Effect of Four *Trichoderma*Species on Growth and Development of *Rhizoctonia solani*, Isolated From Potato (cv. Spunta), Infected With Black Scurf Disease.

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Abstract:

Rhizoctonia solani isolates were obtained from infected potato tubers (cv. Spunta). Four isolates of *Trichoderma* spp., namely *Trichoderma harzianum,T. viride, T. longibrachiatum,* and *T. album*, were applied to test their antagonistic effects on growth and development of the obtained isolates of *R. solani*. Interactions between the antagonistic fungal isolates and *R. solani* were studied in dual culture, antagonism and volatile,nonvolatile techniques. All the tested *Trichoderma* isolates showed significant antagonistic effects on the tested *R. solani* isolates. They produced inhibition zones in front of the *R. solani* colonies, but in varying degrees. *T. harzianum* isolates were able to overgrow the mycelium of *R. solani*, compared to those of the other *Trichoderma* isolates.All the antagonists suppressed the formation of sclerotia. This resulted in the reduction of the mycelial growth of the *R. solani* isolates. The results implied that the extent of inhibition by *T. harzianum* provides the use of excellent potential antagonists capable of controlling the pathogenicity of *R. solani* on Potato.

Key words: Potato, fungal bioagents, antagonism, parasitism, *Rhizoctonia solani*

Introduction:

Potato (*Solanum tuberosum*subsp.*Tuberosum* L), which belongs to family Solanaceae, is considered one of forth important crops in the world after rice barely, wheat and maize (Ahmad*et al*., 1995 and Rauscher *et al.,* 2006). Moreover, potato is one of the most important agricultural and food crops in Libya, where it is grown throughout the year in two seasons, i.e. autumn and spring. It is predicted that by 2050 the world overall population will approximately reach 9 billion.Therefore, to feed this increasing people world population, a raise of about 70% in agriculture food production is necessary (Raney T, 2009).

Biotic stress factors involving fungi, bacteria, virus, nematodes, weeds, and insects cause a yield loss up to 31–42 % (Moustafa-Farag *et al*., 2020). Among these factors, fungal pathogens are considered the most severe limiting factor for crop production worldwide. Greater than 10,000 spp. of fungi are considered responsible for plant disease incidence.

Biological control mechanisms are considered as significant measures for disease management because chemical fungicides adversely affect other non-target organisms (Kohl *et al*., 2019). There are many organisms that infect potato crop, e. g. *Rhizoctonia solani*, which is the subject of the present study, the causative agent of potato black scurf and stem canker (Raju *et al*., 2003, Viterbo *et al*., 2006, Lace *et al*., 2015, and Shukla, *et al*., 2012).

There were many evidences that support the fact that some microorganisms can cause growth inhibition of pathogenic species by decreasing their metabolism and/or establishing a parasitic relationship (Panth *et al*., 2020). Additionally, the application of biological control agents (BCAs) with reduced concentrations of chemicals can stimulate disease suppression in a similar manner as high doses of chemical fungicide treatment (Hyder *et al*., 2017). Around 90% of fungal biocontrol agents, which are applied, against pathogenic microorganisms, are belonged to different strains of *Trichoderma* (Hermosa *et al.,* 2012). *Trichoderma* was isolated for the first time in 1794 from soil and decomposing organic matter (Persoon,

1794). Throughout the world, currently greater than 60% effective bio-fungicides were obtained from *Trichoderma* (Abbey *etal*.,1919). For example, in India, approximately 250 *Trichoderma*-derived bio fungicides products are employed, however, Indian farmers are still relying on synthetic chemical fungicides to a great extent (Singh *et al*., 2009). Different strains of *Trichoderma* (teleomorph Hypocrea) are belonging to fungi imperfecti, which lacking sexual stages in their life cycles (Van Wees *et al*., 2008). These fungi are rapid colonizers, invasive, filamentous, opportunistic, avirulent and exhibit a symbiotic relationship with plants. In pathogen-contaminated soils, they are not only improve plant growth but also inhibit pathogen growth through several antagonistic mechanisms (Vinale *et al*., 2008 and Lorito *et al*., 2010). *Trichoderma* exhibits antagonistic behavior against several phytopathogenic organisms, including bacteria, nematodes and especially fungi, by inhibiting their growth either by direct interaction (e.g., hyperparasitism, competition for nutrient and space, and by antibiosis (Zhang *et al*., 2017), or indirectly by improving plant growth, and enhancing stress tolerance, active uptake of nutrients and bioremediation of contaminated rhizosphere, as well as providing plants with several secondary metabolites, enzymes and pathogen proteins (Kumar, 2013).

Therefore, the current work aims to investigate the antagonistic effect of four of *Trichoderma* species, e.g., *T. viride*, *T. harzianum*, *T.brachiatum*, and *T. album*, on five isolates of *Rhizoctoniasolani*, isolated from infected potato tubers.

Materials and methods:

Sources of pathogen and bioagents isolates :

Infected potato (cv. Spunta) samples were collected randomly from popular markets. The antagonistic fungi *Trichodermaviride*, *T. harzianum*, *T. longibrachiatum*, and *T. album*, applied throughout the present study, were obtained from Botany Department at Saba Bacha Agriculture Faculty, Alexandria University.

Isolation of the pathogen:

Potato tubers infected with black scurf disease were surface sterilized by 0.2% sodium hybrochloride (NaOCl) for two minutes and extensively washed with sterile distilled water. Clot like black spot on

the surface of potato were pealed and placed on petri dishes containing potato dextrose agar medium (PDA), and then incubated at 25±2 °C for 5-7days. The fungal culture growth was purified by subculturing and identified by light microscope after staining with trypan blue dye. Pure culture of *R. solani* was stored at 5 °C in tubes and petri plates containing PDA and sealed with parafilm (Juan-Abgona *etal*.,1996).

Dual culture method:

In vitro antagonistic activity of *T. viride, T. harzianum, T. longibrachtium* and *T.album* against *Rhizoctonia solani* isolates was studied in dual culture technique by following the method by Kucuk and Kivanc (2003). Petri dishes (90 mm) containing 20 ml of sterile PDA were inoculated with a 5 mm in diameter plug of 7- day- old pure culture of antagonistic fungi and pathogens. One mycelial disc of each fungus was placed on opposite poles of PDA plates and incubated at 25°C in incubator and radial growth of pathogen was measured at 7days intervals. Control petri dishes were inoculated with pathogens and a sterile agarplug. Linear growth of the tested fungi was measured when pathogenic fungi have completely covered the surface of the medium in the control treatment. Five replicates were maintained for each treatment. The percentage of inhibition was calculated using the following formula: Percentage of inhibition = A1 - A2 /A1 X 100, Where A1 = Area covered by the pathogen in control, A2 = Area covered by pathogen in dual culture.

Ranking based on Bell *et al*. (1982) scale was used in order to evaluate the antagonistic potential of isolates of *Trichoderma* interactions between *Rhizoctonia solani* isolates (*Table 1*).

Table 1. Scaled to the classes for antagonism of *Trichoderm* spp.with*R. solani* isolates (adapted from Bell*et al*.,1982)

Class	**Characteristics**
1	*Trichoderma* grows and covers completely all colonies of *R. solani* and medium surface.
2	*Trichoderma* grows and covers 2/3 of medium surface.
3	Antagonists and phytopathogen colonize each one, half of the medium surface and no one seems to dominate the other.
4	*R. solani* colonizes 2/3 of medium surface.
5	*R. solani* grows and covers completely all colonies of *Trichoderma* and the medium surface.

Effect of volatile substance produced by *Trichoderma* sppon growth of the pathogen:

The method described by Dennis and Webster (1971)was adopted. Petriplates containing 20 ml of PDA were inoculated separately with 5 mm disc of antagonists and incubated for 5 hours. After this lid of each plate was replaced by a bottom containing PDA previously inoculated with the disc of the pathogen and sealed together with paraffin film. The control sets did not contain the antagonist. The cultures were incubated at 25°C.The studies were carried out in three replicates. Radial growth was measured at 3 and 5 day intervals and percent inhibition was determined using the formula: Percent inhibition = C2 − C1/ C2× 100 .Where, C2 means growth of *R. solani* in control and C1 means growth of *R. solani* in treatment.

Non-volatile activity

Non-volatile activities of fungal biocontrol agents were tested as described by Jariwala*et al*., (1991), 1ml of spore suspension (1 x 10^5 cfu / ml) was inoculated in Potato Dextrose (PD) broth and incubated at room temperature for 1 week. The fungal mat and the spores were removed by filtration through double layer filter paper, followed by

centrifugation at 3000rpm for 15min.The supernatant was used for antibiotic activity. Culture filtrates were added to PD Agar medium at 25%, 50%, 75% and 100% concentration, the pH was adjusted to 6.8 ± 0.2. Medium was then sterilized and poured in the sterile Petri plates. Five day old actively growing *R. solani* cultures were removed from the edge of the colony using 5mm diameter cork borer and placed at the center of these culture medium for each isolates and the plates were incubated 25±2 °C. Five replicates were maintained for each concentration. Plates containing PDA medium with pathogens alone served as control. Radial growth of the fungal colony was measured 7 days after incubation. Percentage of inhibition was calculated using the formula described earlier.

xperimental design and statistical analysis in *vitro* studies were done using a completely randomized design (CRD), each treatment with five replicates. Data were analyzed statistically using the (Minitab) Computer Program. The means were compared using the Fisher LSD (P = 0.05%) (Welkowitz *et al*., 1982).

Experimental results:

In dual culture assays, according to results of Table 2, significant inhibition ratios of *R. solani* hyphal growth was obtained in all *Trichoderma* treatments. However, inhibition ratios differed according to the species of *Trichderma* and the tested isolates of *Rhizoctonia* isolate. *T. viride* gave the highest inhibition ratio (82.96%) on isolate No. 1 of *R. solani*, whereas the lowest inhibition by *T. viride* was obtained on isolate No. 5. On the other hand, the highest inhibition ratio (79.63%) was obtained by *T. harzianum* isolate No.1 of *Rhizoctonia*.The least inhibition ratio (68.52%) was obttained in *Rhizoctonia* isolate No.5. Moreover, the highest inhibition ratio (72.96%) was detected by *T. longibrachiatum*, and was recorded by*Rhizoctonia* isolate No.3, whereas the lowest ratio (54.07%) was detected in *Rhizoctonia* isolate No. 2. Finally, *T. album* treatment showed highest inhibition value in isolate No.1 treatment, and the lowest in isolate No. 4. Furthermore, the *T. harzianum* showed the highest mean of inhibition (73.6%), with the highest levels against isolate No. 1 (61.98 %).Based on the above, all the antagonists were

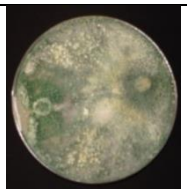
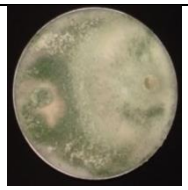
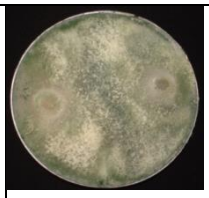
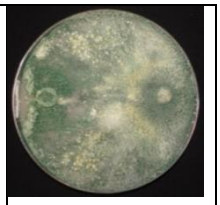
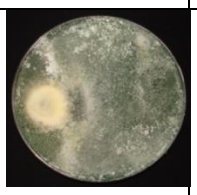
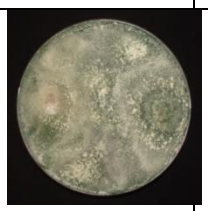
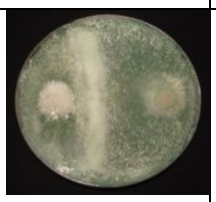
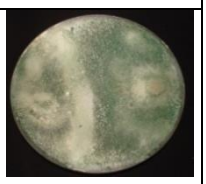
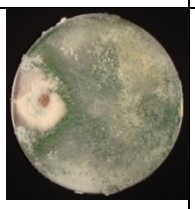
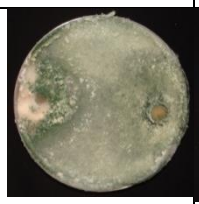
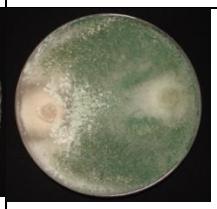
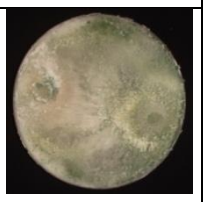
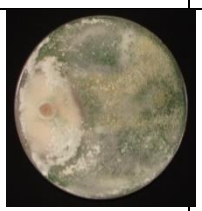
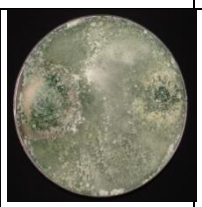
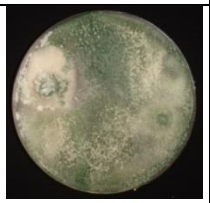
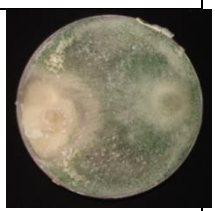
suppressed sclerotia formation on antagonized portion of*Rhizoctonia* isolates hyphalafter 7 days of inoculation.

Table 2. Effect of *Trichoderma* spp on mycelial growth inhibition of *Rhizoctonia solani* isolates.

Bioagents (B)	Growth inhibition % Isolates of*Rhizoctonia solan*i (I)					Mean
	1	2	3	4	5	
T. viride	82.96	72.08	70.74	68.52	63.07	71.4
T. harzianum	79.63	74.85	75.18	70.00	68.52	73.6
T. longibrachiatum	72.59	54.07	72.96	65.56	66.33	66.30
T. album	74.74	60.74	55.22	52.92	53.33	59.39
Control	0.00	0.00	0.00	0.00	0.00	0.00
Mean	61.98	52.35	54.82	51.40	50.25	54.16
LSD at 0.05 (B) = 0.02		LSD0.05 (I) =0.02		LSD0.05 (B x I) =0.21		

Antagonistic potential of *Trichoderma* spp. against *Rhizoctonia solani* in vitro of the four antagonist *Trichoderma* spp evaluated for potential biocontrol of *R. solani*, only in isolates 1, 2, 3, and 4 , showing satisfactory action depending on class 1 of antagonism, adapted from Bell *etal*.(1982). The other isolates of *Trichoderma* spp. showed mild antagonistic potential, pertaining to class 2 of antagonism. In contrast to that, *T. viride* in isolate 5 didn't show high antagonistic action against *Rhizoctonia solani* (Fig.1), whereas isolate T4 (*T. album*) in isolate 5 didn't show antagonistic potential against the pathogen pertaining to class 3. This could be due to the preservation of the isolate, which was obtained from the Micoteca URM collections. According to Smith and Onions (1994), the preservation of microorganisms may alter or inactivate important

physiological characteristics such as pathogenicity, sporulation or enzymes liberation and other compounds. Besides mycelial growth, the level of sporulation of antagonist isolate was also observed. The production of spores of *T.viride*isolates 1, 2, and 3 , *T.harzianum*, isolate 3 presented hardly produced spores while a slight decrease in sporolation production in *T.album*, isolate 5, on the other hand *T. longibrachiatum* was not affected when in contact with pathogen, . Batista (2002) reported that the process of sporulation would be possibly a favorable characteristic to antagonists, therefore, new inoculum was desirable in the presence of pathogen, inhibiting its actions, due to greater density of antagonist inoculum.

Isolate 1				
Isolate 2				
Isolate 3				
Isolate 4				

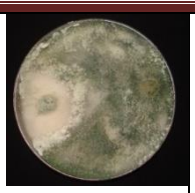
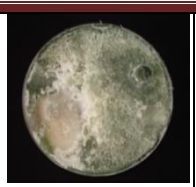
Isolate 5				
	T.viride	*T. harzianum*	*T. longibrachiatum*	*T. album*

Fig 1. The antagonisitic effect of *Trichoderma* spp against *Rhizoctonia solani* isolates

Effect of volatile substance produced by *Trichoderma* spp. on growth of the pathogen.

Determination of inhibition percentages was carried out in two time periods i.e. three days and five days after inoculation. According to the obtained results of the first period, inhibition percentages significantly differed according to the tested *R. solani*isolate and the applied bioagent. In *T.viride*treatment, the highest inhibition % was recorded in*R. solani* isolate 2 (87.50%), whereas the least inhibition (37.12%) was detected in isolate 5. Similarily, in *T. harzianum* treatment, the highest inhibition (68.78%) was detected in isolate 5 of *R. solani*, and the least percent was obtained on isolate 4 (40.67%). The highest inhibition% in *T. longibrachiatum* was similarly detected in isolate 5 (63.52%), whereas isolate1 realized the least percent (37.04%). In contrast to that, *T. album* showed the highest inhibition% on isolate 2 (60.25%) and the least on isolate 5 (28.15%). In the second tested time period (five days of inoculation), the highest inhibition values were produced by *T. harzianum* on isolate 5 (70.90%), *T. viride* on isolate 2 (64.68%), *T. album* on isolate 2 (57.31%). On the other hand, the lowest inhibition values were produced by *T. viride* on isolate 5 (6.04%), *T. longibrachiatum* on

isolate 2 (11.95), *T. album* on isolate 1 (29.44%), and *T.harzianum* on isolate 3 (31.11%) (Table 3).

Table 3 .Volatile activity of *Trichoderma* spp. against *R. solani* isolates in two time periods.

Bioagents(B)	Growth inhibition (%) 3days after inoculation					Mean	Growth inhibition (%) 5 days after inoculation					Mean
	Isolates of *Rhizoctonia solani* (I)						Isolates of *Rhizoctonia solani* (I)					
	1	2	3	4	5		1	2	3	4	5	
T. viride	**40.73**	**87.50**	**47.00**	**40.00**	**37.12**	**50.47**	**37.88**	**64.68**	**24.44**	**24.97**	**6.04**	**31.60**
T. harzianum	**43.07**	**70.17**	**60.00**	**40.67**	**78.78**	**58.54**	**32.77**	**50.00**	**31.11**	**31.85**	**70.90**	**43.33**
T. longibrachiatum	**37.04**	**44.17**	**44.33**	**37.33**	**63.52**	**45.28**	**13.84**	**11.95**	**23.33**	**21.38**	**32.54**	**20.61**
T. album	**35.04**	**60.25**	**38.00**	**36.67**	**28.15**	**39.62**	**29.44**	**57.31**	**32.22**	**32.25**	**23.08**	**34.86**
Control	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Mean	**31.17**	**52.42**	**37.87**	**30.93**	**41.51**	**38.78**	**22.79**	**36.79**	**22.22**	**22.09**	**26.51**	**26.08**
	$LSD_{0.05}$ I, B,T = 0.57 $LSD_{0.05}$IxB= 0.23 $LSD_{0.05}$ IxT, BxT = 0.15 $LSD_{0.05}$IxBxT = 0.33											

Non-volatile activity

Effect of different concetrations of *Trichoderma* spp. (25%, 50%, 75% and 100%) on mycelial growth of the tested isolates of *R. solani* were tested and results were demonstrated in Table. 4,Where:

(1) ***T. viride*** **treatment**: the highest inhibition values (25%, 50%), were detected in isolates 3 (25%), isolate 1, (100%), and 100% inhibition% in all isolates at conc, 75%, and 100%. The lowest inhibition levels at conc. 25 and 50% were obtained in isolates 3 (25%) and isolate 1 (100%), respectively. At cocentrations 75 and 100%, inhibition % was 100% for all the tested isolates.

(2) ***T. harzianum*** **treatment**: The highest inhibition values at concentrations25, 50, and 75% were obtained in isolates 3 (91.35%), isolate 2 (25%), and isolate 1 (100), respectively. At conc. 100%, inhibition% was 100% for all the tested isolates. The lowest inhibition values at coc. 25, 50 and 75% were detected in isolate 1 (0.00%) and isolate 4 (21.67%), respectively. At concentration 100%, inhibition % were 100 for all the tested isolates.

(3) ***T. longibrachiatum*** **treatment**: The highest inhibition values at concentrations 25, 50, and 75%, and 100% were obtained in isolate 2 (11.33%), 2(46.39%), isolate1(81.94%), and isolates 2 and 4 (100%). The lowest inhibition values at concs. 25, 50, 75%, and 100% were detected in isolate 1(0.00%), isolate 1 (0.00%), isolate 3 (16.25%), and isolate 3 (60.63%), respectively.

(4) ***T. album*** **treatment**: The highest inhibition values at concs. 25%, 50%, 75%, and 100% were detected in isolate 3 (11.41%), isolate 2 (54.34%), isolate 2 (79.13%), isolates1,2(100%). The lowest inhibition values at cocs. 25, 50, and 75%, 100% were isolates1,2 ,4(0.00), isolate 1(0.00), isolate 4(10.24%), and in isolate 5(47.12%).

Table 4. Effect of different concentrations of the tested *Trichoderma* spp on mycelial growth of*Rhizoctonia solani* isolates.

Treatements		Growth inhibition (%)					Mean
Bioagent (B)	Concentration % (C)	Isolates of *Rhizoctonia solani* (I)					
		1	2	3	4	5	
T. viride	25	0.00	8.23	25.00	7.69	3.73	8.93
	50	100.00	10.70	49.50	13.75	5.59	35.908
	75	100.00	100.00	100.00	100.00	100.00	100.00
	100	100.00	100.00	100.00	100.00	100.00	100.00
Control	-	0.00	0.00	0.00	0.00	0.00	0.00
Mean		60.00	43.79	54.90	44.29	41.86	88.967
T. harzianum		1	2	3	4	5	Mean
	25	0.00	9.21	13.00	2.14	3.33	5.536
	50	0.00	25.00	31.00	3.93	12.78	14.542
	75	100.00	77.09	46.00	21.67	22.22	53.396
	100	100.00	100.00	100.00	100.00	100.00	100.00
Control	-	0.00	0.00	0.00	0.00	0.00	0.00
Mean		40.00	42.26	38.00	25.55	27.67	34.694
T. longibrachiatum		1	2	3	4	5	Mean
	25	0.00	11.33	4.38	2.80	1.42	3.986
	50	0.00	46.39	11.41	10.49	19.33	17.524
	75	81.94	74.18	16.25	20.37	22.67	26.694
	100	88.79	100.00	60.63	100.00	65.28	82.94
Control	-	0.00	0.00	0.00	0.00	0.00	0.00

Mean		**34.15**	**46.38**	**18.53**	**26.73**	**21.74**	**26.228**
		1	**2**	**3**	**4**	**5**	**Mean**
	25	**0.00**	**0.00**	**11.41**	**0.00**	**2.82**	**2.846**
T. album	**50**	**0.00**	**54.34**	**41.30**	**6.79**	**7.54**	**21.199**
	75	**74.18**	**79.13**	**51.00**	**10.24**	**21.14**	**42.91**
	100	**100.00**	**100.00**	**59.00**	**53.89**	**47.12**	**71.824**
Control	**-**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Mean		**34.84**	**46.69**	**32.54**	**14.18**	**15.72**	**27.755**
$LSD_{0.05}$ I =0.465		**$LSD_{0.05}$ CXI= 1.406**			**$LSD_{0.05}$ C=0.46 5**		
$LSD_{0.05}$ B= 0.416		**$LSD_{0.05}$ BXCXI = 2.081**					

Discussion:

R. solani is widespread and responsible for severe damage to many worldwide economically important agricultural and horticultural crops (Grosch *et al.*, 2006). As for potato high yield losses were reported reaching up to 20 % (Grosch *et al*., 2005). Strategies to control *Rhizoctonia* diseases are limited because of its ecological behavior, large host range and the high survival rate of sclerotia under various environmental conditions (Groth & Bond, 2006). A lot of fungal biota have been reported to be effective biocontrol agents of *R. solani* on potato. Among these are species of *Trichoderma* (Brewer & Larkin, 2005; Grosch *et al*., 2006 and Wilson *et al*., 2008). A biocontrol agent may act against pathogens by using one or more of the following mechanisms: competition, antibiosis, and parasitism as well as activating host defense mechanisms (Papavizas& Lumsden . 1980).

All isolates were tested against *R. solani* isolate in dual culture. Colony and hyphal interactions of these fungal isolates with *R. solani* on PDA are listed in the Tables. Results of the antagonism tests showed that *T. harzianum, T. viride, T. longibrachiatum*and *T. album* spieces were able to overgrow the mycelium of *R. solani* which is compatible with (Chand and Logan, 1984 Andrson , 1988, Nicoletti *et al*.,2004).Antagonism is not the same *in Trichoderma spp*. because different strains or isolates of the same species can exhibit varying biocontrol potential against *R. solani*. The strains or isolates which

posses genes are efficiently and rapidly expressed involved in antagonist activity against *R. solani* are better antagonists (Scherm *et al*., 2009). Until now *Trichoderma spp*. have been successfully applied to diseases of *R. solani* mostly in Greenhouse studies with few studies conducted under field conditions(Da Silva *etal*., 2012), and this is somewhat consistent with our results.

For the control of *R. solani* their extracellular metabolites have been continuously used as biological fungicides (Eziashi *et al*.,2007) Moreover, *Trichoderma spp* more usefull for nutrients as compared to a pathogen which provides them a competitive advantage (Sarrocco *et al*.,2017).As far as interaction between *Trichoderma spp*. and *R. solani* is concerned, the mycoparistim is regarded as a major activity. *Trichoderma spp*. sense small molecules released by *R. solani* .Some of these molecules may be released by proteases enzymes.

Moreover, the *Trichoderma spp*. are showing affinity of cell wall of *Trichoderma spp.,* and *R. solani* which then lead to host cell wall penetration (Schuster & Schmoll, 2010).*Trichoderma spp*. are also suppressing *R. solani* by producing antifungal compounds.Moreover,isolates of *Trichoderma* excrete some growth inhibitory substances. Of these, alkyl pyrons, isonitriles, polyketides, peptaibols diketopiperazines, sesquiterpenes, and steroids have frequently been associated with biocontrol activity (Howell, 1998; Sivasithamparam andGhisalberti, 1998). On the other hand , Vinale *et al*. (2008) reported that *Trichoderma* spp. produced secondary metabolites such as antibiotics (6-pentyl-alpha-pyrone (6pp), isocyanide derivatives), acids (heptelidic and koningic acid), peptaibols and cell wall degrading enzymes (CDWE) that are implicated in inhibits of radial growth of many phytopathogenic fungi (Verma *et al*., 2007)**.** Hyperparasitism and volatile metabolites may be involved in the inhibition of *Fusarium oxysporum*, *Rhizoctonia solani* and *Botrytis cinerea* (Naeimi *et al*.,2010). Cell wall degrading enzymes (CWDEs) such as chitinase, glucanase, and proteases are thought to be closely related to the mycoparasitism of *Trichoderma* strains (Marzano& Altomarem, 2013; Pandey *et al*., 2005 and Saravanakumar *et al*., 2016). Inhibitory volatile substances such as alkylpyrons may also contribute to the biocontrol activity of some *Trichoderma* strains (Claydon *et al*., 1987and Devaki *et al*.,

1992). The antifungal compounds include antibiotics, mycotoxins and lower weight secondary compounds (Schuster and Schmoll ,2010). *Trichoderma spp*. are also well knowing plant growth regulators. They proliferate root and increase the yield by uptake of nutrients (De França *et al*., 2015). As compared to fungicides the effect of *Trichoderma spp*. against *R. solani* is higher because it persists in soil for a long period after application (Gajera ,*et.al*.,2016). Activation of biocontrol genes varied with various *Trichoderma* spp. are only where there is contact with *R. solani* (Harman and Kubicek, 2002).

Conclusion

The work indicates that fungal biocontrol agents were effective against *R. solani.* These biocontrol agents inhibit the pathogen by antibiosis (volatile or non-volatile) or by parasitism of these methods.

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تأثيرأربعة أنواع من فطر *Trichoderma* spp على نمو وتطور *Rhizoctonia solani* المعزولة من البطاطس (صنف سبونتا) المصابة بمرض القشرة السوداء.

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الملخص باللغة العربية

تم الحصول على عزلات *Rhizoctonia solani*من درنات البطاطس المصابة (صنف سبونتا). أستخدمت أربع عزلات من الترايكوديرما والمسماة *Trichoderma harazianum*، *T. viridae*، *T. longibrachiatum*،*T. album* لاختبار تأثيرها التضادي على نمو وتطور عزلات *R. solani*. تم دراسة التداخل والتضاد بتقنية الزراعة المزدوجة والمواد المتطايرة والغيرالمتطايرة ما بين العزلات الفطرية المضادة وفطر *R. Solani*.

جميع عزلات *Trichoderma* spp. أظهرت تأثير معنوي على نمو عزلات *R. solani* المختبرة. أنتجت مناطق تثبيط امام مستعمرات *R. solani* ولكن بدرجات مختلفة.عزلة *Trichoderma harazianum* كانت قادرة على النمو فوق ميسيليوم *R. solani* مقارنة بعزلات الترايكوديرما الاخرى المختبرة. جميع المضادات أكبحت تكون الاجسام الحجرية. أدى ذلك الى تقليل النمو الفطري لعزلات *Rhizoctonia solani* . أشارت النتائج الى أن مدى الثبيط بواسطة *T. harazianum* يشجع على استخدام مضادات محتملة ممتازة قادرة على التحكم في الامراضية لفطر *R. solani* على البطاطس.

الكلمات المفتاحية: البطاطس، العوامل الحيوية الفطرية، التضاد، التطفل *Rhizoctonia solani*,