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SAFE APPROACH TO CONTROL *Fusarium oxysporum* IN SESAME CROP

Hoda A.M. Ahmed* **and M.A. Abdel-Gayed**

Plant Pathol. Res. Inst., Agric. Res. Cent., Giza, Egypt

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ABSTRACT: Our study aimed to use antagonistic fungi, bacteria and chemical formulation, to practically control *Fusarium oxysporum*, the causal of seasame root-rot and wilt diseases. *Trichoderma harzianum, Bacillus subtilis*, *Pseudomonas fluorescens* and chemical antifungal agent (Bion) were tested to evaluate thier capabilities to inhibit *Fusarium oxysporum* growth *in vitro* and to control the disease in greenhouse and field trials. All evaluated treatments in the present study, significantly decreased the diseases incidence in the greenhouse compared to control. *T. harzianum* treatment scored as the most effective one in control study, followed by *B. subtilis* and *P. fluorescens* while Bion gave the lowest effect in this regard. Field experiments at Assiut Governorate, during 2016 and 2017 growing seasons were tried. Results of field experiments were conformed with those obtained from the greenhouse experiment. All treatments increased plant height, number of fruiting branches, number of bearing capsules, seed yield per sesame plant and influenced percentage of oil content of sesame plants positively.

Key words: *Trichoderma harzianum, Bacillus subtilis*, *Pseudomonas fluorescens*, Bion, *Fusarium oxysporum*.

INTRODUCTION

Sesame (*Sesame indicum* L.) is worldwide grown in Asia, Africa and South and North America (Haruna, 2011). In Egypt, sesame is cultivated in Ismailia, Sharkiya, Fayoum and Sohag Governorates and is considered as a food crop rather than oil seed crop (Serry and Satour, 1981). The local production of sesame is very low and does not cover the national requirements, because of seasonal fluctuation in crop due to sensitivity to *Fusarium oxysporum* f. sp. *sesami* (Zaprometoff castellini) causing seedling blight and wilt diseases, along with limited fungicidal control. Successful biological control of diseases has been achieved by a number of researchers under greenhouse conditions as well as in field trials using fungal and bacterial antagonists (Parikh and Jha, 2012).

In fact, chemical fungicides are expensive, however, and can cause environmental pollution. The application of fungicides may also cause the selection of pathogen resistance. The efficiency of fungicides may be reduced if they are absorbed, inactivated or decomposed by other soil managements (Lumsden and Locke 1989; Diehl and Fehrmann, 1999). Therefore, many trials for using biological control to defeat this problem have been achieved (Sallam *et al*., 2009). Successful biological control of plant diseases has been actualized by a bulky number of researchers under greenhouse conditions as well as in field trials using fungal and bacterial antagonists (Parikh and Jha, 2012).

Trichoderma spp. contributed to control many soil borne fungi. In addition, biological control was noted to increase plant growth after application of *Trichoderma* spp. in greenhouse or in field trials. *Trichoderma harzianum*, proven as a fungal antagonist, was conceded due to its ability to parasitize other fungi (Lubaina and Murugan, 2015).

Bacillus subtilis strains are well known as antagonistis for numerous plant pathogens (El Sayed *et al*., 2012). Superior results have

* **Corresponding author: Tel. :** +201002445149
E-mail address: hudafatah@yahoo.com

been obtained with Gram-positive *Bacillus* spp. and Gram-negative *Pseudomonas* spp. in the control of several plant diseases, including fungal diseases caused by *Fusarium* spp. (Haas and Defago, 2005). *Pseudomonas fluorescen*s and other species can produce phenozine antibiotic compound which can inhibit growth of certain plant pathogens. Also *P. fluorescens* is being included with a group of PGPR that always can suppress plant pathogens by multiple mechanisms (Farhan *et al*., 2010). *Bacillus* spp. showed a protective control against Fusarium wilt of sesame, in which antibiosis might be attributed. *Pseudomonas fluorescens* is considered as biological biocontrol agent against various plant related diseases including root diseases (Showkat *et al*., 2012 ; Dalila *et al*., 2013). Sallam *et al.* (2013) showed that twenty-seven isolates of bacteria isolated from rizosphere cantaloupe plants (collected from different localities of Assiut Governorate, Egypt) were tested *in vitro* against the growth of *Fusarium solani.* The tested isolates exhibited varied percentages of mycelial inhibition of *F. solani.* The highly antagonistic bacterial isolates were identified as *Bacillus subtilis*, *Bacillus cereus,* and *Pseudomonas fluorescens*.

Mahmoud (2014) demonstrated that the obtained results confirmed the ability of some bioaegents (*Bacillus subtilis*, *Pseudomonas putida* and *Pseudomonas fluorescens*) to be near to the action of fungicide (Rezolex-T) in reducing peanut damping-off, root and pod rot diseases (*Fusarium solani*, *Fusarium moniliforme, Macrophomina phaseolina*, *Rhizoctonia solani*, *Sclerotium rolfsii*). Where, greenhouse and field trials of *P. fluorescens* (Pf 5.) effect was the nearest one to fungicide effect in minimizing of peanut damping-off, root and pod rots followed by *Brevibacterium carei* (S.5) and *B. subtilis* (Bs1). *Pseudomonas fluorescen*s and other species can produce phenozine antibiotic compound which can inhibit growth of certain plant pathogens. Also, *P. fluorescens* is being included with a group of PGPR that always can suppress plant pathogens by multiple mechanisms (Farhan *et al*., 2010).

The biological control technology may be an alternative approach to diminish the hazardous effects of chemical fungicides.

The objective of this investigation was to evaluate the ability of some biotic and abiotic formulations against *Fusarium oxysporum* f. sp. *sesami* causing seedling blight and wilt diseases of sesame under both greenhouse and field conditions.

MATERIALS AND METHODS

Isolation of Causal Pathogen

The fungal causal pathogen was isolated from diseased sesame plants showing typically symptoms of root-rot and wilt, collected from different districts of Assiut Governorate. Purified and cloned fungi were identified at Assiut University Mycological Centre (AUMC) following description of Booth (1985). The isolate proved its pathogenic capability in the pathogenicity test, were reisolated, maintained on agar slants tubes containing PDA medium, incubated for 7 days at 27°C then kept in refrigerator at 4°C as stock cultures for further study.

Isolation of Bioagents

Bacillus subtilis and *Pseudomonas fluorescens* strains were isolated from the rhizosphere of crusifers plants on King's medium b (KMB) (King *et al*., 1954) and tentatively identified through microbiological and biochemical tests according to Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974). *T. harzianum* was isolated from sesame healthy plant rhizosphere and identified at Assiut University Mycological Centre (AUMC).

Pathogenicity Test

Pathogenicity was carried out in sterilized pots (35 cm diameter) containing sterilized soil. Infestation of soil was made with inocula of 17 isolates of fungi belonging to *Fusarium* genus. Inocula were prepared separately in Barley medium (75 g Barley + 25 pure sand + 2 g sucrose + 0.1 g yeast extract + 100 ml water) according to Abd-El-Moneem (1996). The ingredients were mixed, bottled and autoclaved for 2 hours at 1.5 air pressure. The sterilized medium was inoculated using agar discs, obtained from the margin of 5-day-old colony of each of the tested isolates and incubated at 28℃ for two weeks. Soil infestation was performed

by mixing 5% of the inoculum with soil in each pot (250g/5kg soil) and was covered with a slim layer of sterilized soil, then irrigated directly and kept for 7 days before sowing. Sterilized non-inoculated potted soil was used as control treatment. Each pot was seeded with ten disinfected sesame (Giza 32) seeds. Four pots were used for each isolate as replicates. Percentages of root-rot and wilted plants were recorded after 30 and 90 days from sowing, respectively. The following formulae were used to determine the disease incidence:

Root-rot (%) = No. of diseased seedlings/Total No. of seedlings ×100

Wilt (%) = Number of wilted plants/Total number of plants × 100

In vitro Inhibition of *F. oxysporum* by *Antagonists*

In vitro experiment, *Trichoderma harzianum*, *Bacillus subtilis*, and *Pseudomonas fluorescens* were evaluated for their sensitivity against *F. oxysporum* isolated from sesame plants. Potato dextrose agar plates were inoculated with mycelial disc (5 mm in diameter) of a vigorously growing culture of the aggressively tested isolate of *F. oxysporum* at 1cm far from plate edge. A disc of freshly *Trichoderma* growth (5 mm in diameter) or a streak line with a loop-full of 2 days-old culture from *B. subtilis* or *P. fluorescens* were placed at a constant distance opposite to the other edge of the Petri plate and incubated at 27°C for 7 days. Petri plates were inoculated with the pathogen as the same without bioagents and used as control. When fungal growth was completely covered the surface of control plates the inhibition zones of fungal growth in the treatment were measured. Commercial antifungal biochemical Bion; (benzo (1, 2, 3) thiadiazole-7-carbothioic acid S-methyl ester) (BTH) was used as a control agent and its activity was compared with the bacterial and fungal inhibition zones of fungal growth. The concentration of Bion used was 6 Mm (Ahmed, 2008). The ability of an antagonist to inhibit *Fusarium oxysporum* growth was scored as described by Agarry and Osha (2005) and El-Hamshary *et al.* (2008) using the following formula:

$$\sum A = (A1-A2) / A1 \times 100$$

Where:

$\sum A$ = (%) growth decrease, A1= growth in untreated medium (control) and A2 = growth in the treated medium. The inhibition zone between bacteria and the pathogen was measured as described by Maurhofer *et al.* (1995). All experiments were carried out with five replicates for each treatment. The data obtained were statistically analyzed.

Application of Antagonists to Control *F. oxysporum*

Preparation of fungal inocula

F. oxysporum as a pathogen and *T. harzianum* as an antagonist were grown separstely on potato dextrose agar (PDA) medium at 25°C for 12 days. Conidia were then harvested in sterilized water with sterile brush and filtrated through four layers of strelized cheese cloth to remove the mycelium. The spore suspension was adjusted to 1×10^6 spores/ml using a haemocytometer (Sharma *et al*., 2005).

Preparation of bacterial inocula

Strains of *B. subtilis* and *P. fluorescens* were cultured separately in nutrient broth medium and incubated at 28°C for 48 hr. The resultant cell suspension of each strain was adjusted to provide 10^9 cfu/ml.

Greenhouse experiment

This experiment was carried out in 2016 growing season. Sterilized pots (35 cm in diam.) containing sterilized soil were infested by adding 35 ml of suspension of *F. oxysporum* 10^6 spore/ml. After one week, equal amounts of inocula of the antagonistic fungi and bacteria were separately added to each pot and thoroughly watered. Seeds treated with Bion (by soaking seeds in solution for 4.5 hours) as reported by Ahmed (2008) also were sown in the infested soil. Pots containing inoculum of *F. oxysporum* only were used as control. Four replicates were used for each treatment and 8 sterilized sesame seeds Giza 32 cultivar were sown in each pot. Plants were irrigated when necessary and examined periodically. Percentages of root rot and wilt incidence of sesame were recorded 30 and 90 days after planting, respectively. The formulae used to

determine the diseases incidence were followed as mentioned before.

Field experiment

The experiment was carried out in the farm of Abnob district, Arab-El-Awamer Research Station, Assiut Governorate, Egypt in 2016 and 2017 growing seasons. The field soil is sandy loam, heavily infested with the root-rot and wilt pathogens. The sowing date in both seasons was the first of May. Sterilized sesame seeds Giza 32 were sown in rows in plots (3.2 × 2.4 m) contained 3 rows (60 cm apart). Each row contained 15 hills spaced at 20 cm. Every hill was sown with 5 seeds. A randomized complete block design with four replicates was adopted. Plants were thinned to one plant per hill after 20 days from sowing. The recommended cultural practices for sesame production were adopted throughout the growth season. Percentage of naturally infected plants in every plot was recorded in seedling stage (30 days old) and mature stage (90 days old).

Effect of Sesame Seed Treatment with Biological Control Agents on Yield and Seed Oil Percentage

At harvest time, plant samples (10 healthy plants each) were taken at random from each plot to determine the following : length of plant (cm), number of bearing branches/plant, number of capsules / plant, seed yield / plant (g), and percentage of oil content using petroleum ether (BP 40-60℃) as solvent according to the Official Method (AOAC, 1995).

Statistical Analysis

Analysis of variance (ANOVA) was carried out using M satatc program. The least significant difference (LSD) at P≤0.05 was applied to detect differences among treatments (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The Causal Pathogen of Root-Rot and Wilt of Sesame

Seventeen isolates of *Fusarium* species were recovered from wilted sesame plants (*Sesamum indicum* L.) results are shown in Table 1.

These, were identified as *Fusarium oxysporum* (10 isolates) and others as *Fusarium solani* (7 isolates). The pathogenicity of the recovered isolates was tested on sesame cultivar Giza 32, *Fusarium* isolates varied in the degree of aggressions they caused, thus the isolates of *F. oxysporum* (12, 11 and 13) were more aggressive to sesame than the others.

Fusarium oxysporum is a serious pathogen of sesame which causes wilt disease and limits sesame production. It was reported for the first time from USA in 1950 (Armstrong and Armstrong, 1950). Sesame is infected by several pathogens from the seedling stage to the maturity of crops but the most drastic disease is sesame wilt caused by *F. oxysporum* f sp. *sesami* (Kumar *et al*., 2011). Such results are in accordance with those reported by Jyothi *et al*. (2011), Dong-hua *et al*. (2012), Ziedan *et al.* (2012), Jeyalakshmi *et al*. (2013) and Mahrous *et al.* (2015).

Characteristics of *Bacillus subtilis*

Table 2 illustrates the examined characteristics of *Bacillus* isolates. The results of the tested parameters were according to PIB win software.

Characteristics of *Pseudomonas fluorescens*

Proteolytic activity in supernatant of growth, in broth for 48 hr., *Pseudomonas fluorescens* on king B (King *et al*., 1954), TSB (difco), PDA was tested. The radial diffusion assay in skim milk agar plate agar (Wretlind, 1977) was used as zones of clearing (mm) around the wells were measured. The pH with media was checked before inoculation of bacterial strains and after their growth.

In vitro Evaluation of Antagonism *Against F. oxysporum*

Trichoderma harzianum, Pseudomonas fluorescens and *Bacillus subtilis* strains were evaluated for antagonistic effect against *Fusarium oxysporum* on Petri dishes containing PDA medium.

Table 3 shows that the bioagent strains decreased the radial growth of *F. oxysporum T. harzianum* was more active than *P. fluorescens* and *B. subtilis* in such effect being 21.50, 39.55 and 47.33 cm, respectively compared to control while Bion was the least. Moreover, *T. harzianum* impaired the over growth of *F. oxysporum* comparing to *P. fluorescens* and *B. subtilis*.

Table 1. Pathogenicity of fungal isolates on Giza 32 sesame cultivar

Isolate number	Fungal isolate	Infected plant (%)	
		Root-rot	Wilt
1	*Fusarium solani* (Mart.) Sacc.	10.00	17.50
2	*Fusarium solani* (Mart.) Sacc.	7.50	30.00
3	*Fusarium solani* (Mart.) Sacc.	12.5	10.00
4	*Fusarium solani* (Mart.) Sacc.	25.00	27.50
5	*Fusarium solani* (Mart.) Sacc.	22.50	12.50
6	*Fusarium solani* (Mart.) Sacc.	42.50	12.50
7	*Fusarium solani* (Mart.) Sacc.	20.00	47.50
8	*Fusarium oxysporum* (Zaprometoff castellini)	20.00	45.00
9	*Fusarium oxysporum* (Zaprometoff castellini)	40.00	30.00
10	*Fusarium oxysporum* (Zaprometoff castellini)	15.00	37.50
11	*Fusarium oxysporum* (Zaprometoff castellini)	30.00	47.50
12	*Fusarium oxysporum* (Zaprometoff castellini)	47.50	50.00
13	*Fusarium oxysporum* (Zaprometoff castellini)	30.00	40.00
14	*Fusarium oxysporum* (Zaprometoff castellini)	20.00	22.50
15	*Fusarium oxysporum* (Zaprometoff castellini)	35.00	17.50
16	*Fusarium oxysporum* (Zaprometoff castellini)	25.00	15.00
17	*Fusarium oxysporum* (Zaprometoff castellini)	35.00	12.50
Control		0.00	0.00
LSD at 5%		**24.55**	**21.09**

Data recorded after, 30 and 90 days from sowing for root-rot and wilt, respectively.

Table 2. Biochemical and morphologcial characteristics of *Bacillus* isolates

Test	Result
Gram stain	Gram positive
Spores shape	Oval
Spores position	Central
Spores bulging	negative
Casein hydrolysis	positive
Hippurate hydrolysis	positive
Starch hydrolysis	positive
Urease	positive
Chloramphenicol resistance	S
Nalidixic acid	S
Polymyxin B	R
Streptomycin	S
Acid from Fructose	positive
Acid from Galactose	negative
Acid from Lactose	negative
Acid from Xylose	Positive
Citrate utilization	Positive
Growth at 50 0C	Positive
Growth in 10% NaCl	Positive
Anaerobic growth	negative
Nitrate reduction	positive
Oxidase reaction	positive
Voges-Proskauer test	positive

Table 3. ***In vitro*** **evaluation of the effect of antagonists and chemical inducer on** ***F. oxysporum***

Treatment	Fusarium growth (mm)	Decrease (%)
T. harzianum	21.50	76.11
B. subtilis	39.55	56.05
P. fluorescens	47.33	47.41
Bion	63.11	29.87
Control	90.00	0.00
LSD at 5%	1.95	6.12

The decreased growth percentage of *F. oxysporum* reached 76.11, 56.05, 47.41 and 29.87%, respectively, at the same descending order as shown in Table 3. This behavior represents an important approach for controlling a root rot and wilt disease of sesame plants. The pronounced antagonistic effect of the used strains could be attributed to their effect to secrete hydrolytic enzymes or antifungal metabolites. These findings are in harmony with those obtained by Kamala and Devi (2012) and Lubaina and Murugan (2015) whose reported that *T. harzianum* may produce extracellular β-(1,3)-glucanases, chitinases, lipases, and proteases when they are grown on cell walls of pathogenic fungi. These enzymes degrade pathogenic fungal cell walls may be another mode of mycoparasitic action against fungal plant pathogens. Rajkonda *et al*. (2011) also reported that *Trichoderma harzianum* significantly inhibited the mycelial growth of many plant pathogenic fungi and well known for their biological control capabilities against a wide range of important plant pathogens. Moreover Vinale *et al.* (2008) suggested that *T. harzianum* can be used effectively as a biocontrol against the tested fungal pathogen. Antibiosis and mycoparasitism, lead to the production of cell wall degrading enzyme or competition for nutrients or space are considered as the mechanism of antagonistic action involved in biocontrol of pathogen (McLean *et al.,* 2004). Similarly, they are known to produce a number of antibiotics, such as trichodermin, trichodermol A and harzianolide. As well, Farhan *et al.* (2010) found that *Pseudomonas fluorescens* as biocide inhibited *Fusarium* fungi of sesame crop more than fungicide treatments. Such suppression in fungal growth, may be related to the siderophores and other metabolic compounds which are being produced by *Pseudomonas* isolates. Most of *P. fluorescen*s and other species can produce phenazine antibioti which inhibits growth of plant pathogens (Thomashow and Weller, 1988). This is in agreement with other workers in this regard, Ganeshan and Kumar (2005) and Vignesh *et al*. (2016) pointed out the inhibition of *Fusarium moniliforme* growth *in vitro* up to a maximum of about 61.2%. Moreover, El-Hamshary *et al.* (2008) reported that *Bacillus subtilis* and *B. cereus* have been shown to possess *in vitro* inhibitory activity against *Fusarium oxysporum* f. sp. *sesame*. Many strains of *B. subtilis* have the potential as biocontrol agents against fungal pathogens.

Efficiency of Antagonists and Bion on Sesame Root Rot and Wilt in Greenhouse

Results in Table 4 show that all treatments significantly decreased the disease incidence compared to the control. The most effective treatment was *T. harzianum* followed by *B. subtilis, P. fluorescens* whithout significant differences while Bion gave the lowest protection against the disease. Similar results were reported by Kamala and Devi (2012) who observed that *T. harzianum* could completely protect the plants against *F. oxysporum* f. sp. *sesame* through several mechanisms such as hyperparasitism, inhibition and antibiosis. Mahrous *et al*. (2015) proved that *Bacillus* spp. and *Pseudomonas fluorescens* highly decreased sesame seedling infection by *F. oxysporum*. Elkichaoui (2016) mentioed that the carbendazim ability is little more efficient than the *Bacillus subtilis* in watermelon wilt disease control but has a similar effect in cucumber and muskmelon.

Table 4. Effect of antagonists on the incidence of sesame root rot and wilt diseases under greenhouse conditions

Treatment	Infected plants (%)	
	Root-rot	Wilt
T. harzianum	12.5	18.00
B. subtilis	18.75	24.99
P. fluorescens	21.87	27.97
Bion	31.25	40.83
Control	59.37	87.5
LSD at 5%	14.18	21.10

Antagonists and Bion Agents in Disease Control Under Field Conditions

Under field conditions, all treatments decreased the incidence of root rot and wilt diseases compared to control as reported in Table 5. The results showed that *T. harzianum* proved to be the most effective in controlling the diseases followed by *B. subtilis, P. fluorescens* while Bion treatment showed the least effect. *T. harzianum* greatly decreased disease severity and wilt incidence on sesame plant, and conformed with the previous studies of other works using *T. harzianum*, *T. hamatum* and *T. asperellum* as in managing diseases and growth promotion on many plant species (Hohmann *et al.,* 2011; Kamala and Devi, 2012; Sundaramoorthy and Balabaskar, 2013; Jeyalakshm *et al.,* 2013; Lubaina and Murugan, 2015). With regard to *B. subtilis*, these results may be explained by direct antagonism against the pathogens, competition for essential nutrients and improvement in plant growth (Akhtar *et al.,* 2010). Moreover the use of *Bacillus* spp. may result in rapid colonization of all tissues in tomato, and induced resistance against *F. oxysporum* (Benhamou *et al.,* 1996). A decrease in root-rot disease of chickpea by *Bacillus* spp. (B22) in *Macrophomina phaseolina*-infected plants was also reported (Akhtar and Siddiqui*,* 2006). In addition, *Pseudomonas* spp. may have the ability to suppress root pathogens *via* production of biologically active substances; as they also synthesize an enzyme that modulates hormone levels, limits the available iron through siderophores, and kill sensitive pathogens by producing antibiotics (Siddiqui, 2006). Siddiqui *et al.* (2007) reported that the wilting index is reduced by the application of fluorescent pseudomonads and *Bacillus* spp. in pigeon pea. Similar results were obtained by Elewa *et al*. (2011) and Ziedan *et al*. (2011). The main facts were the induction of a structural response at the sites of pathogen entry and abnormal accumulation of electron-dense substances in colonized areas. *Bacilli* are known to suppress diseases by the inhibition of pathogens *via* diffusible or volatile products, induction of resistance in plants, aggressive root colonization, and stimulation of plant growth.

Results in Table 6 show that each treatment on plant height, number of bearing branches, number of capsules, plant seed yield and percentage of oil content, in the two tested seasons. Values of parameters of sesame plants were significantly increased with the dual inoculation of *T. harzianum, B. subtilis*, *P. fluorescens* and Bion. The increase of plant growth could be attributed to the aforementioned role of both microorganisms present in dual inocula. Soil inoculation with *T. harzianum* gave higher records of all parameters followed by *B. subtilis, P. fluorescens* and Bion. The increase of sesame resistance obtained in this study, could be related to the role of *T. harzianum* as plant growth promoters. Lubaina and. Murugan (2015) reported that formulation of *T. harzianum* treatments not only suppressed the disease but also enhanced the growth and biomass of

Table 5. Effect of antagonists on the incidence of root rot and wilt of sesame plants under field conditions (2016 and 2017 seasons)

Treatment	Infected plants (%)			
	Root-rot		Wilt	
	2016	2017	2016	2017
T. harzianum	4.45	4.45	12.22	11.11
B. subtilis	5.56	6.00	17.78	16.11
P. fluorescens	7.22	7.98	21.11	20.56
Bion	10.56	11.67	28.33	28.89
Control	40.00	42.78	77.78	77.78
LSD 5%	7.42	3.82	6.65	6.39

Table 6. Effect of sesame seed treatments with the tested antagonists on growth, yield and seed oil percentage during 2016, 2017 growing seasons

Treatment	Height of plant (cm)		Number of fruiting branches per plant		Number of capsules per plant		Seed yield per plant (g)		Oil content (%)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T. harzianum	191.50	188.58	7.95	7.00	278.68	274.20	38.00	37.59	56.79	57.65
B. subtilis	186.40	182.28	5.95	5.85	230.78	229.58	35.22	32.29	53.10	53.46
P. fluorescens	180.20	177.95	6.53	6.50	224.64	216.45	33.31	32.29	51.14	51.76
Bion	177.95	172.73	5.15	5.13	193.28	187.00	28.99	27.99	50.30	49.50
Control	172.73	170.00	4.95	5.08	173.93	174.50	22.99	21.58	44.50	45.75
LSD at 5%	NS	NS	0.95	0.74	25.51	19.16	3.15	3.12	6.43	6.96

sesame plants compared to the infected control. The reduction in disease incidence and increasing the yield after treatment by formulations of *T. harzianum* has been reported in several crops (Kamala and Devi, 2012). Many results indicated that the application of *Bacillus subtilis* changes the phytohormone balance in the plant in such a manner that greater quantities of reserve substances are incorporated into storage organs. Hence the plant root length, stem length and dry weight are expected to be improved by application of biocontrol agents (Elkichaoui, 2016). While, added *P. fluorescens* this may be related to the variation in siderophores compounds which produced by them, and to its tolerance to field conditions. The high inhibition in growth characters in all fungi treatments may be related to the toxic compounds which produced from plant pathogenic fungi to inhibit activity of seed embryo. This agrees with Farhan *et al*. (2010). Who found that *Pseudomonas putida 2* and *Pseudomonas fluorescens* 3 increased branch No./plant, height of plant (cm), leaf area/plant (cm^2) weight of 1000 grains (g), Total yield of grains per plot (g) and percentage of oil in grains of sesame crop planted in soil contaminated with *Fusarium* fungi under normal conditions. This may be related to the ability of *Pseudomonas* sp to produce promoter compounds (Abed *et al*.,

2009) which can stimulate the growth and productivity of plants and inhibit growth of fungi successfully. Also Elkichaoui (2016) found that the root length was significantly increased in the biologically treated group but not in the chemically treated group. Gondim *et al*. (2008) found that BTH treatments affect the plant growth and this effect was more pronounced in both the shoot height and the size of the secondary leaves which were smaller than those of controls.

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أســـــلوب أمـــن لمقـــاومـــة فطـــر الفيـــوزاريـــوم أوكسيسبـــورم فى محصول السمـــسـم

هدى عبد الفتاح مصطفى أحمد – محمد أحمد عبدالجيد

قسم البصل والثوم والمحاصيل الزيتية - معهد بحوث أمراض النباتات - مركز البحوث الزراعية - الجيزة - مصر

هدفت هذه الدراسة إلى استخدام الفطريات المضادة والبكتيريا والمواد الكيميائية (بيون)، للتحكم فى أمراض أعفان الجذور والذبول المتسبب عن فطر الفيوزاريوم أوكسيسبورم فى محصول السمسم، تم اختبار الترايكوديرما هارزيانم، باسلس ستلس، سيدوفوماس فلورسنس والمادة الكيميائية (بيون) لتقييم القدرة على تثبيط فطر الفيوزاريوم أوكسيسبورم في المعمل والصوبة والحقل، جميع المعاملات خفضت بشكل معنوي من الإصابة بمرض عفن الجذور والذبول في الصوبة مقارنة مع الكنترول، وسجلت المعاملة بالترايكوديرما هارزيانم أكثر فعالية في السيطرة على المرض تليها باسلس ستلس ثم سيدوموناس فلورسنس في حين أعطى البيون أدنى انخفاض في هذا الصدد، تمت التجارب الحقلية في محافظة أسيوط خلال عامي ٢٠١٦ و ٢٠١٧، وكانت نتائج التجارب الحقلية مطابقة لتلك التي تم الحصول عليها من التجربة التى أجريت فى الصوبة، وكذلك أدت جميع المعاملات السابقة إلى ازدياد طول وعدد النباتات، وعدد الكبسولات المحملة، ومحصول البذور لكل نبات من السمسم، و كذلك كان لها تأثير إيجابى على النسبة المئوية لمحتوى الزيت في بذور السمسم.

المحكمون :

١- أ.د. محمد فاروق عطيـــة أستاذ أمراض النبات – كلية الزراعية – جامعة القاهرة.

٢- أ.د. محمد إبراهيم أبو زيد أستاذ أمراض النبات المتفرغ – كلية الزراعة – جامعة الزقازيق.