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Research Paper

Enhancement of Seed Yield and Its Components in Some Promising Sesame Lines Using Antagonism of *Trichoderma spp.* Against Soil-borne Fungal Diseases

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Abstract: Biological control by *Trichoderma spp*. has been considered as a biocontrol agents to protect plants against diseases in several crops. Its environmentally friendly antagonists against plant pathogenic fungi, especially soil born fungi, compared with chemical control. Therefore, a pot experiment at the Experimental Plant Breeding Farm, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt was conducted over two years (2009 and 2010) to study the possibility of enhancement the yield and its components of sesame promising lines under soil-borne diseases using antagonism of Trichoderma spp. The experiment was established as a randomized complete block design with 3 replications. In general, the result of variance analysis showed that the effects of years (y), inoculation (i), promising sesame lines (Psl) and year x promising sesame lines (y x Psl) interactions were statistically significant in most measurements. The degree of Trichoderma antagonism varied against the soil borne of pathogens through the promising sesame lines, where reduced the growth of (percentage of infection) the three soil borne pathogens (*F. oxysporum, M. phaseolina and R. solani*) significantly and, therefore, can be incorporated for integrated disease management of pathogens. Moreover, inoculation sesame seeds by T. harzianum increased the yield and most of its yield components of sesame lines under artificial infection conditions by the fungal pathogens The results also showed that sesame line S1 and S6 recorded the highest values for number of fruiting branches/plant, number of capsules/plant, thousand seed weight, and single plant yield and lowest values for days to 50% flowering and maturity day when their seeds was inoculated by T. harzianum. Neither inoculated T. *harzianum* nor non-inoculated treatment affects on height of first fruiting branch and oil seed content over all ecological conditions of T. *harzianum* and fungal pathogens of evaluation. Based on these results, the sesame lines, S1, S6 and Taka 2 can be recommended for similar ecological conditions because of their high seed yield and yield components with their resistance to fungal pathogens in response to T. *harzianum*.

Key words: Biological control, *Fusarium oxysporum* (FOS), *Macrophomina phaseolina* (MPH), *Rhiozoctonia solani* (RHS), *Sesamum indicum*, soil borne, yield component.

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Introduction

Sesame, *Sesamum indicum* L. is an ancient oil crop known, and it is probably the first oilseed crop used by humanbieng, according to some archaeological findings (Bedigian and Harlan, 1986). The cultivation goes back to 2130 B.C. (Weiss, 1983), while its recorded history in Egypt returned to 1300 B.C. (Burkill, 1953). Sesame has been cultivated for centuries, particularly in Asia and Africa, for its high content of edible oil (48 to 60%) and protein (18 to 23.5%). Moreover, it is an important source of food worldwide and constitutes an inexpensive other source of fat, minerals, carbohydrate and vitamins (Salunkhe *et al.,* 1991; Namiki, 1995; Kahyaoglu and Kaya, 2006). In spite of this, it considered to be still at an early stage in breeding, the fact that sesame is a crop of mainly developing countries (Ashri, 1998), with limited available research funds for long term breeding programmes, resulted in very few breeding efforts in research stations. Furthermore, sesame is not a mandate crop of any of the international agriculture research centers. However, the major problem is that in sesame crop plants are susceptible to fungle diseases, whereas it is liable to attack at least by eight economically important fungal diseases (Kolte, 1985). Among these, Fusarium wilt disease, which cause by Fusarium oxysporum f.sp. sesami (Zaprometoff) (FOS), where cause a vascular wilt disease and causing sudden death of sesame plants. Also charcoal root rot disease caued by Macrophomina phaseolina (Tassi) Goidanich (MPH) and Rhiozoctonia solani (RHS), infected plants at all stages, damage can result in poor seedling establishment, pre and post emergence damping off and reduced vigor and productivity of older sesame plants. Major symptoms on infected sesame plants are stunting, chlorosis, premature defoliation, early maturity and death (Abawi and Corrales, 1989; Aly et al., 2001; Aly *et al*., 2006). These fungle (FOS, MPH and RHS) are soil-born pathogens caused yield losses in sesame ranging from 50 to 100% and survival in soil for several years (Gaber *et al*., 1998; Khaleifa, 2003; El-Bramawy, 2003; 2006; 2008; El-Bramawy and Abul Whahid, 2007; El-Bramawy and Shaban, 2008; El-Bramawy *et al.,* 2008).

Soil borne pathogens viz., F. oxysporum (FOS), M. phaseolina (Tassi) Goid. (MPH), R. solani (RHS) are complex not only in their behavioral pattern, but also in their biochemical constituents. Hence, it is not very easy to control these pathogens. Understanding and dealing with soil borne pathogens is a very difficult and challenging task. At present, with an effective management of plant diseases and microbial contamination in several agricultural commodities is generally achieved by the use of synthetic fungicides. However, the incessant and indiscriminate application of these chemical fungicides has caused health hazards in animals and humans due to residual toxicity.

In current years, large number of synthetic fungicides has been banned in the worldwide, because of their undesirable attributes such as high and acute toxicity. In developing countries such Egypt, they are still being used despite their harmful effect. Many pathogenic microorganisms have developed resistance against chemical fungicides. This seriously hinders the management of diseases of crops and agricultural plants. Considering the deleterious effects of synthetic fungicides on life supporting systems, there is an urgent need for alternative agents for the management of these pathogenic microorganisms under greenhouse and field conditions (Kumar and Mukerji, 1996; Paterson and Lynch, 2001, Neha and Dawande, 2010). Intensified use of fungicides has resulted in the accumulation of toxic compounds potentially hazardous to humans and environment also in the build up of pathogens resistance. In order to tackle these local, national and global problems, alternatives of chemical control are investigated by the use of antagonistic microbes (Deacon, 1991).

Biological control means control of the disease through some biological agency that is any living microorganism. Biocontrol of the soil-borne plant pathogens (FOS, MPS and RHS), affecting agricultural plants via Sesamum indicum can be controlled by the use of species of Trichoderma, Aspergillus, Trichothecium and Epicoccum in Egypt. There are also some antagonistic bacteria like Bacillus subtilis, Enterobacter aerogenes, Pseudomonas fluorescence, Streptomyces spp. and actinomycetes, can use in the diseases control. The specific need of Egypt is of complete disease control, which the biological agent seldom offers due to the problems associated with distribution of pathogen propagates in soil, and certainly effects greatly losses not only soil, but also in yield and its attributes components, which grown in this soil. Hence, biological control of plant pathogens has been considered as a potential control strategy in this work. Trichoderma is the most commonly used fungal biological control agent and have long been known as effective antagonists against plant pathogenic fungi (Chet *et al*., 1981; Papavizas, 1985, Chet, 1987; Kumar and Mukerji, 1996). Figure1 . Shows the general shape of *Trichoderma harzianum*.

In biocontrol mechanisms of Trichoderma, its may suppress the growth of the pathogen population in the rhizosphere through competition and thus reduce disease development. It produces antibiotics and toxins such as trichothecin and a sesquiterpine, Trichodermin, which have a direct effect on other organisms. The antagonist (*Trichoderma*) hyphae either grow along the host hyphae or coil around it and secrete different lytic enzymes such as chitinase, glucanase and pectinase that are involved in the process of mycoparasitism. Examples of such interactions are T. harzianum acting against *F. oxyporum*, *F. roseum*, *F. solani, R. solani, M. phaseolina, P. colocaciae* and *Sclerotium rolfsii*. In addition, *Trichoderma* Enhances yield along with quality of produce (Chang et al., 1986; Nelson et al., 1994; Kheyrodin, (2011). Figure 2. Shows general shape of Trichoderma's mycelium parasitizing to mycelium of pathogen fungi.

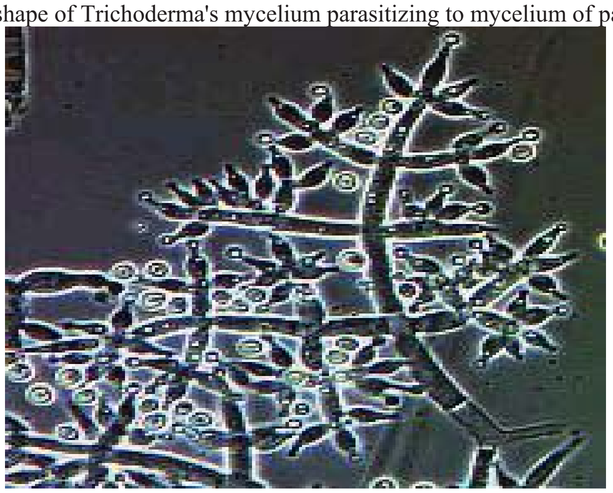

Figure 1. *Trichoderma harzianum*

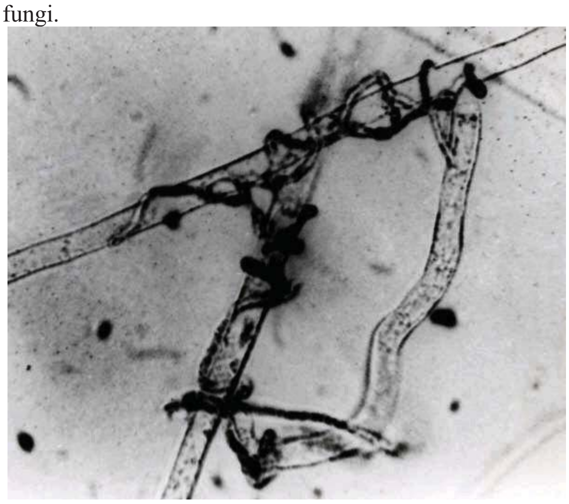

Figure 2. *Trichoderma's* mycelium parasitising to mycelium of pathogen fungi

The beneficial fungus Trichoderma sp. attacks R. solani through a chemical released by the pathogen. Beneficial fungal strands (hyphae) entangle the pathogen and release enzymes that dehydrate *R. solani* cells, eventually killing them (Figure 3). Currently, Trichoderma sp. cultures are available as commercial products against the damping off disease of several crops (Kheyrodin, 2011).

Figure 3. Trichoderma sp. attacks R. solani through a chemical released

However, Several strains of the fungus Trichoderma have been isolated and found to be effective biocontrol agents of various soil-borne plant pathogenic fungi under greenhouse and field conditions (Chet, 1990; Haggag and Mohamed (2002); Cardona and Rodríguez, 2006; Aly *et al.,* 2007; Islam et al., 2007; Pramod and Palakshappa, 2009; Mohamed *et al.,* 2010). Therefore, the aim of this work was to evaluate, for two years in the field disease, the application effect of Trichoderma harzianum on the incidence of Fusarium wilt (*F. oxysporum*) and charcoal root rot (*M. phaseolina* and *R. solani*) on some promising lines of sesame crop by measurements of seed yield and yield components of these lines as an indicator.

Materials and Methods

Plant materials.

Six sesame promising lines with one check variety (Taka 2) were used in this study. These promising lines had previously been evaluated for their resistance to the three fungal pathogens diseases (*F. oxysporum*, *M. phaseolina* and *R. solani*) (El-Bramawy and Abdul Wahid, 2007). These lines were originated by hybridization and selection methods through sesame breeding program during the period between 1997 until 2003 in the Experimental Farm of the Faculty of Agriculture at Suez Canal University and private Farm, Ismailia, Egypt. In addition, Taka 2 was obtained from Nuclear Research Center, Atomic Energy Authority, Cairo, Egypt and used as model resistance genotypes for three fungal pathogens. The name, source and pedigree of sesame promising lines and the check variety are listed in Table 1.

Fungal isolates

Pathogens isolates, production and preparation for soil infestation

F. *oxysporum* (FOS), *M. phaseolina* (MPH) and *R. solani* (RHS) fungi were isolated from diseased sesame plants collected from different sesame growing fields at Ismailia Governorate. The isolation of pathogen and pathogenicity test was carried out at Botany Department, Faculty

Science, Suez Canal University, Ismailia, Egypt. Substrate for growth of FOS, MPH and RHS isolates was prepared in 500-ml glass bottles, each bottle contained 100g of sorghum grains and 80 ml of tap water plugged with cotton wool. Contents of each bottle were autoclaved for 30 minutes. Inoculums isolate, discs (10 mm diameter) were cut out from the growing edges of 10-day-old culture on potato dextrose agar (PDA), in each fungus (FOS, MPH and RHS), separately using a sterile stainless steel cork borer, then was aseptically introduced into the bottle and allowed to colonize sorghum. After that bottle were incubated at room temperature for three weeks.

Antagonism isolates production and seed incoulatuion

The Trichoderma *harzianum* was originally isolated from sesame roots according to approaches of Madhumita *et al*. (1999). This isolate had been fulfilled in the same place, mention above. Inoculum of T. *harzianum* isolate was prepared as previously mentioned method for three fungal. However, antagonist-sorghum mixture was air-dried in the greenhouse. The dry mixture was triturated to a fine powder in a blender (Papavizas and Lewis 1981).

Experimental site and soil analysis

Two pot experiments were conducted during the 2009 and 2010 growing seasons under greenhouse conditions. About 15 kg of dry sandy texture soil (93.89% sand, 2.55% silt and 3.56 clay) was filled into the pots (40 cm in diameter). The total fungi through microbiological soil analysis were adapted at 5 x 106 cfu/g as per Tate (1995) method. The pH value of the soil was 7.61. The soil contained 3.13 ppm available N,1.83 ppm available P, 11.70 ppm available K and 0.06% organic matter through both seasons experimental. These analysis were done at the soil and water Department, Fac. of Agric., Suez Canal Univ.

Artificial infestation of the fungal pathogens (FOS, MPH and RHS)

Pots (40-cm-diameter) were used in this experiment. Each pot received about 15 kg clay (15 kg capacity) with the inoculum consisted of mycelia and scleroia growing of each fungus (FOS, MPH and RHS), separately on sorghum bottle (Bottle incubated at room temperature for three weeks). The content of the bottles was mixed with pot soil at ratio of 3.6% w/w (from herein called `mixed soil'). This ratio of 3.6% w/w was used in pervious work by El-Shazly *et al*. (1999). After thoroughly mixing, infested soil was dispensed into 40-cm-diameter pots. The artificial infestation by each of FOS, MPH and RHS was done, separately in pots was completed before one week of sowing date.

Trichoderma harzianum inoculum and sowing seeds.

T. harzianum inoculum consisted of mycelia and scleroia growing on sorghum. At the time of sowing, promising sesame seeds and seeds of Taka 2 (check variety) were treated with the powdered inoculum of T. *harzianum* isolate at the rate of 6 g/kg seeds according to Bell *et al*. (1982). Each pot received 10 sesame seeds (seeds treated by T. *harzianum*) of promising sesame lines and the check variety (Taka 2). In the control treatment, sesame seeds materials (6 promising lines and the check variety) were also treated by the same rate of sorghum powder, but without T. *harzianum*.

Experimental design and agronomic practices

A randomized complete block design with three replications was used in the study. Each replicate contained the six sesame promising lines with the check variety. Three pots were used for each one of the above mentioned for each pathogen, in separately. Agriculture practices e.g. irrigation, weed control,.etc for sesame plants in pots were conducted if needed it.

Measurements of infection percentage

The percentage of diseased sesame plants infected by *F. oxysporum, M. phaseolina and R. solani* under *T. harzianum* treatment were estimated depends on a specific disease symptoms for each fungus, FOS, MPH and RHS. Its recorded weekly throughout the crop growth up to the stage from 15 days after sowing till the end of the experiment according to Smith and Carvil (1997).

Re- isolation of the Fungal Pathogens

To assure the existence of a relation between diseases pathogens (FOS, MPH and RHS) and the developed or non-developed diseases, some of the wilted and rooted sesame plants of the diseased plant were considered as a sample to re-isolate, which pathogens (FOS or MPH or RHS) developed typical wilting and charcoal root rot symptoms. The re-isolation of FOS or MPH or RHS, was carried out at Botany Dep., Fac. of Sci., Suez Canal Univ.

Scoring of sesame promising for resistance scale

Definitive scale was propose and recommended for evaluation of the sesame promising lines reaction with each of the FOS or MPH or RHS fungle on the basis of pervious scale was used before. This scale (Table 2) was attended according to El-Bramawy (2010). The wilted and rotted sesame plants were counted and calculated as percentage of infected plants. Percentage data were transformed into arcsine angles before carrying out the ANOVA to produce approximately constant variance according to Federer (1963).

Agronomic characters data

Agronomic characters i.e. days to 50% flowering, maturity date, plant height, number of fruiting branches per plant, height of the first fruiting branch, number of capsules per plant, thousand seed weigth and single plant yield were recorded for inoculum and non-inoculum treatment. Oil content percentage of the seed was also determined by Soxhlet method, according to A. O. A. C. (1990).

Analysis of statistical data

Analysis of variance (ANOVA) of the data was performed by using the SAS statistical software Version 6.311 (Co Hort software, Berkeley, CA 94701). Least significant difference (LSD) was used to compare between means of T. *harzianum* isolate within F. oxysporum, M. phaseolina and R. solani pathogens. Also, data for yield and its components considering work under inoculated and non-inoculated T. *harzianum* isolate throughout FOS, MPH and RHS pathogens infestation, was taken from the remaining of the sesame plants a live all potted.

Results and discussion

Fusarium oxysporum (FOS), the causal of Fusarium wilt and *Macrophomina phaseolina* (MPH) as well as *Rhiozoctonia solani* (RHS), the causal of charcoal and/or root-rot are the main destructive fungal pathogens on sesame plants in Egypt (Khalifa, 1997; Abdou *et al*., 2001; Ammar *et al*, 2004; El-Bramawy, 2006, 2008 and 2010; El-Bramawy and Abul Wahid, 2007; Baymui and El-Bramawy, 2007; El-Bramawy and Shaban, 2007; El-Bramawy and Abul Wahid, 2007; El-Bramawy *et al*., 2008 and 2009). Infection percentage of *F. oxysporum* (FOS), *M. phaseolina* (MPH) and *R. solani* (RHS) pathogens under inoculation and non-inoculation conditions by T. *harzianum* for promising sesame lines growing through seasons of 2009 and 2010 were presented in Table (3), in respectively. The check variety, Taka 2 was the lowest one in percentage of infection level among all test sesame lines. It is was possessed the resistance degree (R), with scored 3.20 and 3.40 for FOS, 4.50 and 4.90 for MPH as well as 4.10 and 3.94 for RHS in 2009 and 2010 seasons under non-inoculation conditions respectively (Table 3). However, it decreasing in percentage of infection with keeping the same rank (R) with inoculation by T. *harzianum* to be at the same order in above 0.80 and 0.70 for FOS, 1.01 and 0.80 for MPH as well as 0.90 and 1.01 for RHS in 2009 and 2010. These results indicated that T. *harzianum* reduced the growth of all the three soil borne pathogens significantly and, therefore, can be incorporated for integrated disease management of soil borne plant pathogens. Similar finding was confirmed by the results detected before by Nelson *et al*., 1994; Ragab *et al*. (2002); El-Bramawy *et al.* (2008 and 2009). On the other hand, the sesame line S1"P3", under non-inoculation conditions showed lowest infection percentage (3.30 % for season 2009 and 4.26 % for season 2010) by FOS (Fusarium wilt) and scored as resistance (R), while it scored the tolerance rank (T) with MPH (charcoal root-rot) by values of 15% (2009) and 10.19% (2010). Also, the same category (Tolerance rank) was noted with R. solani (RHS) by values of 14.40% (2009) and 13.10% (2010) (Table 3). But, with inoculation conditions it also decreasing in the infection percentage with keeping the resistant rank (R) with FOS and MPH and the tolerance rang (T) with RHS. In this case, it can predict that Trichoderma sp. attacks pathogens fungi such as *R. solani* (Figure 2) through a chemical released by the pathogen (Kheyrodin, 2011).

The parent P4 "S6" possessed the tolerance level (T) in all cases, with exception season 2010 in each of MPH and RHS, where possessed the level of moderately susceptible (MS) with scored 15.12 % and 15.92%, respectively. However, for instance, the sesame parent (L.R20 "P6") with non inculcation conditions (Table 3), possessed high infection percentage with keeping their susceptible (S) characters in reaction with the fungi pathogens, whereas scored 35.13% and 31.62% with FOS, 30.12% and 38.43% with MPH and 31.71% and 34.14% with RHS, in season 2009 and 2010, respectively. On the other side, with inculcation conditions by T. *harzianum* (Table 3), it reduction/lessening in the infection percentage, then transfer and changed to score the rank of tolerance (T). This sesame line had 14.10% and 11.11% with FOS, 5.10% and 9.13% with MPH and 8.72% and 11.11% with RHS, in season 2009 and 2010, respectively. Such parents might be helpful for breeding program due to their tolerant or susceptible stability. Similar finding was detected before in previous researches done by El-Bramawy (1997, 2003, 2010).

On the other hand, the rest of sesame promising via H4 , H10 and L.R10 possessed highest infection percentage through the both years (2009 and 2010) under fungal pathogens infection without or non inoculation by T. *Harzianum* were recorded a character rank varied from moderately susceptible (MS) to susceptible (S) as presented in Table (3). All these sesame promising (H4, H10 and L.R10) with inoculation by T. *Harzianum*, were declined in their rate of pathogens infection and possessed the rank of resistance (R) or tolerance (T) and little pit a few cases of moderately susceptible (MS) as shows in Table (3). These results confirmed that T. *harzianum* can reduced the infection percentage of the three pathogens (FOS, MPH and RHS), significantly and may be incorporated for the integrated disease management of these soil borne pathogens. These results are in harmony with the results reported by Mujerki and Garq. 1988; Cardona and Rodríguez (2006), Kheyrodin (2011).

Only one case of highly susceptible (HS) was recorded by interaction of H4 "P1" with F. oxysporum (FOS) in season of 2009 (50.06%) under non inoculation conditions (Table 3). Meanwhile, with inoculation conditions by T. *harzianum*, it decline in the incidence of fungal pathogen (FOS), where recorded 18.03 % in season of 2009, with rank of moderately susceptible (MS) as shows. Therefore, its conferming to the important role of T. *harzianum*, which can reduced the growth of the fungal pathogen via F. oxysporum (FOS). On the other side, no immune sesame line was found among all sesame lines nether non-inoculation conditions or inoculation conditions by T. *harzianum* (Table 3).

Therefore, according the present results, the sesame parent were resistance or tolerance to wilt disease (FOS) or charcoal root rot disease (MPH & RHS), could be considered as a source of resistance or tolerance in breeding programs or directly to economic production under field conditions with supporting of seed inculcation by Trichoderma harzianum as a bio-control agent for management soil born diseases due to it reducing the growth of the three soil borne pathogens significantly and, therefore, can be incorporated for integrated disease management of these soil borne plant pathogens. These findings are in harmony with the results reported earlier by Cardona *et al.* (1998); Nelson *et al.,* 1994; Ragab *et al.* (2002); El-Fiki *et al*. (2004); Bayoumi and El-Bramawy (2007); El-Bramawy *et al*. (2008); Kheyrodin, (2011). On the other hand, the absent of immune plants in sesame genotypes were reported earlier in the literature by Li *et al.* (1991), while in contrast, Shazly *et al*. (1999) reported before existence of the immune plants in sesame genotypes through their studied sesame materials.

The effect of the Trichoderma harzianum fungus as inoculated or non inoculated treatment on the incidence of the Fusarium wilt (FOS) and charcoal root-rot (MPH and RHS) diseases, hence their effects on yield and its components of sesame promising lines was investigated through the currant work and the results with its discussion were presented as they following,

Results regarding yield and its components of the inoculated (by T. *harzianum*) and non-inoculated promising sesame lines through infection by FOS, MPH and RHS during its grown in seasons 2009 and 2010 are summarized in Table 4. The results of variance analysis showed that the effects of years (y), inoculation (i), promising sesame lines (Psl) and year x promising sesame lines (y x Psl) interactions over all studied characters (days to 50 % flowering, maturity date, plant height, height of first fruiting branch, no. of branches/plant, no. of branches/plant, no. of capsules/plant, thousand seed weight, single plant yield and oil seed content) were showed a significant to highly significant differences. Only in character of height of first fruiting branch on the main shoot/steam (cm), there was no significant like above, but only in inoculation (i), through the three pathogen fungal (FOS, MPH and RHS). Therefore, we can conclude that the highest values of yield and its components characters was obtained from inoculated promising sesame lines (Psl) by T. *harzianum* against FOS, MPH and RHS (Table 4). These results due to that may be T. harzianum can reduced the infection percentage of the three soil borne pathogens significantly, hence, can be incorporated for integrated disease management of pathogens. Non-inoculated promising sesame lines had the least values of yield and its components characters. Because of the different reaction of (Psl) to inoculation between the years, year x Psl interaction was found significant (Table 4). These results were in harmony with results reported by Tan and Serin (1995); Antal *et al*. 1997; Salama and Khlifa, 1997; Wadhwa *et al.* 1997); Albayrak *et al.* (2006); Ganesan et al. (2006); Mohamed *et al*., 2010).

However, in this connect; the effect of the T. harzianum fungus on the incidence of the charcoal root rot disease in sesame was also studied by Cardona and Rodríguez (2006). They, found that the variance analysis combined over three years of the essay did not show statistical differences between years neither between treatments, but it did between the interaction years x treatments, subsequently evaluating each year separately obtaining an inconsistency in results by the absence of statistical differences between treatments for each year. Also, Bordbar *et al*. (2010), found that two isolates of Trichoderma virens were effective in controlling decay of apple fruits caused by Penicillium expansum. Their results indicated that T6 and T8 isolates of T. virens caused the increase in β-1, 3-glucanase activity that reached maximum levels 4 and 6 days after inoculation with pathogen, respectively. Progress in the understanding of the biology of soil-borne fungal pathogens of grain legumes is also reviewed by Stephan *et al*., 2002; Infantino *et al.* (2006), with particular reference to the genetic structure of their populations, diagnosis and host–pathogen interaction during screening techniques and sources of resistance to root diseases.

Therefore, our finding results, confirmed the presence of sufficient variability for a yield and its components of the promising sesame lines over these factors, which could be considered valuable for further biometrical assessments. This was not surprising, since these sesame lines originated from different genetic backgrounds as mentioned before (Table1). The existence of genetic variation for the yield and its components characters in sesame including their behavior with diseases has been previously reported by Ammar *et al*. (2004), El-Fiki *et al*. (2004), Cardona and Rodríguez (2006), Guleria and Kumar, 2006, Bayoumi and El-Bramawy (2007), El-Bramawy and Shaban (2007), El-Bramawy, 2008, 2010), Ali (2010). However, in this connection, this genetic variation can be used in breeding programs to improve the potential of yield and yield components as well as resistance to infection (%) by FOS, MPH and RHS (El-Bramawy and Abul Wahid, 2007, El-Shakhess and khalifa, 2007, Islam *et al*., 2007, El-Bramawy *et al*., 2009; Pramod and Palakshappa, 2009; Mohamed *et al*., 2010).

With an overview of the Tables (5, 6 and 7), we can note the main points, which following, effect of T. *harzianum* on fungal pathogens diseases, effect of promising sesame lines and their agronomic characters, and overlap between the T. *harzianum* inculcation and promising sesame lines under infection conditions of the three pathogens fungi. This will be the presentation and discussion of these points together, and that society as follows,

Days to 50% flowering (days), maturity date (days) and plant height (cm) in the inoculated and non-inoculated promising sesame lines grown in seasons during 2009-2010 were posted in Table (5). Both of S1 and S4 inoculated sesame lines were the earlier in days to 50% flowering and maturity date through both seasons compared non-inoculated sesame lines. While, inoculated and non-inoculated H4 sesame line was the later one among all in date to 50% flowering as well as maturity date under infection of F. oxysporum, M. phaseolina and R. solani during first and second season. However, the check variety (Taka 2) scored medium values of both characters in case of inoculated as well as non-inoculated. Whereas recorded 48.38, 49.23, 47.91 and 115.87, 116.23, 114.86 (2009), 48.01, 48.79, 47.50 and 115.77, 116.85, 114.89 (2010) in inoculated by T. *harzianum* and 50.04, 50.50, 50.97 and 116.84, 117.05, 115.97 (2009), 50.26, 50.67, 49.68 and 115.89, 116.01, 112.07 (2010) in non-inoculated case for days to 50% flowering and maturity date, respectively. Hence, inoculated treatment values in both traits were smaller (Earlier) than non-inoculated treatment values through all pathogens during the both seasons. Therefore, it can conclude that inoculated treatment by T. harzianum encouraged on flowering early and then end their life cycle (early maturity date) in a lesser amount compared to non-inoculated treatment under infection conditions of FOS, MPH and RHS. This finding may be believed that the treatment by T. harzianum leads to speed up plant growth and then short period of the life in case of pathogens infection. These results confirmed the importance of inoculated treatment by T. harzianum for flowering early with resistance to diseases. These results are in more or less agreement with results reported by Hussain *et al*. (1990); Mousa and Mousa (1994); Sankar and Sharma (2001); El-Fiki *et al.* (2004); Ganesan and Sekar (2004a); Albayrak *et al*., 2006).

Highest values of plant height were noted by H4 inoculated more little non-inoculated sesame line, in both seasons under infection by FOS, MPH and RHS. On the other side, S6 possessed the lowest values of plant height an average of the two seasons neither inoculated conditions by T. harzianum (132.54,131.54 and 128.43,) or non-inoculated conditions (130.02, 127.73 and 123.99) through FOS, MPH and RHS, in respectively (not showed). However, the average of plant height was scored 142.98, 141.45, 140.19 (2009) and 143.12, 141.77, 141.08 (2010) under inoculation, while was 138.90, 138.11, 136.28 (2009) and 139.24, 138.30, 137.67 (2010) under non-inoculation treatment (Table 5). The results indicated that the application of the T. harzianum as a biological-organism successfully increases the growth of the sesame plants via plant height and also decreases the diseases incidence of fungal pathogens this findings are in agreement with the results detected by Mohamed et al. (2010). However, the check variety, Taka 2, had a medium plant height over all conditions (Table 5), while Mohamed et al., (2010) reached to that check plants during their studies had the lowest growth parameters (plant height) in both seasons during their work.

Data presented in Table (6) indicated that the application of T. harzianum did not appear any affects with height of first fruiting branch under infection of FOS, MPH and RHS during first and second season. However, data of Mohamed et al. (2010), showed that the percentage of root rot disease incidence was higher in untreated plants under natural infested condition with S. rolfesii. On the other hand, the treatment of the sesame seeds with Trichoderma harzianum resulted in reducing the infection percentage by the fungal diseases with higher of fruiting branches/plant (6.35, 6.26, 5.96 in 2009, 2.07, 5.94, 5.73 in 2010) and number of capsules/plant (75.39, 77.69, 72.92 in 2009 and 72.69, 77.89, 71.80 in 2010) compared to the non-inoculated treatment thought FOS, MPH and RHS, in respectively (Table 6). Among all sesame lines, S1 and S4 gives the highest number of branches and capsules per plant through the above conditions. Average over the two seasons, the number of branches for inoculated treatments were 7.00, 6.78, 6.98 for S1 and 6.80, 6.56, 6.73 for S4 , whereas, for non-inoculated treatment were 6.27, 6.22, 5.87 for S1 and 6.61, 6.14, 6.64 for S4 (not showed) under FOS, MPH and RHS infections, respectively. In this respect, treatment of the bean seeds with Trichoderma viride mutants resulted in reducing colonization of *S. rolfesii* and *S. sclerotiorum* in bean rhizosphere compared with treatment with their parental wild type and increased pods number/plant (Mohamed *et al*., 2010). Also, Chakraborty *et al.* (2003) reported that combined application of Trichoderma harzianum and Bradyrhizobium japonicum significantly reduced root rot disease in soybean. In this same context, control of some fungal pathogens using Trichoderma harzianum and increasing growth parameters was reported by several researchers (Muthamilan and Jeyarajan, 1996; Ganesan *at al*., 2003 and 2006; Ganesan, 2004; Ganesan and Sekar, 2004 b; Ganesan *et al*., 2007). It enhances the impact of T. harazianum it is will known that it producing a several poisoning and antibiotic compounds that can protect plant from pathogenic organisms in soil (Maplestone *et al*., 1991; Dipietro, 1995; Wu and Wu, 1998).

With regard to the check variety (Taka 2), found it was high in both previous two characters (branches number and capsules number per plant) harder than the other sesame lines, but a little less of the mentioned sesame lines (S1 and S4). So, this variety is characterize to be modeling for the medium branches and capsules number per plant under our a valuable conditions, which research is working (Table 6).

Thousand seed weight was affected by year, inoculation, sesame lines and year x sesame lines. Inoculation by T. harazianum resulted in increases in both seasons, whereas, the highest thousand seed weight was obtained from the inoculated compared to non-inoculated sesame seeds lines (Table 7). Such as sesame line, S1 obtained 4.10, 3.98, 3.89 g and 4.08, 3.84, 3.87 g as well as S 4 obtained 4.13, 4.09, 3.99 g and 4.05, 4.00, 4.09 g during seasons 2009 and 2010, in respectively (Table 7). While, the least thousand seed weight was obtained from the non-inoculated sesame line H4, (3.52, 3.46, 3.40 g) in season 2009 and (3.59, 3.66, 3.46 g) in season 2010 (Table 7). This result came in agreement with Albayrak *et al*. (2006); Stephan *et al.* (1996); Kumar and Hooda (2007); Mohiddin *et al.*, (2010) results, who are reported that T. harazianum gave the favorite results against growth and reproduction of *M. javanica* and consequently enhanced the growth plants and the fruit weight of tomato and eggplants.

In the first season, the highest single plant yield was obtained from inoculated sesame line S6 (21.04, 19.15, 17.81 g/plant), while in the second season, sesame line S1 had the highest yield (19.96,19.48, 18.69 g/plant) (Table 7). Non-inoculated sesame line L.R20 had the least single plant yield (9.04, 8.78 and 7.51 g) in first sesaon and (10.30, 9.18 and 7.59 g), in the second season at the infection level of FOS, MPH and RHS, respectively. On the other hand, the situation of the check variety, Taka 2 has taken an average of between sesame lines, since its status of their single plant yield was found to be taken on average situation among tested sesame line. Whereas did not exceed the two sesame lines (S 1 and S 6), which high yield, but it pass the other sesame lines of their seed yield. In this regard, Cardona and Rodríguez (2006); Aly *et al*. (2007); Mohiddin *et al*. (2010); Mohamed *et al*., (2010); Neha and Dawande (2010); Anitha and Arun Das (2011) concluded that the application of seed inoculated by T. harzianum fungus, have found to be more effective biocontrol agents of various soil-borne plant pathogenic fungi viz. FOS, MPH and RHS under greenhouse and field conditions and increased the plant yield, in addition, Trichoderma enhances yield along with quality of produce. Our findings also came in agreement with each of Stephan *et al.* (1996); Antal *et al.* (1997) results, who reported that T. harazianum gave a positive results against growth and reproduction of M. javanica and consequently enhanced the yield of the crops. However, several studies such as Susan *et al*., (2000); Haggag and Amin (2001); Howell (2003); Siddiqui and Shaukat (2004); Santhosh *et al.* (2005) showed the using of Trichoderma for inhibiting the growth of plant parasitic nematodes with increasing seed yield.

Oil seed content (%) in the inoculated and non-inoculated promising sesame lines grown in seasons 2009 and 2010 (Table 7) shows a little pit variation between inoculated treatment by *T. harzianum* and non-inoculated treatment. The same trend also was noted in both seasons through the infection percentage of *F. oxysporum* (FOS), *M. phaseolina* (MPH), *R. solani* (RHS). The highest oil seed content (%) was scored by sesame lines L.R 10 (57.65, 56.92, 57.44 and 57.77, 57.14, 57.42%) under inoculated treatment, while scored (57.33, 56.89, 57.21 and 57.55, 56.97, 57.29%) under non-inoculated treatment in season 2009 and 2010, respectively. On the other hand, the lowest oil seed content (%) was recorded by sesame lines H 10 (52.05, 51.79, 52.24% and 52.74, 52. 48, 52.42%) under inoculated treatment, but recorded (51.56, 51.68, 52.01% and 52.05, 51.79, 52.24%) under non- inoculated treatment in season 2009 and 2010, respectively.

In general, the overlap between the T. *harzianum* inculcation and promising sesame lines under infection conditions of the three pathogens fungi showed that it became clear that there is significant effect of T. *harzianum* treatment and effective on the majority of the sesame lines traits, where the degree of impact on different sesame lines, there was more responsive not so others and as pointed out by the results we obtained.

Conclusion

It can be concluded that the tested *Trichoderma* isolate reduced the growth of all the three soil borne pathogens significantly and, therefore, can be incorporated for integrated disease management of soil borne plant pathogens. Moreover, inoculation sesame seeds increased seed yield and most of its yield components of sesame lines under artificial infection conditions by the fungal pathogen via *F. oxysporum, M. phaseolina and R. solani*. It was observed that the inoculated sesame line by T. harzianum gave higher number of fruiting branches per plant, number of capsules per plant, thousand seed weight, single plant yield, with short the period of flowing and maturity date as well as no effects of height of first fruiting branch and oil seed content compared to the non-inoculated sesame seeds. Further investigations are needed on pathogen- antagonist interactions in the complex soil ecosystem to select Trichoderma isolates, which could be utilized in field to manage soil borne plant pathogens.

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