitis, toothache, skin infections, asthenia and haemorrhoids. It is also ascribed narcotic, anti-asthmatic and antirheumatic properties (Daunay *et al*., 2003).

The major constraint, however, in the production of eggplant is the Fusarium wilt disease. *Fusarium oxysporum* f. sp. *melongenae* (Fomg) is the most destructive pathogen of Fusarium wilt of eggplant. The soil-borne fungus invades the vascular bundles, causes severe wilting and death of the above ground parts of plants by blocking the xylem transport system (Altınok, 2005). It is extremely difficult to control soil-borne fungi useing conventional method such as the use of synthetic fungicides. Since their spores are able to survive for many years in the soil, biological control strategies for this pathogen should, therefore, be carefully selected and handled in an eco-friendly way instead of using chemical fungicides.

The application of microorganisms as biocontrol agents is important, since they may increase beneficial

* Corresponding Author:
Email: fowzy_2008@yahoo.com

microbial activity which extends for a long period of time. *Trichoderma* spp. are considered as potential biocontrol and plant growth promoting agents for many crop plants (Verma *et al*., 2007; Bai *et al*., 2008; Savazzini *et al*., 2009). The competition with pathogens, parasitism and the production of antifungal compounds are the most important mechanisms in biocontrol activity (Verma *et al*., 2007; Savazzini *et al*., 2009). Trichoderma populations can be established relatively easily in different types of soil and can continue to persist at detectable levels for months.

In the above context, the present study was undertaken to isolate the eggplant vasicular wilt pathogen and evaluate the biocontrol potential of indigenous isolates of *Trichoderma* spp. applied by soil drench to control the disease under pots and field conditions. Also, the effect of *Trichoderma* spp. on growth parameters and fruit yield attributes were evaluated under field conditions.

MATERIALS AND METHODS

Pathogen Isolation: Eggplant plants showing wilt symptoms were collected from different fields at flowering stage growing in El-Kharga Oozes- New Valley, Egypt. Small pieces of diseased specimen were grown on Fusarium selective medium (Nash and Snyder, 1965). After purifications, isolates were identified according to morphological characteristics with the help of standard key (Nelson *et al.*, 1983). Pathogenicity tests were conducted on potted plants and after reisolation, a pathogenic isolate of *Fusarium oxysporum* was selected for further studies.

Sources of *Trichoderma* Isolates: Isolation of *Trichoderma* spp. from soil was done following the technique used by Rifai (1969). For this purpose soil samples were collected from potato root rhizosphere (20 cm. deep) of different fields. Twenty g of each soil sample were gently mixed with 500 ml distilled water containing 0.2% citric acid, five ml of prepared solution were added to Petri plates containing 15 ml water agar at 50 ºC and shaken to mix properly. After solidification, five mm plugs of these cultures were transferred into Petri plates containing Davet selective medium (Davet, 1979) and were incubated at 25 ºC. After proper growth, isolates were purified and identified according to standard keys (Bissett, 1991).

Antagonistic activity: Five mm plugs of seven-day-old cultures of *F. oxysporum* f. sp. *melongenae* and *Trichoderma* were placed against each other on plates containing PDA. In case of control instead of *Fusarium oxysporum* plugs, PDA plugs were used each treatment was triplicated. Plates were incubated at 25 ºC for 7 days and the% of radial growth rate inhibition were calculated by the following formula:

$$\% \text{ Inhibition} = \frac{\text{Dia. of colony growth in control} - \text{Dia. of colony growth in treatment}}{\text{Dia. of colony growth in control}} \times 100$$

Evaluation of *Trichoderma* Isolates against Fusarium Wilt Disease in Greenhouse

Preparation of Inocula of *F. oxysporum* and *Trichoderma* Isolates: In order to prepare *F. oxysporum* f. sp. *melongenae* inocula, Erlenmeyer flasks containing 100 g of barley and 100 ml of water were autoclaved at 121 ºC for 1 h on three successive days. After cooling, about 5-7 small plugs of seven- day- old culture of *F. oxysporum* f. sp. *melongenae* were dropped into each flask under sterilized condition. The flasks were kept at 25 ºC for 4 weeks. Colonized barley grains were then transferred into paper pockets, and were dried and ground. Fourteen g of prepared powder was used to infest 1 Kg of soil (Frommel *et al.,* 1991). For preparation of *Trichoderma* inocula moistened wheat bran was poured into Erlenmeyer flasks which were autoclaved at 121 ºC for 1 h on three successive days. The substrate mixture was then inoculated with a homogenized suspension of spore + mycelia of seven days old culture of *Trichoderma* isolates under aseptic conditions. Erlenmeyer flasks were incubated at 27 ºC for 14 days. Ten g of this inoculum (10^5 – 10^7 CFU) was used to add to 1 Kg of pot soil (Ommati and Zaker, 2012). Surface sterilized eggplant transplanting (cv. Black Beauty) were grown in pots. All of the Trichoderma isolates performing well in lab. tests, were used in this experiment. Five seedlings per treatment were sown in plastic pot (30 cm in dim.), and four pots were used for each treatment as replicates. In control treatment, eggplant seedlings were planted in infested soil only and area under wilt progress curve was recorded.

Disease Assessments: Wilt severity was estimated at 10 days interval for 60 days after transplanting according to Abdou *et al.* (2001) using a rating scale of (0 – 5) based on leaf yellowing grading, *viz*., 0 = healthy, 1= one leaf yellowing 2= more than one leaf yellowing, 3= one wilted leaf, 4= more than one leaf wilted, and 5= completely dead plants. Disease severity index (DSI)

described by Liu *et al*. (1995) was adapted and calculated as follows:

$$DSI= \Sigma d/(d\ max \times n) \times 100.$$

Where: d is the disease rating of each plant, d max the maximum disease rating and n the total number of tested plants/samples examined in each replicate.

The mean of area under disease progress curve (AUDPC) for each replicate was calculated as suggested by Pandy *et al.* (1989).

$$AUDPC= D [1/2 (Y1+Yk) + (Y2+Y3+……..+Yk-1)]$$

Where D= Time interval; Y1= First disease severity; Yk= Last disease severity; Y2, Y3,……Yk-1= Intermediate disease severity.

Field Experiments: Field experiments were carried out at New Valley Agric. Res. Station Farm, New Valley governorate during 2011-2012 and 2012-2013 seasons, to evaluate the efficiency of the tested *Trichoderma* spp. as Bio-control agents for controlling wilt disease of eggplant plants as well as its effect on growth parameters and fruit yield components. The chosen field test area was naturally infested with *F. oxysporum*. The experimental design was a complete randomized block with four replicates. The experimental unit area was 15 m^2 (5 × 3 m). Each unit included three rows; each row was 5 m in length and 1 m width. Soil treatments were done by applied 150 g of the prepared formulation/plot at the same time of planting. Eggplant seedlings (cv. Black Beauty) transplanted into the field in 1 October in both seasons at rate 10 seedlings per row; one seedling/hill was sown with 50 cm apart between hills. Untreated seedlings were used as control. The NPK mineral fertilizers were applied at the recommended dose of Ministry of Agriculture and Land Reclamation. Disease severity was recorded every 30 days for 4 months. The mean of area under disease progress curve (AUDPC) for each replicate was calculated as above. Plant height, number of branches, number of fruits $plant^{-1}$, fruits yield $plant^{-1}$ (Kg), fruit weight (gm), No of fruit Kg^{-1}, fruit length (cm), fruit diameter (cm) and the estimated fruits yield $fed.^{-1}$ (ton) were calculated at the end of the growing season.

Statistical Analysis: All experiments were performed twice. Analyses of variance were done using MSTAT-C program version 2.10 (1991). Least significant difference (LSD) was calculated at $P \leq 0.05$ according to Gomez and Gomez (1984).

RESULTS

Isolation, Purification and Identification of the Fungi Associated with Eggplant Diseased Plants: Nine fungal isolates were isolated from eggplant plants collected from different locations in New Valley, governorate that show wilt symptoms. Hyphal tip cultures of grown fungi were maintained on PDA medium. All fungi were purified using single spore technique cultures, then they were identified. Results indicate that all isolated fungi which identified as *F. oxysporum* f. sp. *Melongenae.*

Pathogenicity Test: The first sign of wilting on eggplant appeared around 40 days after inoculation and gradually intensified. Lower leaves developed the wilting first, then extended to the upper leaves. Vascular discoloration was evident from the early stages of infection, extending, upward throughout the plant. Data present in Fig (1) show that the most virulent isolates against eggplant plants w*ere F. oxysporum* f sp. *melongenae* isolate FO3 (77.23%) and isolate FO7 (72.36%). While isolates FO5 and FO8 recoded the lowest virulent ones (25.45 and 36.36%, respectively).

***In Vitro* Evaluation of Antagonism of *Trichoderma* spp. Against *F. oxysporum* f. sp. *melongenae*:** Under *in-vitro* conditions all the antagonists Trichoderma species i.e. *Trichoderma spirale, T. hamatum*, *T. polysoprium*, *T. harzianum* and *T. viride* inhibited mycelial growth of *F. o. melongenae* ranged between 43.58 and 56.25 % as compared to control (Fig. 2). *T. viride* isolate TVM-5 and *T. harzianum* isolate THM-4 were found to be the most potent antagonistic *F. oxysporum* f sp. *melongenae*, whereas inhibited the mycelia growth with 76.25 and 69.36%, respectively. On the other hand, *T. spirale* (TSM-1) recoded the lowest inhibition of *F. o.* f. sp *melongenae* (43.58%).

Effect of Soil Treatment with Trichoderma species on Wilt Disease under Greenhouse Conditions: A pot experiment was carried out to examine the efficiency of *Trichoderma* spp. to antagonize *F. oxysporum* f. sp *melongenae* under greenhouse conditions. Data presented in fig. 3 reveal that all *Trichoderma* spp. significantly decreased area under wilt progress curve (AUWPC) compared with control.

T. viride was the most effective one for reducing UDWPC from 1125.33 in control to 244.0 AUWPC followed by and *T. hamatum* (325.33 UDWPC). While *Trichoderma spirale* (TSM-1) and *T. polysoprium* (TPM-3) recoded the lowest redauction for AUWPC caused by *F. oxysporum* f. sp *melongenae* (685.36 and 845.74 AUWPC, respectively).

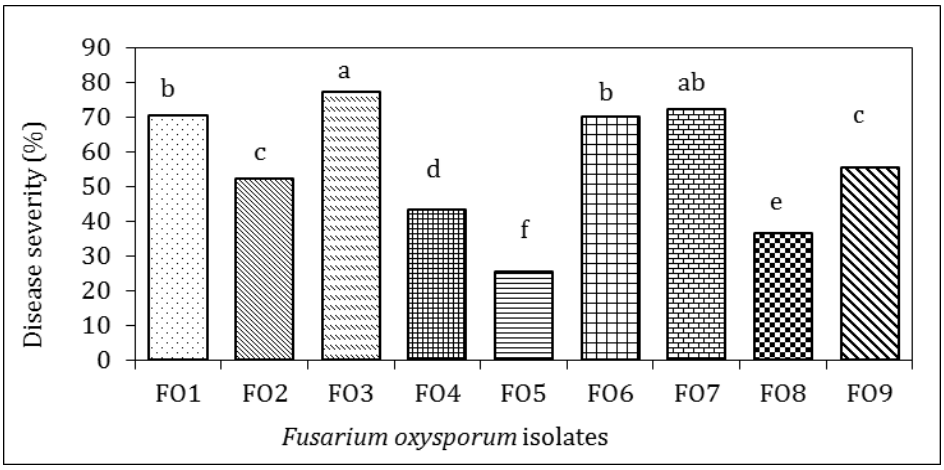

Figure 1. Pathogenicity tests of *Fusarium oxysporum* f. sp. *melongenae* isolates collected from different location to eggplant cv. Black Beauty. Different letters indicate significant differences between eggplant *Fusarium oxysporum* f. sp. *melongenae* isolates according to LSD test ($P \leq 0.05$).

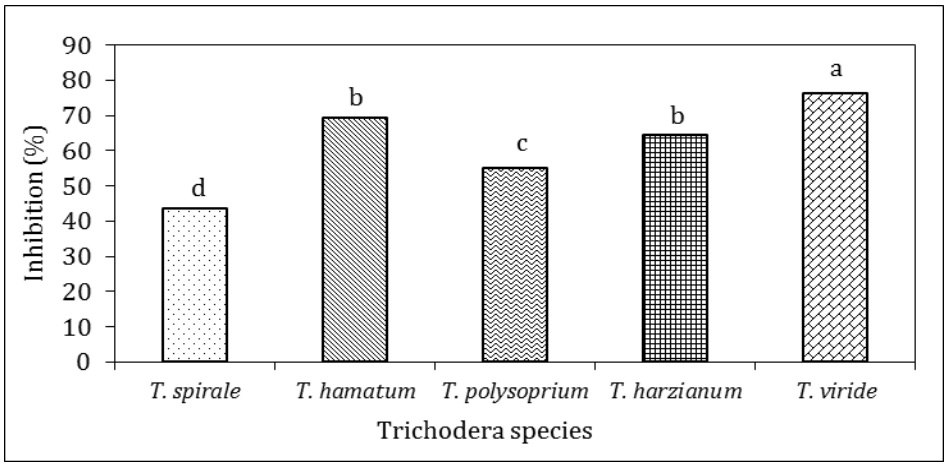

Figure 2. Antagonistic activity of *Trichoderma* spp. against growth of *Fusarium oxysporum* f. sp. *melongenae in vitro*. Values in the column followed by different letters indicate significant differences among treatments according to LSD test ($P \leq 0.05$).

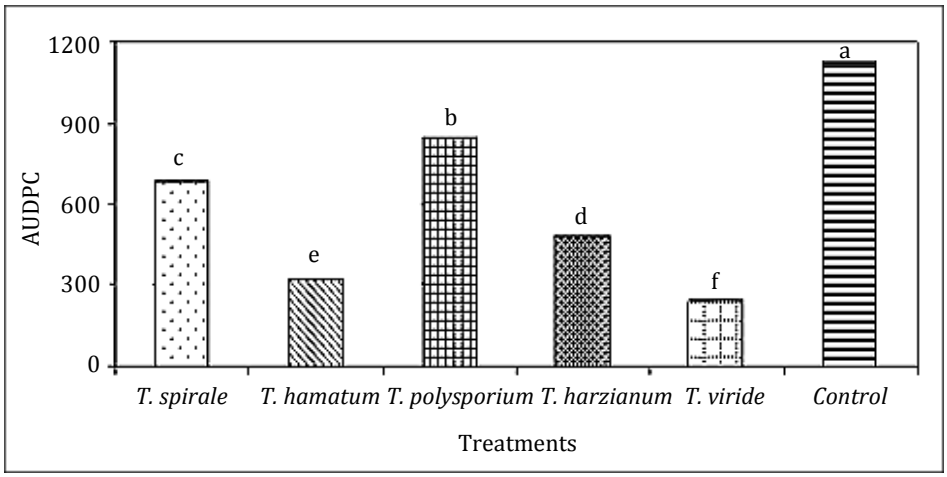

Figure 3. Effect of soil treatment with formulated *Trichoderma* species on Area under wilt progress curve of eggplant (cv. Black Beauty) under pot experiments. Values in the column followed by different letters indicate significant differences among treatments according to LSD test ($P \leq 0.05$).

Effect of Trichoderma species on Wilt Decease under Field Conditions: Effects of *Trichoderma* spp. on wilt disease incidence, some growth parameters, yield components of eggplant plants under field conditions in New Valley governorate was studied.

A) Effect of *Trichoderma* Species on Area under Disease Progress Curve: Data in Fig. 4 indicate that all *Trichoderma* species exhibit significant protection against wilt disease compared with control in both growing seasons (2011-2012 and 2012-2013). However, the most effective *Trichoderma* species were *T. viride* (159.36 and 163.58 AUWPC) followed by and *T. hamatum* (221.36 and 253.67 AUWPC) during both growing seasons, respectively. Conversely, *Trichoderma spirale* and *T. polysoprium* showed the lowest protection against wilt disease which recorded the AUWPC from 956.38 and 989.36 to 422.0, 489.36 and 658.74, 715.69 AUWPC in first and second growing seasons, respectively.

B) Effect on Growth Parameters: All the tested *Trichoderma* species significantly increased growth parameters i.e. plant height and branches number per plant compared with control treatment in both growing seasons (Table 1). *T. viride* was the most effective one for increasing plant height from 66.26 and 65.48 cm in control to 93.06 and 92.36 cm followed by *T. hamatum* (67.66, 67.67 cm in first and second growing seasons, respectively).

Conversely, effect of *T. polysoprium* for increasing of plant height was lower compared with the others. The same trend was also observed in case of number of branches plant^{-1}, while *T. viride* recorded the highest branches number plant^{-1} (22.35 and 23.25 branch plant^{-1}) followed by *T. hamatum* (20.22 and 19.36), however *T. polysoprium* recorded the lowest one in first and second growing seasons, respectively.

C) Effect on yield components: Data in Table (2) revealed a decrease in the yield components of eggplant plants, i.e. number of fruits plant^{-1}, fruits yield plant^{-1}, fruit weight, No of fruit Kg^{-1}, fruit length, fruit diameters and the estimated fruits yield fed.$^{-1}$ of control treatment. However, significant increase was determined with the *Trichoderma* species treatments. The most effective *Trichoderma* species were *T. viride* for all fruit parameters, number of fruit plant^{-1} (14.73 and 14.89), fruit yield plant-1 (4.27 and 4.19 Kg), fruit weight (289.88 and 281.47 gm), No. of fruit Kg-1 (3.45 and 3.55), fruit length (13.44 and 13.24 cm), fruit diameter (12.67 and 11.97 cm) and total yield fed. -1 (26.59 and 25.49 ton) compared with 9.57 and 8.75, 2.29 and 2.08, 239.6 and 241.25, 4.17 and 4.15, 7.28 and 7.05, 7.1 and 6.80, 12.65 and 11.25 in control treatment in both seasons, respectively. *Trichoderma hamatum* came after of *T. viride* in increased all fruit parameters in both growing seasons. On the other hand**,** *T. harzianum* and *T. spirale* recoded the lowest increased of all fruit parameters in this respect during both growing seasons.

DISCUSSION

Many soil borne fungi play a major role in causing several diseases such as damping-off, root-rot, seed decay, collar rot, crown rot and wilt, etc. eggplant, an important vegetable crop is attacked by several diseases, mostly caused by fungi and bacteria leading to severe crop losses. Among the fungal diseases, the wilt incited by *Fusarium oxysporum* f. sp. *melongenae* (Fomg) is a major constraint in the production of eggplant under greenhouse and fields (Altınok, 2005 and Baysal *et al*., 2013).

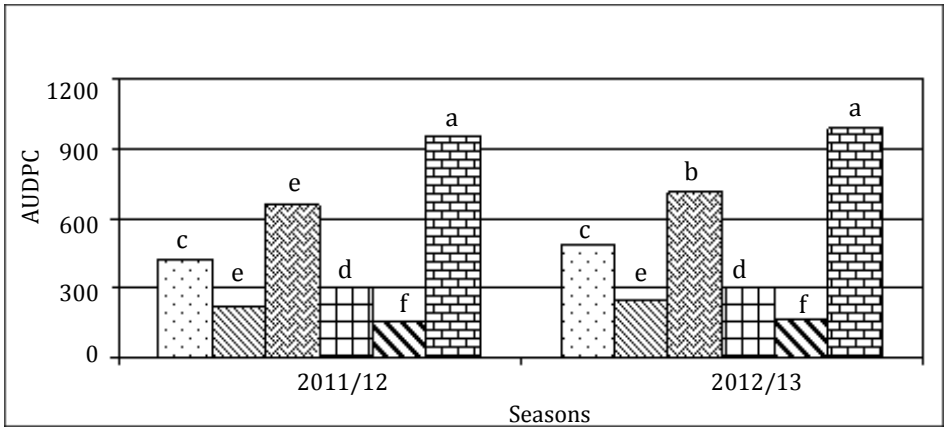

Figure 4. Effect of soil treatment with formulated Trichoderma species on area under wilt progress curve (AUWPC) of eggplant (cv. Black Beauty) under field conditions during seasons 2011-2013 and 2012-2013. Values in the column followed by different letters indicate significant differences among treatments according to LSD test (P≤0.05).

Table 1. Effect of soil treatment with formulated *Trichoderma* species on plant height and branch numbers plant^{-1} of eggplant (cv. Black Beauty) under field conditions during 2011-12 and 2012-13 growing seasons.

Treatments	Season 2011-2012		Season 2012-2013	
	Plant height (cm)	Branch numbers plant^{-1}	Plant height (cm)	Branch numbers plant^{-1}
T. spirale	86.00 b	21.22 a	85.14 b	20.02 b
T. hamatum	91.33 a	20.22 ab	93.63 a	19.36 b
T. polysoprium	78.66 c	15.56 bc	75.14 c	13.25 c
T. harzianum	81.34 c	20.22 ab	82.36 b	18.24 b
T. viride	93.06 a	22.35 a	92.36 a	23.25 a
Control	66.26 d	15.22 c	65.48 d	13.18

Different letters indicate significant differences among treatments within the same column according to LSD test ($p \leq 0.05$).

Table 2. Effect of soil treatment with formulated *Trichoderma* species on fruit yield components of eggplant (cv. Black Beauty) under field conditions during 2011-2012 and 2012-2013 growing seasons.

Season 2012-2013							
Treatments	No. of fruits plant^{-1}	Fruit yield plant^{-1}	Fruit weight (gm)	No. of fruit Kg^{-1}	Fruit length (cm)	Fruit diameter (cm)	Total fruit yield fed.$^{-1}$(Ton)
T. spirale	11.04 cd	2.89 d	262.60 bc	3.81 abc	9.86 c	9.33 bc	20.59 b
T. hamatum	14.73 b	4.27 b	289.90 a	3.45 c	13.44 a	12.67 a	26.59 a
T. polysoprium	12.60 bc	3.28 c	260.60 bc	3.84 abc	8.33 de	8.55 cd	17.51 bc
T. harzianum	10.08 d	2.53 e	251.30 cd	3.98 ab	9.15 cd	9.52 bc	14.87 cd
T. viride	18.21 a	5.01 a	275.10 ab	3.64 bc	11.62 b	10.90 ab	24.94 a
Control	9.57 d	2.29 e	239.60 d	4.17 a	7.28 e	7.10 d	12.65 d
Season 2012-2013							
T. spirale	10.08 bc	2.75 d	253.70 bc	3.94 ab	8.36 c	9.01 cd	19.36 bc
T. hamatum	14.89 a	4.19 b	281.50 a	3.55 c	13.24 a	11.97 a	25.49 a
T. polysoprium	11.48 b	3.19 c	251.00 bc	3.98 ab	8.08 cd	8.34 d	15.69 cd
T. harzianum	11.39 b	2.49 de	248.00 c	4.03 a	9.01 c	9.28 bc	14.05 de
T. viride	16.25 a	5.01 a	264.30 b	3.78 bc	10.99 b	9.89 b	22.47 ab
Control	8.75 c	2.08 e	241.30 c	4.15 a	7.05 d	6.80 e	11.25 e

Different letters indicate significant differences among treatments within the same column according to LSD test ($p \leq 0.05$).

During this investigation, nine *Fusarium oxysporum* f. sp. *melongenae* isolates were isolated from eggplant roots collected from different locations in New Valley governorate. In pathogenicity tests, all the isolates were pathogenic to eggplant with different degrees of disease severity. These results are in agreement with those reported by Altınok, 2005; Baysal *et al*., 2013.

The management of this disease is difficult owing to long saprophytic survival ability of pathogen in soil (Dey, 2005). Control of the plant diseases by chemicals can be spectacular but this is relatively a short term and moreover, the accumulation of the harmful chemical residues sometimes causes serious ecological problem. In recent years, the increasing use of potentially hazardous pesticides and fungicides in agriculture has been the result of growing concern of both environmentalists and public health authorities.

Biological methods can be economical, long lasting and free from residual side effects and safe on human and animal health. The main purpose of the biological control of the plant disease is to suppress the inoculum load of the target pathogen to a level, which would not cause potential economic loss in a crop. Fungal species belonging to the genus *Trichoderma* are worldwide in occurrence and easily isolated from the soil. The potential of *Trichoderma* species as bioconrol agents against various plant diseases has been reported by several workers (Verma *et al*., 2007; El-Nagdi and Abdel-Khair, 2008; Bai *et al.*, 2008; Savazzini *et al*., 2009; Joshi *et al*., 2010 and Sundaramoorthy and Balabaskar, 2013). In this study, five Trichoderma species *viz. Trichoderma spirale, T. hamatum, T. polysoprium, T. harzianum* and *T. viride* were evaluated *in vitro* and *in vivo*. The obtained data indicated that all Trichoderma spp. suppressed mycelia growth of *F. oxysporum* f. sp. *melongenae in vitro*. *Trichoderma viride* (TVM-5) and *T. harzianum* (THM-4) were found to be the most potent antagonistic against the pathogen. The inhibition of *Fusarium oxysporum* f. sp. *melongenae* by Trichoderma species could probably be due to the secretion of extracellular cell degrading

enzymes such as chitinase β-1, 3- glucanase, which help mycoparasites in the colonization of their host. The inhibition of pathogen may be also being attributed to the production of secondary metabolites by antagonists such as glioviridin, viridin and gliotoxin. (Kamlesh and Gurjar, 2002; Muhammad and Amusa, 2003; Rehman *et al*., 2013). The secondary metabolites of Trichoderma includes chitinase enzyme considered that most effective component against pathogenic fungi. Chitinase enzymes degrades the fungal cell walls which composed of chitin (Lorito *et al*., 1996).

Also, all the tested Trichoderma species significantly reduced area under wilt progress curve (AUWPC) under pot and field conditions compared with control. *Trichoderma viride* and *T. hamatum* recorded the highest reduction of AUWPC compared with the other tested Trichoderma species. Trichoderma spp. is now the most common fungal biological control agents that have been extensively researched and deployed throughout the world. The primary mechanism of antagonism in Trichoderma is mycoparasitism. Lytic activity is the key feature responsible for the expression of mycoparasitism against several fungal pathogens (Chet, 1987). Trichoderma spp. is also good competitors in soil and producers of volatile and nonvolatile antibiotics to suppress target pathogens (Chet, 1987). Because of their effectiveness and ease of production for commercial application, at least nine commercial biological control products based on Trichoderma species are manufactured and marketed in Belgium, Sweden. Israel, USA, Denmark, India and New Zealand for use on several crops (Navi and Bandyopadhyay. 2002).

On the other hand, all *Trichoderma* species improved growth parameters (plant height, No. of branches plant^{-1}) and fruit yield components (number of fruits plant^{-1}, fruits yield plant^{-1}, fruit weight, No of fruit Kg^{-1}, fruit length, fruit diameters and fruits yield fed^{-1}). *Trichoderma viride* (TVM-5) and *T. hamatum* (THM-2) gave the highest increament in all tested plant growth parameters and yield components. Similar results on increased plant growth due to application of *Trichoderma gamsii* in tomato (Ozbay *et al*., 2004 and Sundaramoorthy and Balabaskar 2013). The increase in plant growth might be associated with secretion of auxins, gibberellins and cytokinins. The increase in biomatter production may be due to the production of plant growth promoters or through indirect stimulation of nutrient uptake and by producing siderophore or antibiotics to protect plants from deleterious rhizosphere organisms (Sundaramoorthy and Balabaskar, 2013).

REFERENCES

Abdou, El-S., H.M. Abd-Alla and A.A. Galal. 2001. Survey of sesame root/rot/wilt disease in Minia and their possible control by ascorbic and salicylic acids. Assuit J. of Agric. Sci.; 32(3): 135-152.

Altınok H.H. 2005. First report of Fusarium wilt of eggplant caused by *Fusarium oxysporum* f. sp. *melongenae* in Turkey. *Plant Pathology, 54:577.*

Bai, Z., B. Jin, Y. Li, J. Chen and Z. Li. 2008. Utilization of winery wastes for *Trichoderma viride* biocontrol agent production by solid state fermentation. J. Environ. Sci. 20, 353-358.

Baysal Ö., Ç. Karaaslan, M. Siragusa, R. Alessandro, F. Carimi, F. De-Pasquale and S.J.A. Teixeira-da. 2013. Molecular markers reflect differentiation of *Fusarium oxysporum* forma speciales on tomato and forma on eggplant. Biochemical Systematics and Ecology 47: 139–147.

Bissett, J. 1991. The revision of the genus *Trichoderma* II. infrageneric classification. Canadian. J. of Botany, 69: 2357-2372.

Chet, I. 1987. *Trichoderma* - application, mode of action, and potential as a biocontrol agent of soilborne plant pathogenic fungi. In: I. Chet (ed.), Innovative Approaches to Plant Disease Control, pp. 137-160. John Wiley & Sons: New York.

Daunay, M.C., M.L. Chadha and L. Solanum-Melongena. 2003. PROTA 2: Vegetables PROTA. Wageningen. Italy. Soil Biol. Biochem. 41, 1457-1465.

Davet, P. 1979. Technique pour 1' analyse des population et de *Trichoderma* et de *Gliocladium virens* dans le sol. Annual Review of Phytopathology, 11: 529-533.

Dey, T.K. 2005. Effect of soil solarization in controlling damping-off disease of true potato seedlings. Bangladesh J. of Plant pathology, 21(1-2): 93.

El-Nagdi1, W.M.A. and H. Abd-El-Khair. 2008. Biological control of *Meloidogyne incognita* and *Rhizoctonia solani* in Eggplant. Nematol. Medit., 36: 85-92 85.

Frommel, M.I., G.S. Pazos and J. Nowak. 1991. Plant-growth stimulation and biocontrol of Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) by co-inoculation of tomato seeds with *Serratia plymuthica* and *Pseudomonas* sp. Fitopathology, 26: 66-73.

Gargi, C. and M.C. Kalita. 2012. Biocontrol potential of *Pseudomonas fluorescens* against bacterial wilt of Brinjal and its possible plant growth promoting effects. Annals of Biological Res., 3 (11):5083-5094.

Gomez, K.A., and A.A. Gomez. 1984. Statistical procedures for Agricultural Research. Interscience Publication. New York.

Joshi, B.B., R.P. Bhatt and D. Bahukhandi. 2010. Antagonistic and plant growth activity of Trichoderma isolates of Western Himalayas. J. of Environmental Biology, 31(6) :921-928.

Kamlesh, M. and R.S. Gujar. 2002. Evaluation of different fungal antagonistic, plant extracts and oil cakes against *Rhizoctonia solani* causing stem rot of chilli seedlings. Annual Plant Prot. Sci. 10 (2):319-322.

Liu, L., J.W. Kloepper and S. Tuzun. 1995. Introduction of systemic resistance in cucumber against Fusarium wilt by plant growth-promoting rhizobacteria. Phytopathology. 1995; 85: 695-698.

Lorito, M., V. Farkas, S. Rebuffat, B. Bodo and C.P. Kucibek. 1996. Cell wall synthesis is a major target of mycoparasite antagonism by Trichoderma harzianum, J. of Bacteriology. 178, 6382–6385.

MSTAT-C. A. 1991. Software Program for the Design, Management and Analysis of Agronomic Research Experiments. Michigan State University, pp. 400.

Muhammad, S. and N.A. Amusa. 2003. *In-vitro* inhibition of growth of some seedling blight inducing pathogens by compost-inhabiting microbes. Afr. J. Biotechnol. 2(6):161-164.

Nash, S.M. and W.C. Snyder. 1965. Quantitative and qualitative comparisons of Fusarium populations in cultivated fields and noncultivated parent soil. - Can. J. Bot. 43: 939-945.

Navi, S.S. and R. Bandyopadhyay. 2002. Biological control of fungal plant pathogens. In: Waller, J.M., Lenne, J.M. and Waller. S.J. (eds) Plant Pathologists' Pock book CAB International. Wallingford. UK. pp. 354-365.

Nelson, P.E., T.A. Toussoun and W.F.O. Marasas. 1983. Fusarium species. An illustrated manual for identification. The Pennsylvania State University Press. 193 pp.

Ommati, F. and M. Zaker. 2012. Evaluation of some *Trichoderma* isolates for biological control of potato wilt disease (*Fusarium oxysporum*) under laboratory and greenhouse conditions J. Crop Prot. 2012, 1 (4): 279-286.

Ozbay, N., S.E. Newman and W.M. Brown. 2004. The Effect of the *Trichoderma harzianum* Strains on the Growth of Tomato Seedlings. Acta Hort. 635, ISHS 2004. 131-135.

Pandy, H.N., T.C.M. Menon and M.V. Rao. 1989. Simple formula for calculating area under disease progress curve. Rachis. 8 (2):38-39.

Rehman S.U., R. Lawrence, E.J. Kumar, M.A. Talat, S.A. Ganie, W.A. Dar and J.A. Bhat. 2013. Eco-friendly management of root-rot of chilli caused by *Rhizoctonia solani* Kuhn. African J. of Agricultural Res. 8(21): 2563-2566.

Rifai, M.A. 1969. A revision of the genus *Trichoderma*. Mycological Papers. 116: 1-156.

Savazzini, F., C.M.O. Longa and I. Pertot. 2009. Impact of the biocontrol agent *Trichoderma atroviride* SC1 on soil microbial communities of a vineyard in northern mycoparasite antagonism by *Trichoderma harzianum,* J. of Bacteriology. 178, 6382–6385.

Sundaramoorthy S. and P. Balabaskar. 2013. Biocontrol efficacy of *Trichoderma* spp. against wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici*. Journal of Applied Biology & Biotechnology. Vol. 1 (03), pp. 36-40.

Verma, M., S.K. Brar, R.D. Tyagi, V. Sahai, D. Prévost, J.R. Valéro and R.Y. Surampalli. 2007. Bench-scale fermentation of Trichoderma viride on wastewater sludge: rheology, lytic enzymes and biocontrol activity. Enzyme Microb. Technol. 41:764-771.