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COMPARATIVE PATHOGENICITY OF *RHIZOCTONIA SOLANI* AGAINST DIFFERENT PLANT SPECIES WIDELY CULTIVATED IN MOROCCO

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Abstract

The pathogenicity of *Rhizoctonia solani* isolates derived from strawberry plants was evaluated against ten crops mostly grown into or closely to strawberry plantation areas plots. 13 weeks after inoculation, strawberry plants showed symptoms when they were inoculated by making collar injury using wooden toothpick whereas those inoculated by using root dip didn't be affected. 20 days after inoculation, different levels of infection were observed in plants of the other species with more susceptibility of tomato, eggplant, green bean and lettuce plants followed by those of pepper, cucumber while the rice, watermelon and zucchini were the least.

The most pathogenic *R. solani* isolates were R1 and R2 inducing symptoms on the roots, stems and leaves. In the presence of both isolates, the severity index reached 100% in eggplant and 91.66% in tomato. They altered seriously tomato and eggplant stems with severity notes of 3.66 and 2.33, respectively. Moreover, a weak root development was observed reaching a note of 0.33 (tomato) and 0 (eggplant).

The vigor of the affected plants estimated by the fresh, dry weight and the length of aerial and underground parts decreased significantly compared to the control. In fact, R1 and R2 isolates reduced the height of the aerial part of the eggplant to 0 cm causing their death one week after the inoculation. That of tomato was 1.3 cm compared to the control (25.3 cm)

Similarly, in lettuce and green bean, the reduction of growth parameters was moderate to significant varying respectively from 3 to 10 cm and 3.33 to 14.6 cm compared to controls, respectively 21.3 and 23 cm.

The lowest re-isolation percentage of *R. solani* was (20%) noted for H1 from strawberry not wounded and zucchini and the highest (100%) was recorded by R1 recovered from eggplant, Zucchini and lettuce as well as for R2 re-isolated from lettuce and eggplant. From the soil of all plants species culture artificially inoculated, the re-isolation percentage was greater than 52%.

Key words : *Rhizoctonia solani*, pathogenicity, strawberry, vegetables crops, Morocco.

Introduction

The Basidiomycete *Rhizoctonia solani* Kühn (teleomorph *Thanatephorus cucumeris*) is considered the most ubiquitous species within a heterogeneous genus of soilborne fungi, characterized by a global distribution and pathogenic on a wide variety of major crops (Cubeta and Vilgalys, 1997; Bacharis et *al*., 2010). *Rhizoctonia solani* Kühn refers to a species complex, because it accumulates related but genetically distinct groups with diverse morphology, ecology, and pathology (Cubeta and Vilgalys, 1997; Hane *et al*., 2014). Thus, this fungus is divided into anastomosis groups (AG) based on hyphal anastomosis reactions between isolates and it's composed of 14 AGs designated as AG-1 through 13 and AG-bridging isolate (AG-BI) (Sneh *et al*., 1991; Ogoshi, 1996; Carling *et al*., 1999, 2002; Taheri et Tarighi, 2012a and 2012b). The host range of *R. solani* is extensive, including a large number of vegetables (Anees *et al*., 2016), some cereals (Lakshmanan *et al*., 1979; Gokulapalan *et al*., 2000; Singh *et al*., 2002; Santha Kumari and Rehmath

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Niza, 2005; Ali, 2002; Rajput and Harlapur, 2014; Pavani and Singh, 2018), horticultural and ornamental crops and weeds (Ou, 1972). This fungus is known to induce various plants diseases such as collar and root rot (Carling and Sumner, 1992; Jacobsen, 2006; Kühn *et al*., 2009), seedling damping-off (Orie and Makoto, 1996; Yangui *et al*., 2008), stem canker (Daami-Remadi *et al*., 2008), crown rot, foot rot (Misawa and Kuninaga, 2010), bud and fruit rots (Strashnov *et al*., 1985), rotting sprouts (Simson et *al*., 2017), stem dry rotting and smallpox (Read *et al*., 1989; Yao, 2002) as well as foliar blight disease (Belmar *et al*., 1987). Among these, Rhizoctonia root rot as mostly soil-or seed-borne disease (Tsror, 2010) is a major limitation to improve production efficiency and crop quality (Morsy *et al*., 2005; Tewoldemedhin *et al*., 2006; El-Shennawy *et al*., 2010; Abd El-Hai *et al*., 2017). The causal organism is responsible for economic yield losses on a high diversity of crops (Sneh *et al*., 1996; Verma, 1996; Kiewnick *et al*., 2001; Büttner *et al*., 2003; Führer Ithurrart *et al*., 2004; Paulitz *et al*., 2006) as lettuce (Davis *et al*., 1996; Wolf and Verreet, 1999), watermelon (Aiello *et al*., 2012), tomato (Santander *et al*., 2003; Berta *et al*., 2005; Rini and Sulochana, 2007; Karaca *et al*., 2002; Solanki *et al*., 2012; Ouhaibi-Ben Abdeljalil *et al*., 2016), pepper (Velásquez and Victoriano, 2007; Serdar and Cafer, 2013;Tuncer and Eken, 2013; Mannai *et al*., 2018**)**, potato tubers (Kanetis *et al*., 2016), cucumber (Erper *et al*., 2002; Yousef *et al*., 2013), winter squash (*Cucurbita maxima* Duch.) (Erper *et al*., 2015), pea crops (Sharma-Poudyal *et al*., 2015), eggplant (Hadwan and Khara, 1992; El-Nagdi and Abd-El-Khair, 2008), kiwifruit (Erper *et al*., 2013). Likewise, *R. solani* is a veritable threat to commercial strawberry production worldwide (Zeller, 1972; Aerts, 1977; Tanaka *et al*., 1995; Matsumoto and Yoshida, 2006; Manici and Bonora, 2007; Juber *et al*., 2016). In Morocco, this fungus has been reported to be responsible of damping- off on cedar seedlings (Bakry and Abourouh, 1992), soft rot of chickpea (Singh and Reddy, 1991), dieback of lentil plants (Mabsoute and Saadaoui, 1996), potato rhizoctoniasis (Chibane, 1999, Kotba *et al*., 2018) and bottom rot of lettuce (Elattir *et al*., 2003). Also, it has been isolated from the roots of apparently healthy olive trees (Chliyeh *et al*., 2014). It exhibited a high occurrence on roots and crowns of strawberry plants grown in 7 farms in Gharb and Loukkos areas (Mouden *et al*., 2013, 2016a, 2016b).

Indeed, three quarters of farmers in the different strawberry plantings cultivate the same pre-crops which are in the majority potato, cereals, peanuts and salads being adopted in rotation crop with strawberry (Al Batnan *et al*., 2015). However, this approach can influence preplant inoculum of soil-born fungi and increases the phytosanitary risks in field soils (Peters *et al*., 2004; Wiggins and Kinkel, 2005). Furthermore, the susceptibility of the preceding crops to *Rhizoctonia solani* will also affect the strawberry soil-borne disease incidence and development due to its survival capacity in soil and on buried plant residues.

Thus, the aim of this study was to verify the pathogenicity of seven isolates of *R. solani* isolated from strawberry towards ten plant species widely cultivated in the Gharb-Loukkos region of Morocco and to examine their virulence characters on these plant species under controlled environmental conditions.

Materials and Methods

Fungal isolates

The seven isolates of *Rhizoctonia solani* (R1, R2, H1, G1, M1, ZAC, and For) were isolated from the roots of plants of different varieties of strawberry collected from farms located in the commune of Moulay Bousselham (northwestern Morocco) (table 1) and maintained on the PSA medium (200 g of potato, 20 g sucrose and 20 g Agar-agar) at 24°C in the dark.

Plant material

Seeds of green bean "Theresa" variety, lettuce "Madrilène" variety and rice "Ociano" variety were sanitized in a 1% sodium hypochlorite solution (NaOCl) for 10 minutes, washed several times at the tap water then placed to dry on the filter paper during 15 minutes. Twenty surface sterilized seed of each vegetable species were placed in each Petri dishes containing sterilized cotton soaked with sterile distilled water then incubated at 28°C in a growth chamber under laboratory condition for 3 days. The germinated seeds were taken from Petri dishes and transferred into plastic plug tray containing the peat and placed in a greenhouse for four weeks. The seeds of tomato "Thuraya" variety, pepper "Mansoura" variety and eggplant "Vernal" variety were disinfected

Table 1 : Origin of *Rhizoctonia solani* isolates recovered from strawberry plants.

Isolates	Varieties	Origin sites
R1	Venicia	Dlalha, Moulay Bousselham, Morocco
R2	Venicia	Dlalha, Moulay Bousselham Morocco
G1	Festival	Dlalha, Moulay Bousselham Morocco
M1	Festival	Dlalha, Moulay Bousselham Morocco
H1	Camarosa	Gnafda, Moulay Bousselham Morocco
For	Fortuna	Dlalha, Moulay Bousselham Morocco
ZAC	Camarosa	Lanabssa, Moulay Bousselham Morocco

as described above prior to sowing. Disinfected seeds were hand sown in plastic plug trays containing peat watered then covered with plastic film mulch and placed in the greenhouse for 48h under natural daylight.

The bare-root strawberry plants of "Festival" variety and the plug plants of watermelon variety "Delta" reported from a certified nursery were grown in pots containing 50% black peat and 50% of Mamora soil, placed in a greenhouse and watered daily until to the stage of five leaves required for inoculation. The seedlings of the various vegetable were watered daily with the tap water up to the stage of 4 to 5 leaves required for inoculation.

Fungal inocula preparation

The mycelial suspension of each fungal isolate was obtained by harvesting the mycelium mats from ten days old fungal culture isolates grown on PSA. A sterile spatula was used to scrub the surface of the fungus plates. A 6 g of a mycelia mat was added to 100 mL of sterilized distilled water and then milled using a mixer. The whole was adjusted to a volume of 200 mL.

Inoculation

The roots of seedlings of 10 plant species tested were cleared from peat and slightly injured with friction before being dipped in the mycelial suspension of *Rhizoctonia solani* isolates for one hour. After inoculation, plantlets were transplanted into pots containing the soil of the Maamora and the remaining mycelial suspension is poured onto surface of the soil. The roots of control plants were dipped in distilled water. Then, they were placed under greenhouse conditions with temperature varying from 18°C at night to 30°C during the day.

A second inoculation technique was used for strawberry plants. At the stage of 8-9 leaves, the strawberry plantlets were inoculated by making collar injury using wooden toothpick. Prior to use, the toothpicks were sterilized by autoclaving twice in deionized water. Six plants were inoculated with each isolate by inserting a colonized toothpick into each crown. Sterile toothpicks dipped in sterile distilled water were inserted into the crowns of corresponding control plants. Inoculated seedlings are replanted into pots containing Mamora soil and the remaining mycelial suspension is poured onto surface of the soil. The inoculated plantlets were incubated in a greenhouse with three replicates of three plants each per plant species and isolate tested.

Results notation

13 weeks after inoculating of strawberry plantlets and 20 days for the other plants species, stem rot and roots development were rated using a numerical scale of the 0-4 index defined by Aoyagi *et al*. (1998) :

The stem rot note : 0 : 0% no obvious symptoms ; 1 : 1% of the stem affected (with symptoms), 2 : 5% of the stem rotted (affected), 3 : 30-60% of the stem with symptom and 4 : 60-100% of the stem affected.

The disease severity index (SI) was calculated using the formula:

$$I.S. = \sum \left\{ \frac{Stem\ \ rot\ note\ delivered\ to\ inoculated\ plant}{Maximal\ note} \right\} \times 100$$

The root development note: 0: No development (dead plant); 1: Low development; 2: Normal development (healthy control); 3: Good development and 4: Very good development.

Re-isolation of *R. solani* from the inoculated plants

The roots removed from their ground gangue were washed with running water several times, cut out into small pieces of 0.5 to 1 cm, disinfected with alcohol 95° for five minutes, rinsed with sterile distilled water several times and dried on sterile filter paper. The fragments were deposited in sterile Petri dishes containing water agar medium (15 g Agar-agar and 1000 mL distilled water) and incubated in the dark at 24°C for 48H. After that, the colonies formed were transferred to PSA agar plates and incubated then in the same conditions for 7 days (Rapilly, 1968).

The isolation percentage of *R. solani* ($PR_{R.\ Solani}$ %) was obtained by the following formula:

$$PR_{R.\ Solani}\ (\%) = \frac{Nf_{R.\ Solani}}{NTf} \times 100$$

$Nf_{R.\ Solani}$: Number of segments containing the fungal specie x.

NTf: Total number of segments used in the isolation

Isolation of *R. solani* from the culture soil

The technique of "Soil plates" of Warcup (1950) was adopted for the isolation of *R. solani.* The culture soil was dried at 30°C in Petri dishes funds and grounded in a sterilized mortar. An amount of soil (5 mg to 15 mg) was dispersed in sterile Petri dishes (9 cm of diameter) to which are added 1-2 drops of sterile distilled water and spread out on the medium. Agar plates were incubated for 5 days in the darkness at 22°C. Five replicates were made for each treatment. After 5 days incubation, the number of colony forming units (CFU) per gram of soil was estimated for each replicate.

Agronomic parameters

At the end of experiments, the different plants species were removed from their culture substrate. The perpendicular diameter of the strawberry rosette or the length of the aerial part for the other species. The lengths of the root system were measured using a ruler. The fresh weight of the aerial part and the underground part were weighed by a precision balance and the dry weight was also weighed after drying at 70°C in an oven for 4 hours.

Statistical analysis

Data were analyzed by one-way analysis of variance (ANOVA) and LSD test at 5% level. The percentages were transformed into Arcsin $\sqrt{P}$ (where, P is the proportion of percentage).

Results

Three weeks after inoculation with *R. solani* isolates, alteration symptoms in varying degrees were observed on the seedlings of the nine plant species tested (rice, cucumber, lettuce, pepper, eggplant, tomato, green bean, watermelon and zucchini) or on strawberry plants after 13 weeks of inoculation. The *R. solani* isolates success to cause stem rots (figs. 1A and 1B), both root and crown rots (fig. 1D), wilting of the youngest leaves (Figs. 1C et 1E) and even plants mortality (figs. 1G, 1H and 1I).

13 weeks after inoculation, the *R. solani* isolates exhibited a variable pathogenic capacity on the strawberry plants. Thus, on the plants inoculated by making injury in collar with toothpick dipped in the mycelial suspension of *R. solani*, all the tested isolates induced significantly the same note of stem rot corresponding to 2 except R2, for which, it is equal to 1. In comparison with the note of root development of control plants equal to 4, no significate change was observed on strawberry plants inoculated with ZAC and For, the note of root development was equal to 3. Whereas in presence of other isolates, the note of the root development was lesser especially for R1 and R2, equal to 1 (fig. 2).

Contrarily, inoculation by soaking the roots of the strawberry plants in the mycelial suspension of isolates didn't cause stem rot and the root development of plants had a score of 2 which was not significantly different from that of the control except the isolate For presenting a note equal to 1 (fig. 3).

Also, the representative isolates of *R. solani* from strawberry plants were able to attack to varying degrees the other plant species after 3 weeks of their inoculation by soaking in the mycelial suspension of roots slightly injured by friction.

Thus, the results showed that the isolates R1 and ZAC appeared to be more aggressive on lettuce for inducing both reduction of root development (0.33) and more extent stem rot (3.66) than the other ones resulting in a note of 1 and 3 for root development and the stem rot, respectively (fig. 4). Symptoms caused by *R. solani* started initially as reddish to brown lesions observed on the sides of the lettuce leaves in contact with soil. At harvest, the lower part of the leaves become rotten without wilting of the plants.

In green bean plants, the isolate R1 caused significant stem rot with a score of 3.66 significantly equal to those reached by ZAC, H1 and G1 with a low root development score of 0.33 (fig. 5).

On tomato plants, the three isolates R1, R2 and Z.A.C. were most pathogenic compared to the other isolates with respectively rot stem and root development notes equal to 3.66 - 2.33 and 0.33 - 0.65 (fig. 6). A higher susceptibility of eggplant plants to R1 and R2 illustrated by notes of stem rot and root development attaining respectively 4 and 0, superior than those of G1 (3.66-0.33) and leading to death of plants (fig. 7).

Concerning cucumber plants, their infection was less evident presenting a slight stem rot when inoculated with G1, H1 and M1 isolates not exceeding score 2 compared to other isolates that were less virulent (fig. 8). Other types of symptoms were apparent on leaves on contact of ground where isolates produced a large spots or irregular brown lesions.

In the pathogenicity tests of pepper plants, only R1 isolate seemed to affect stems which rot stem note was equal to 1 (fig. 9) and leaves showed symptoms of yellowing and wilting. However, a reduction in root development was obtained in the presence of all isolates with score not exceeding 1.5. Those of G1 and For were significantly similar to the control (fig. 9).

The rice and zucchini plants subjected to inoculation tests were weakly affected by the tested isolates. Their stem rot note was equal to 1 on rice (Fig. 10) and 0 on zucchini plants (fig. 11) while root development was not affected. As for watermelon plants, both notes attributed to stem rot and root development were significantly identical to those of control plants (fig. 12).

Isolates of *R. solani* showed variable disease severity on the ten plant species. *R. solani* isolates were very aggressive on eggplant, tomato, lettuce and green beans. Disease severity of 100% on eggplant and 91.66% on lettuce, green bean and tomato were achieved by isolate R1 followed by isolate R2 which gave severity of disease 100% on eggplant, 91.66% on tomato and 75%

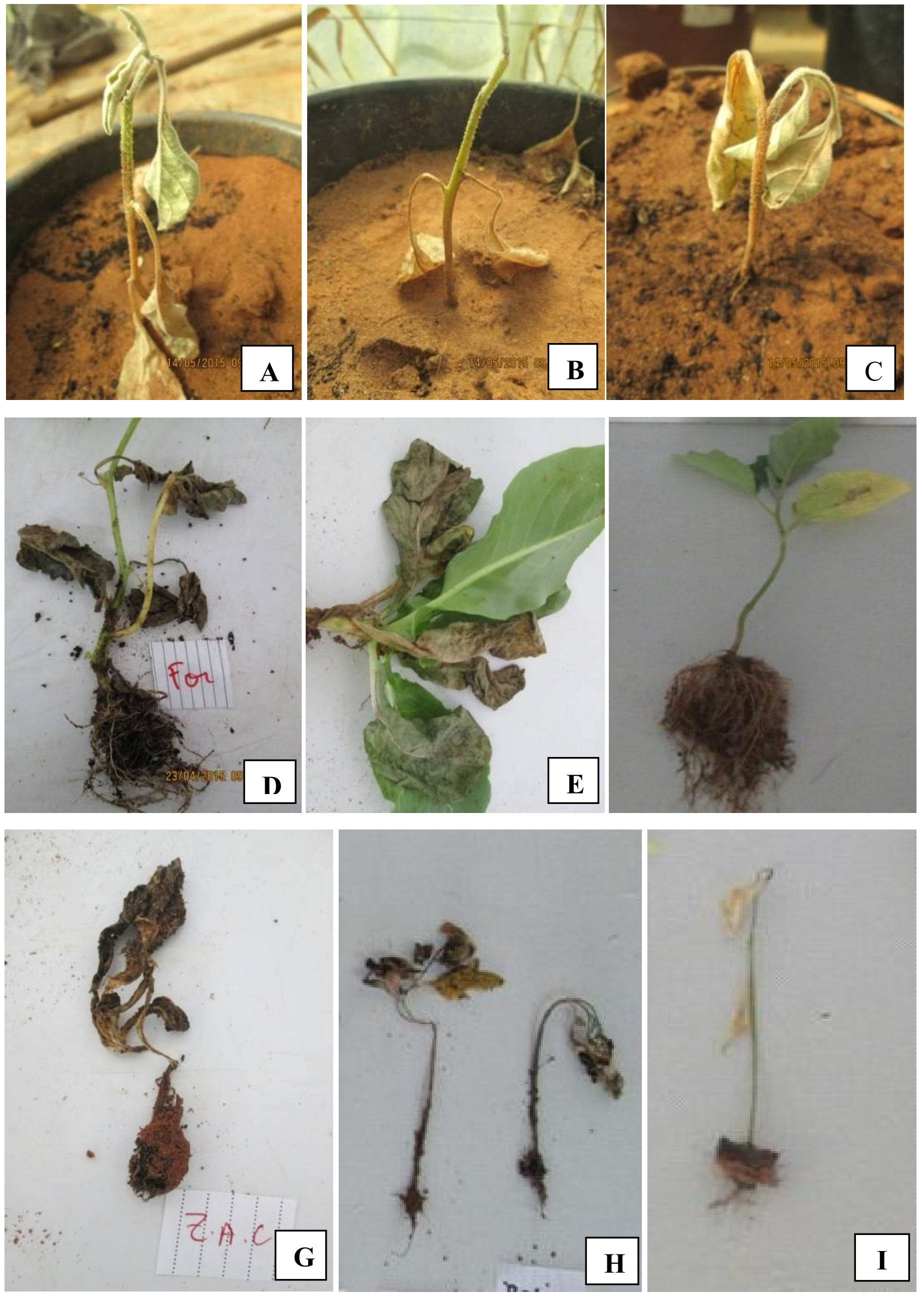

Fig. 1 : Symptoms of stem rot on eggplant seedlings (A and B), wilt of eggplant leaves (C) and lettuce (E), crown rot and watermelon roots (D), seedling death of lettuce (G), tomato (H) and pepper (I) caused by *Rhizoctonia solani.*

on lettuce. The severity of the disease caused by the different isolates was moderate to low on the strawberry inoculated by injury of the collar and the cucumber, weak on the rice and null on pepper, zucchini, watermelon and strawberry inoculated by the suspension (table 2).

The comparison of disease severity of *R. solani* isolates obtained from strawberry plants on the most susceptible botanical species all combined, the strawberry plants inoculated using collar injury, the lettuce, the green bean, the tomato and the eggplant, showed that the isolate R1 was significantly the most aggressive with a disease severity of the 84.99% followed by the other isolates with index severity varying from 50 to 63.33% (fig. 13).

The pathogen was re-isolated from the root of the infected seedlings but not from the control plants and the culture obtained was found to be similar with the original culture.

The re-isolation percentages were variable regarding plant species and isolate. The lowest was (20%) noted for H1 from strawberry not wounded and zucchini even though was reisolated from lettuce as percentage of 100%. Similarly, this higher percentage was reached by

Table 2 : Disease severity induced by *Rhizoctonia solani* isolates on plant species (expressed in %).

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	50^{a}	0^{a}	75^{b}	50^{e}	75^{b}	25^{c}	$33{,}33^{b}$	0^{b}	25^{a}	0^{a}	0^{a}
G1	50^{a}	0^{a}	75^{b}	$66{,}66^{d}$	$16{,}66^{f}$	75^{b}	50^{a}	0^{b}	25^{a}	0^{a}	0^{a}
H1	50^{a}	0^{a}	75^{b}	$83{,}33^{b}$	$33{,}33^{e}$	25^{c}	$33{,}33^{b}$	0^{b}	25^{a}	0^{a}	0^{a}
For	50^{a}	0^{a}	75b	50^{e}	50^{d}	25^{c}	25^{c}	0^{b}	25^{a}	0^{a}	0^{a}
R1	50^{a}	0^{a}	$91{,}66^{a}$	$91{,}66^{a}$	$91{,}66^{a}$	100^{a}	25^{c}	25^{a}	25^{a}	0^{a}	0^{a}
R2	25^{b}	0^{a}	75^{b}	25^{f}	$91{,}66^{a}$	100^{a}	25^{c}	0^{b}	25^{a}	0^{a}	0^{a}
Z.A.C	50^{a}	0^{a}	$91{,}66^{b}$	75^{c}	$58{,}33^{c}$	25^{c}	25^{c}	0^{b}	25^{a}	0^{a}	0^{a}
Control	0^{c}	0^{a}	0^{c}	0^{g}	0^{g}	0^{d}	0^{d}	0^{b}	0^{b}	0^{a}	0^{a}

Values in the same column followed by the same letter are not significantly different at the 5% level.

Table 3. Re-isolation of *Rhizoctonia solani* from roots of the ten plants species tested (expressed in %)

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	80^{bc}	66.6^{b}	66.6^{c}	80^{ab}	$66{,}6^{a}$	100^{a}	53.3^{c}	80^{ab}	40^{ab}	40b	60^{b}
G1	93.3^{ab}	86.6^{a}	86.6^{b}	66.6^{b}	60^{a}	100^{a}	$66.6b^{c}$	73.3^{ab}	26.6^{bc}	33.3^{b}	93.3^{a}
H1	80^{bc}	20^{c}	100^{a}	100^{a}	73.3^{a}	60^{c}	86.6^{a}	86.6^{a}	66.6^{a}	$20b^{c}$	86.3^{a}
For	$66.^{6c}$	93^{a}	100^{a}	40^{cd}	46.6^{a}	66.6^{c}	46.6^{c}	60^{b}	46.6^{ab}	33.3^{b}	73.3^{ab}
R1	93.3^{ab}	100^{a}	100^{a}	100^{a}	80^{a}	100^{a}	93.3^{a}	$66{,}6^{b}$	40^{ab}	100^{a}	73.3^{ab}
R2	100^{a}	100^{a}	100^{a}	60^{bc}	80^{a}	100^{a}	60^{c}	73.3^{ab}	46.6^{ab}	93.3^{a}	66.6^{ab}
Z.A.C	93.3^{ab}	100^{a}	100^{a}	33.3^{d}	86.6^{a}	86.6^{b}	$80a^{b}$	93.3^{a}	33.3^{b}	26.6^{bc}	80^{ab}
Control	0^{d}	0^{d}	0^{d}	0^{e}	0^{b}	0^{d}	0^{d}	0^{d}	0^{c}	0^{c}	0^{c}

Values in the same column followed by the same letter are not significantly different at the 5% level.

R1 recovered from eggplant, Zucchini and lettuce as well as for R2 re-isolated from lettuce and eggplant (table 3). For M1 and G1, their re-isolation percentages attained 100% and varied between 26.4% and 40% on rice and zuchini (table 3).

The re-isolation from the soil of all plants species culture artificially inoculated with different isolates of *R. solani* has confirmed the presence of the isolates with a percentages greater than 52% (table 4).

A significant differences ($p<0.05$) were found among different isolates and plant species investigated for measured agronomic growth parameters, including plant height, fresh root weight, dry plant weight and dry root weight.

The results shown in tables 5, 6, 7, 8, 9, 10 illustrate a decrease in all growth parameters after inoculation of plant species by *R. solani* isolates compared to control plants. Thus, the height of the aerial part of the eggplant plants was reduced to 0 cm in the presence of the H1, R1 and R2 isolates compared to the control (37.33 cm) causing their death one week after the inoculation. The size of tomato plants was 1.3 cm in the presence of isolates R1 and R2 compared to the control (25.3 cm). A moderate to low reduction in the size of the aerial part was noted in the other plant species. As for the perpendicular diameter of the rosette of the strawberry plants inoculated by collar injury, it varied from 19.3 to 22.5 cm compared to 32.8 cm in the control plant (table 5).

The isolates Z.A.C and R1 had severely affected the height of lettuce plant reduced to 8 and 10 cm, respectively, relative to control (18 cm). Those of cucumber and pepper plants ranged from 14.6 to 20.6 cm and 18 to 28 cm, respectively, compared with controls (28 and 34.6 cm). While, the reduction was lesser in zucchini and watermelon plants. However, no effects were observed on the development of strawberry plants inoculated with the mycelial suspension and on rice (table 5).

A significant diminution in the length of the root system was observed in the eggplant and tomato plants inoculated by the different *R. solani* isolates where it reached 0 and 0.6 cm respectively for the isolates R1 and R2 compared to the controls (26.3 and 10 cm). Also null growth was noted in the presence of the H1 isolate for the first one.

The negative effect of *R. solani* isolates on root growth was important to moderate on lettuce and green beans which their average size varied respectively from 3 to 10 cm and 3.33 to 14.6 cm compared to controls (21.3 and 23 cm) except for M1 without apparent effect on lettuce roots.

In addition, an average reduction in root size of zucchini and strawberry plants inoculated by collar injury whereas, it was weak to null in pepper, rice, watermelon and strawberry plants inoculated with mycelial suspension (table 6).

A diminution in the fresh weight of the aerial part was noted in tomato, eggplant, lettuce and green bean plants inoculated by the different isolates of *R. solani*, reaching respectively 1.4, 0.4, 1.1 and 1.4 g for isolate R1 compared to controls 11, 8.8, 6.1 and 7.3 g (table 7). As for the fresh weight, the root part was reduced in all species except the strawberry inoculated by the suspension (table 8). A reduction in the dry weight of the aerial and root system is also noted in all plant species (tables 9 and 10).

Discussion and Conclusion

This is the first study to demonstrate diûerential pathogenic abilities of isolates of *R. solani* known as one of the most common pathogens isolated from declining strawberry plants (Fang *et al*., 2011) and among the prevailing fungal species colonizing currently available commercial strawberry cultivars grown in Morocco (Mouden *et al*., 2016a) on eight vegetables and two fruit crops.

The results of the pathogenicity tests showed clearly that the strawberry isolates of *R. solani* caused disease in the different plant species tested and that the virulence of the isolates, in most cases, varied depending on the host and the isolates. Inoculation of seedlings by the mycelial suspension of different isolates of *R. solani* induced stem and root rot, reduction in root development of lettuce plants, green beans, tomato and eggplant as well as decreasing in the growth and weight of the aerial and root parts. Though cucumber, pepper, rice, zucchini, watermelon showed some or little resistance to *R. solani* isolates. Similarly, the evaluation of pathogenic effects of this fungus ranked him as an aggressive pathogen to young pepper plants and a minor pathogen to older plants causing root or crown rot (Sneh, 1991; Velásquez *et al*., 2001; Hane *et al*., 2014; Wang *et al*., 2015).

According to others researchers, most of the rice varieties are susceptible while some of them do exhibit moderate to high degree of disease tolerance (Pan *et al*., 1999; Ghosh *et al*., 2014). In the pathogenicity tests on zucchini seedlings where isolates of *F. culmorum*, *F. equiseti* and *F. oxysporum* isolates dominated the fungal

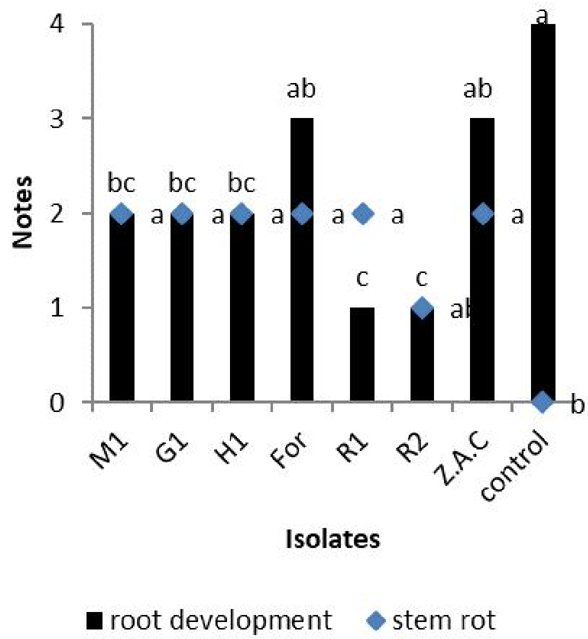

Fig. 2 : Stem rot and root development of strawberry plants noted 13 weeks after the inoculation by making collar injury with *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

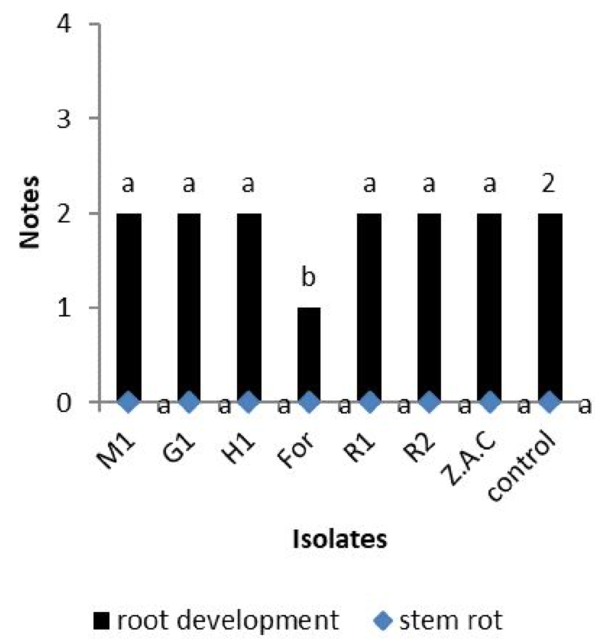

Fig. 3 : Stem rot and root development of strawberry plants noted 13 weeks after the inoculation by mycelial suspension of *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

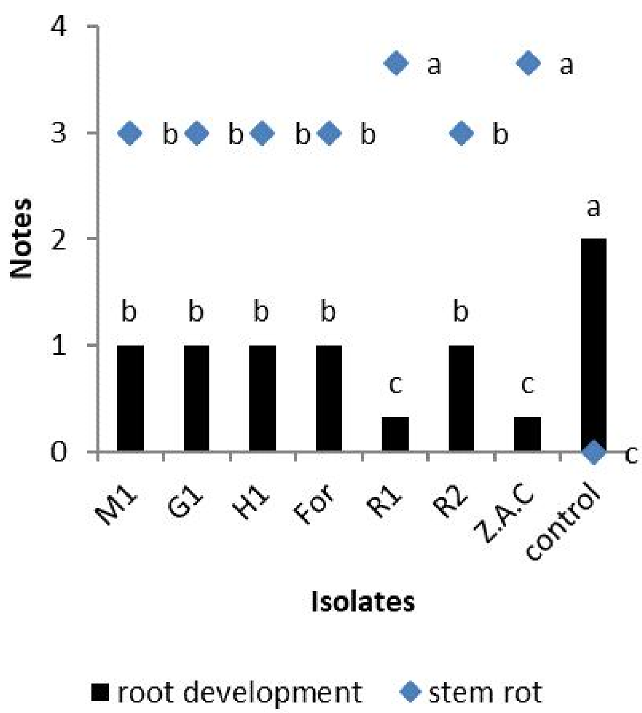

Fig. 4 : Stem rot and root development of lettuce seedlings noted 3 weeks after the inoculation by *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

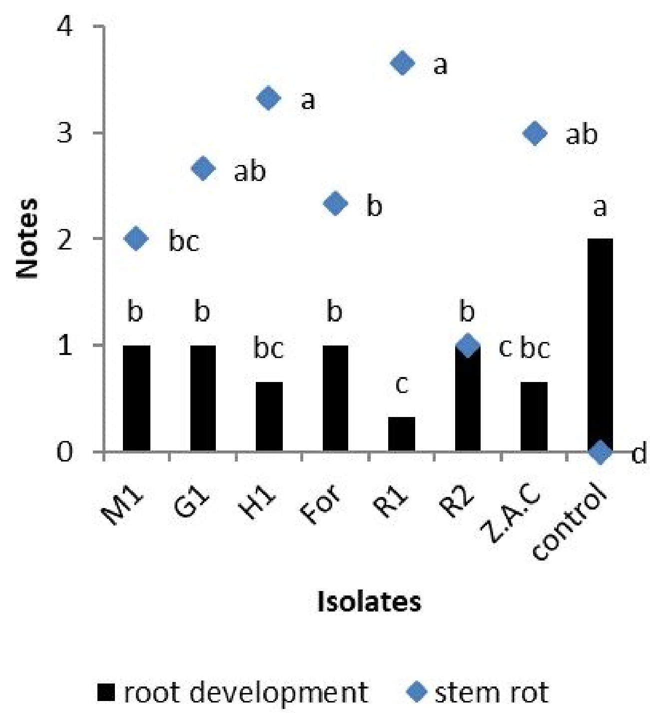

Fig. 5 : Stem rot and root development of green bean seedlings noted 3 weeks after the inoculation by *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

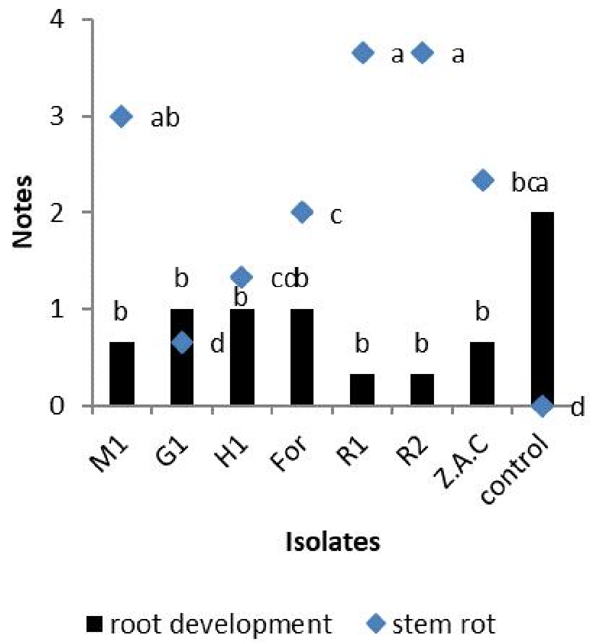

Fig. 6 : Stem rot and root development of tomato noted 3 weeks after the inoculation by *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

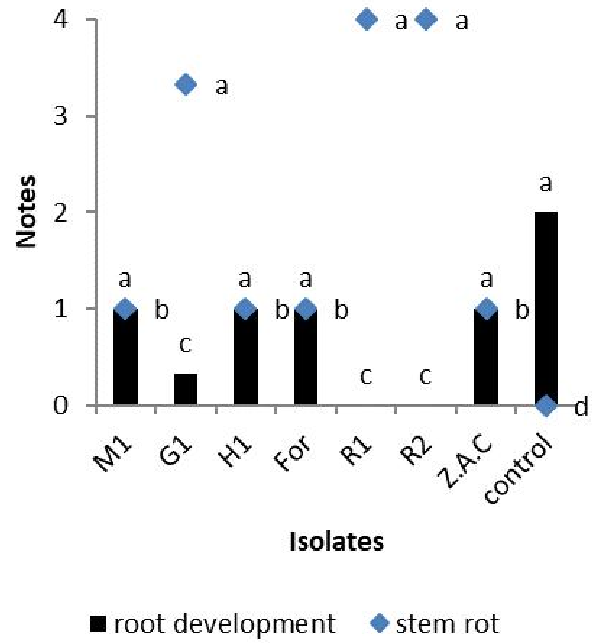

Fig. 7 : Stem rot and root development of eggplant noted 3 weeks after the inoculation by *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

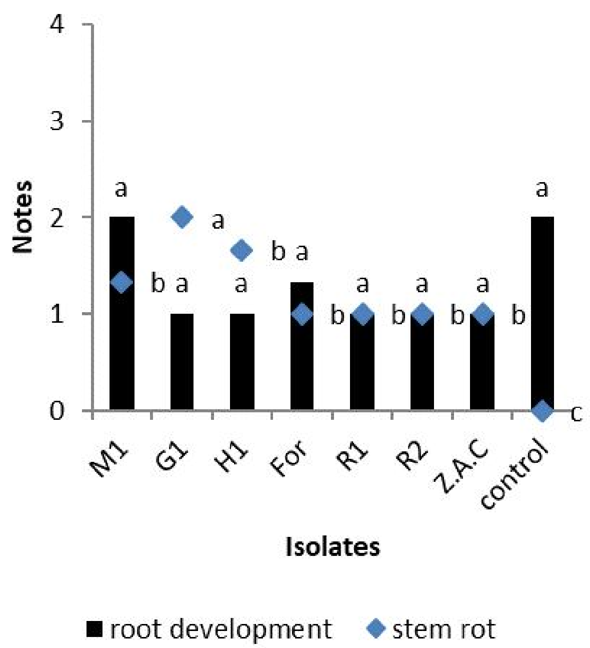

Fig. 8 : Stem rot and root development of cucumber seedlings noted 3 weeks after the inoculation by *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

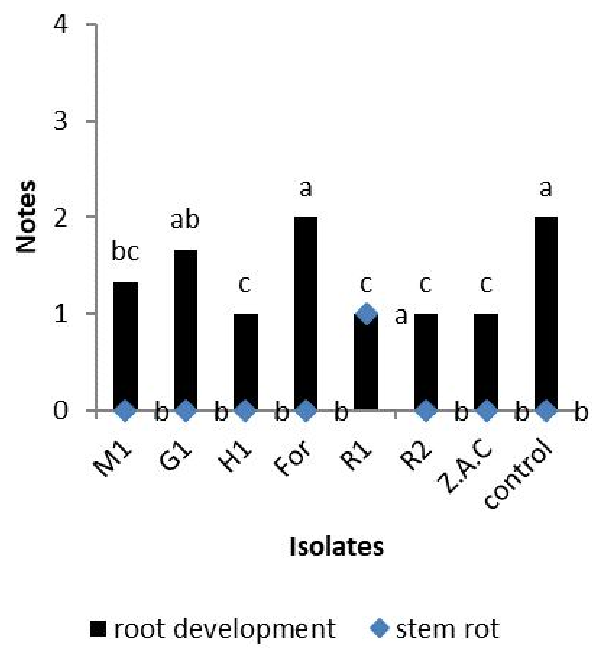

Fig. 9 : Stem rot and root development of pepper seedlings noted 3 weeks after the inoculation by *R. solani* isolates.

Two results affected by the same letter show no significant difference at 5% level.

communities recovered from roots, proved to be pathogenic causing stunting, stem and root rot while *R. solani* with a minor occurrence was not (Jamiołkowska *et al*., 2011). Under greenhouse and field conditions zucchini is usually infected by pathogens specific for Cucurbitaceae but also by microorganisms pathogenic to other crops (Kimati *et al*., 1997; Sumner *et al*., 1995). The most important among them are Fusarium spp.

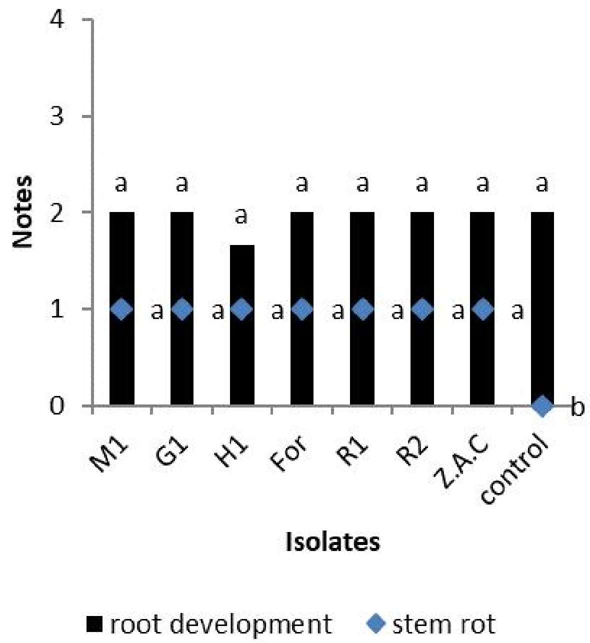

Fig. 10 : Stem rot and root development of rice noted 3 weeks after the inoculation by *R. solan*i isolates.

Two results affected by the same letter show no significant difference at 5% level.

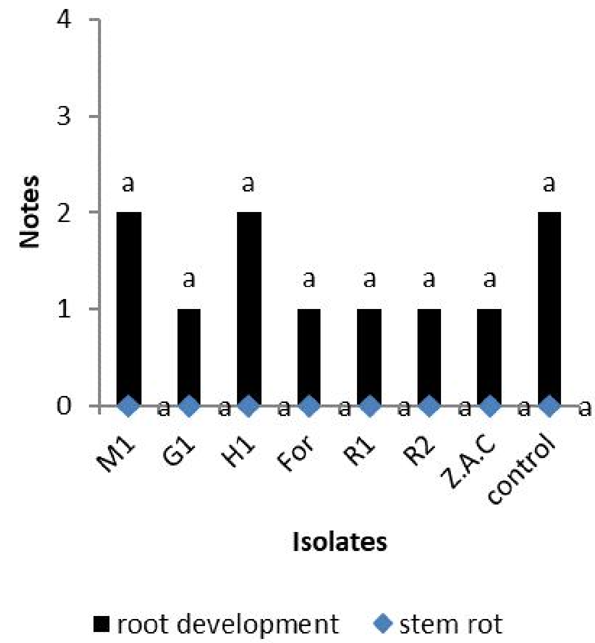

Fig. 11 : Stem rot and root development of zucchini seedlings noted 3 weeks after the inoculation by *R. solan*i isolates.

Two results affected by the same letter show no significant difference at 5% level.

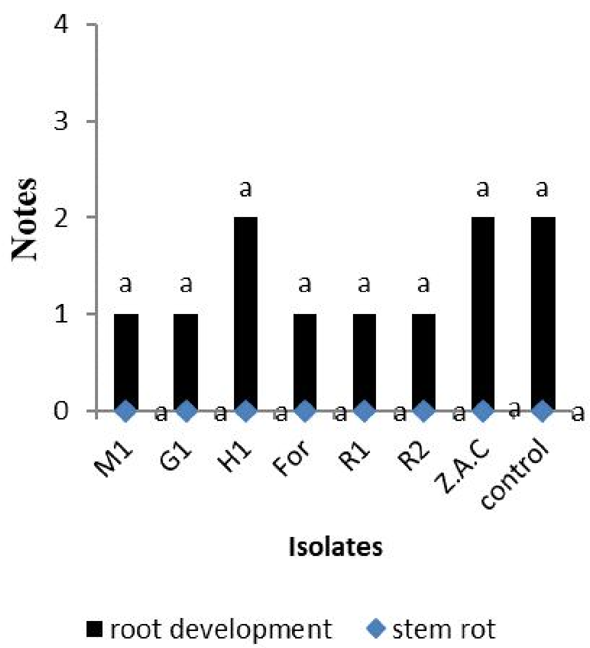

Fig. 12 : Stem rot and root development of watermelon noted 3 weeks after the inoculation by *R. solan*i isolates.

Two results affected by the same letter show no significant difference at 5% level.

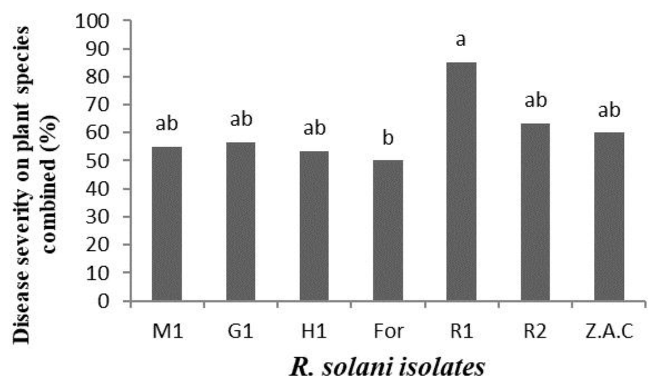

Fig. 13 : Comparative disease severity induced by *Rhizoctonia solani* isolates on plant species all combined: strawberry plants inoculated by collar injury, lettuce, green bean, tomato and eggplant.

Two results affected by the same letter show no significant difference at 5% level.

surviving in the soil environment as saprotrophic mycelium and chlamydospores such as *F. avenaceum* and *F. culmorum* known to be pathogens of zucchini and other vegetables causing plant decay due to the colonization of their underground organs (Nelson *et al.*, 1983; Jamiołkowska and Buczkowska, 2009).

The success of *R. solani* isolates to induce infection symptoms on strawberry plants was approved by Botha *et al.* (2003) and Martin (2000). The symptoms produced by artificial inoculation of strawberry plants with AG 1-2 and AG-5 of *R. solani* appeared either as a rot of petiols, crowns, leaf blight, which were essentially identical with those in the field (Kim *et al.*, 1992) or root necrosis, wilting and severe stunting of plants. Frequently, lesions caused by *R. solani* were formed just below the crown area of the plant, causing the roots to break off or become non-functional near the crown (Botha *et al*., 2003).

In comparison with other studies, an obvious negative effects on the growth was observed on tomato seedlings showing stem cankers and root turning brown (Rashid *et al*., 2016). It has been found that *R. solani* had an adverse effect on bean plant growth (Matloob and Juber, 2013). Farrag (2011) indicated that *R. solani* was very aggressive on different bean varieties and caused 94% disease incidence in susceptible varieties and 39% in resistant varieties and caused reduction in length and weight of roots. Xi *et al*. (1995) affirmed that *R. solani* can cause seedling rot, damping-off, hypocotyl rot, root rot resulting in plant stunting and yellowing, delayed plant development, and reduced yield. All of these harmful effects may be due to killing and damage of root system that reduced absorption surface and uptake of essential nutrients and water (Hussain *et al*., 1989; Porter *et al*., 1990). Moreover, the infection with root rot fungi causes chlorosis of leaves associated with a reduction in photosynthetic capacity and net photosynthesis (Saleh, 1997). The anatomical study of the lentil roots infected by pathogenic fungi either *F. oxysporum* or *R. solani* presented a disruption of the epidermal and cortical cells in both cultivars of lentil roots, in turn causes damping-off (Abd Al Hai *et al*., 2017). Following Ghosh *et al.* (2017), *R. solani* pathogenesis leads to down regulation of photosynthesis, increased respiration and secondary metabolism and cell death in rice.

Rhizoctonia solani also showed a pathogenic character on several plant species used in rotation crop such as beans (Matloob and Juber, 2013), pea (Sharma-Poudyal *et al*., 2015), broccoli (Misawa *et al*., 2015), sweet corn, oats, Sudan grass (Seigies and Pritts, 2006). Indeed, *R. solani* successfully infected different plant species belonging to various families. The host range of *R. solani* causing rice sheath blight comprises twenty five plant species which are commonly found in rice growing ecosystem and whose diseased tissues produced typical symptom of sheet blight, root rot and bark peeling depending to the plant species family (Nagaraj *et al*., 2017). Also, rice, carrot, cucumber, tomato and country bean were among all of thirty five crop species that were found infected by this fungus under field and laboratory conditions (Goswami *et al*., 2010). Similarly, on pepper, lettuce, watermelon and green beans, *R. solani* aggressiveness was significant as obtained in previous studies (Güney and Güldür, 2018). Nevertheless, Mannai *et al*. (2018) recorded a lowest disease index on pepper plants inoculated with Rhiz.5 originally recovered from potato and the highest one those challenged with pepper-associated isolates causing a significant disease severity.

Otherwise, in agreement with our results, a wide variation in virulence of *R. solani* isolates has been observed (Bolkan and Ribeiro, 1985; Carling *et al.*, 1999; Meinhardt *et al*., 2002; Mathew *et al*., 2012). The pathogenicity of binucleate Rhizoctonia and virulence of different isolates on watermelon seedlings showed statistically significant differences on the disease incidence and severity among them (Aiello *et al*., 2012). In pea fields, a variable virulence potentials had characterized the subspecies of *Rhizoctonia* (10 AGs) where *R. solani* AG4 caused the most severe root rot, stunting and reduction in pea seedling biomass in comparison to AG K detected mostly from pea plant than baited from soil, caused limited root rot and did not reduce plant height root length, and dry weight. Similarly, AG K have been reported as non-pathogenic on other crops including sugar beet, tomato, carrot and onion but caused root rot on strawberry (Fang *et al*., 2013). For Botha *et al*. (2003), *R. solani* (AG 6) was the most virulent causing severe stunting of strawberry plants. Bolkan and Ribeiro (1985) indicated that among AG isolates both AG2 and AG3 show a great host specificity whereas AG-4 lack this specificity.

In the current study, strawberry plants inoculated with the mycelial suspension were less susceptible than those inoculated with crown wounds. Several studies had shown that Rhizoctonia root rot is more severe in the presence of root-knot nematodes, including the root rot disease complex caused by *R. solani* and *Meloidogyne incognita* on green beans (Anwar and Khan, 2002; Mokbel *et al*., 2007; Bhagawati *et al*., 2007; Abuzar, 2013). On eggplant seedling, the incidence of root rot disease incited by *R. solani* of 15.7% was signaled in soil samples infested by *M. incognita* responsible of root knot disease (Hadwan and Khara, 1992). Therefore, an increase of root rot would result in a synergistic interaction leading to a greater plant damage (Al-Hazmi and Al-Nadary, 2015). According to Porter *et al*. (2015), infested and damaged pea roots by the root lesion nematode *Pratylenchus penetrans* allowed other root rot fungi to infect the root system at an early vegetative growth stage.

Moreover, factor such as the impact of temperature seems unavoidable, Hwang *et al*. (2007) found that a temperature of 17.5°C or higher was optimal for development of the pathogen on pea seedlings. These authors indicated that in a temperature gradient study, seedling infection was highest when mean daily temperatures were 17.5°C or higher. It has been shown that AG-I is more virulent in colder conditions (10-15ºC)

(Martin, 2000; Botha *et al*., 2003). At cool temperature, isolates of *R. solani* AG-3 are more virulent but it damaged roots at all three temperatures 10, 15.5°C and 21.1°C (Carlin and Leiner, 1990). The effect of temperature on virulence of *Rhizoctonia solani* on soybean leaves and seedlings was demonstrated by Kousik *et al*. (1995). According to Xi et *al*. (1995), the timing of initial pea seed infection by *Pythium ultimum* and *R. solani* varied with inoculum density and temperature. In lettuce, the development of bottom rot disease was favored by higher temperature conditions but, after *R. solani* infection, a reduced plant growth was observed at 15°C during the day (Grosch and Kofort, 2003). On potato, soil temperature is the greatest factor that influences root colonization of *Colletotrichum coccodes* and *R. solani* as well as the soil inhabiting fungi (Manici *et al*., 2016). The damage to winter wheat affected by *R. solani* was more significant at low than at high temperature (Smiley and Uddin, 1993). Sivalingam *et al*. (2006) affirmed that decline in survival of *R. solani* was detected when temperature was higher than optimum for pathogen but it remained quite high at the time of sowing of crop during the next crop season.

Furthermore, using different inoculation methods might also result in variable expression of foliar, stem and root symptoms as well as the agronomic parameters (Güney and Güldür, 2018). Most of the studies used sorghum grain inoculums, millet seed-based inoculum or rice-grain inoculum for testing pathogenicity of *R. solani* and *Macrophomina phaseolina* (Holmes and Benson, 1994; Aly *et al*., 2007; Mikhail *et al*., 2009; Fang *et al*., 2013; Mahmoud and Abo-Elyousr, 2014; Prasad *et al*., 2014). In another study, conducted by Nallabeema (2014), tomato seedlings, showed typical damping of symptoms as yellowing of older leaves followed by development of light brown lesion at collar region after 28 days of root dip inoculation.

Conclusively, this study revealed that all isolates were pathogenic causing stem, root rot and showed adverse effects on seedling and plant species growth. The success of tested *R. solani* isolates on 10 crops used as preceding crops of strawberry cropping (Al Batnan et *al*., 2015) allows to suggest that they may played a critical role in disease development in the succeeding crop. Hwang *et al*. (2009) suggested that diverse crops in the rotation may reduce the population of *Fusarium*, *Pythium* and *Rhizoctonia* sp. in the soil and may contribute to improve the overall growth. The extensive host range (including both crops and weeds) and lack of host specificity (Qin *et al*., 2006) reduce the usefulness of some crop rotations for Verticillium wilt management (Huisman and Ashworth,

Table 4. Re-isolation of *Rhizoctonia solani* from soil culture of surveyed ten plant species (Expressed in %).

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	64.4^{a}	73^{a}	83.3^{a}	55.3^{c}	62.66^{c}	83.6^{ab}	40^{c}	68^{a}	56^{d}	56^{f}	56^{d}
G1	$72.7a^{b}$	100^{a}	70.4^{ab}	75^{a}	86.3^{ab}	78.6^{ab}	$65a^{b}$	70^{a}	48^{f}	60^{d}	74^{b}
H1	75^{a}	73^{a}	67.6^{ab}	65.6^{b}	77.3^{b}	82^{ab}	73.3^{a}	76^{a}	52^{c}	58^{e}	65^{c}
For	62.5^{b}	86.6^{a}	62^{b}	78.3^{a}	96.6^{ab}	28.3^{c}	74.6^{a}	70.6^{a}	66^{b}	72^{b}	54^{e}
R1	71^{ab}	100^{a}	70^{ab}	78^{a}	63.6^{bc}	85.6^{a}	62^{b}	71^{a}	68.5^{a}	76^{a}	82^{a}
R2	73.3^{ab}	86.6^{a}	68.5^{ab}	$72a^{b}$	97.6^{a}	85.3^{a}	73.3^{a}	67.6^{a}	62^{c}	69^{c}	74^{b}
Z.A.C	65.5^{ab}	100^{a}	77.3^{ab}	75^{a}	63.6^{bc}	70.6^{b}	$67a^{b}$	74.3^{a}	55^{d}	68^{c}	66^{c}
Control	0^{c}	0^{b}	0^{c}	0^{d}	0^{d}	0^{d}	0^{d}	0^{b}	0^{g}	0^{g}	0^{f}

Values in the same column followed by the same letter are not significantly different at the 5% level.

Table 5 : Effect of the *R. solani* isolates on the height of the aerial parts of the ten plant species tested (Expressed in cm).

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	20.8^{b}	13.8^{a}	$16a^{b}$	22^{bc}	14^{c}	16^{d}	17.3^{b}	25^{bc}	23^{a}	34.3^{ab}	64^{a}
G1	30.3^{b}	13^{a}	15.6^{ab}	23^{bc}	21^{b}	30.3^{b}	19^{b}	29.3^{ab}	23^{a}	29.3^{c}	45.6^{b}
H1	21.6^{b}	9.8^{a}	13^{bc}	25^{b}	20^{2}	0^{c}	20.6^{b}	20.6^{cd}	21^{a}	28.6^{c}	55.6^{ab}
For	22^{b}	13.1^{a}	12^{c}	$22,6^{bc}$	6.3^{e}	20.6^{c}	14.6^{b}	31.3^{a}	22^{a}	26.6^{c}	56.6^{ab}
R1	22.5^{b}	13.3^{a}	10^{cd}	21^{c}	1.3^{f}	0^{c}	18^{b}	18^{d}	22^{a}	33.3^{b}	46^{b}
R2	19.3^{b}	13.6^{a}	15^{abc}	25^{b}	1.3^{f}	0^{c}	17.3^{b}	28^{b}	22^{a}	28.6^{c}	52^{ab}
Z.A.C	21.6^{b}	12.5^{a}	8^{d}	24.3^{b}	8.3^{d}	22^{c}	18.3^{b}	28^{b}	22.3^{a}	$31b^{c}$	40^{b}
Control	32.8^{a}	14.5^{a}	18^{a}	$28,6^{a}$	$25,3^{a}$	$37,33^{a}$	28^{a}	$34,6^{a}$	$23,6^{a}$	40^{a}	64^{a}

Values in the same column followed by the same letter are not significantly different at the 5% level (LSD).

Table 6 : Effect of the *R. solani* isolates on the length of the underground parts of the ten plant species tested (Expressed in cm)

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	21.3^{b}	20^{a}	21.3^{a}	14.6^{b}	6.6^{b}	11^{c}	44^{bc}	22^{bc}	17^{b}	10.3^{c}	22^{b}
G1	21.6^{b}	18^{a}	10^{b}	13.6^{b}	9.6^{a}	17.3^{b}	63.6^{abc}	20^{cd}	18^{b}	10.3^{c}	22^{b}
H1	18.3^{b}	19.3^{a}	$8,3^{b}$	5.6^{c}	7^{b}	0^{d}	28.6^{c}	18.3^{d}	18^{b}	13.6^{b}	19^{cd}
For	18.3^{b}	21^{a}	7.6^{bc}	19.3^{b}	6^{bc}	12^{c}	69.3^{ab}	24.3^{b}	21.3^{a}	12.3^{bc}	20^{c}
R1	19^{b}	21.3^{a}	3^{cd}	4.33^{c}	0.6^{d}	0^{d}	47.3^{bc}	21.6^{bc}	17^{b}	11.3^{bc}	16^{e}
R2	19.3^{b}	13.3^{a}	9.3^{b}	15^{b}	0.6^{d}	0^{d}	69.3^{ab}	23.6^{b}	15^{b}	9.3^{c}	18^{d}
Z.A.C	26^{b}	18.6^{a}	3.6^{cd}	3.33^{c}	5.3^{c}	10^{c}	42.6^{bc}	23.6^{b}	19^{b}	11.3^{bc}	20^{c}
Control	48.3^{a}	20.3^{a}	21.3^{a}	23^{a}	10^{a}	26.3^{a}	94.66^{a}	30.6^{a}	21^{a}	25^{a}	32^{a}

Values in the same column followed by the same letter are not significantly different at the 5% level (LSD).

Table 7 : Effect of the *R. solani* isolates on fresh weight of the aerial parts of the ten plant species tested (Expressed in cm).

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	12.4^{b}	7.6^{a}	3.3^{bcd}	5.6^{a}	3.2^{b}	4.2^{c}	5.4^{c}	8.9^{ab}	3.5^{b}	27.6^{abc}	31.4^{abc}
G1	12.5^{b}	7.9^{a}	3.7^{ab}	5.26^{abc}	8.9^{a}	9.6^{ab}	13.7^{bc}	8.1a^{bc}	4.3^{a}	26.06^{bc}	16.7^{d}
H1	11.1^{b}	5.5^{a}	3.2^{bc}	1.66^{bc}	7.9^{a}	3.3^{c}	9.9^{bc}	4.3^{c}	3.7^{ab}	33^{ab}	31.8^{abc}
For	10.5^{b}	6.2^{a}	2.5^{bc}	5.43^{a}	5.4^{ab}	8.6^{ab}	16.6^{b}	11.3^{a}	3.2^{b}	20.3^{c}	28.3^{bc}
R1	7.2^{b}	6.6^{a}	1.1^{c}	1.4^{c}	1.9^{b}	0.4^{c}	13.4^{bc}	6.06^{bc}	3.5^{b}	24^{c}	21.6^{cd}
R2	10.9^{b}	9.6^{a}	4.6a^{b}	8.4^{a}	3.5^{b}	0.3^{c}	14.9^{bc}	8.4a^{bc}	3.3^{b}	27.2^{abc}	35^{ab}
Z.A.C	15.3^{b}	6.3^{a}	1.3^{c}	1.9^{bc}	5^{ab}	5.8^{bc}	13.9^{bc}	8.4a^{bc}	4.4^{a}	27.2^{abc}	28.1^{bc}
Control	28.43^{a}	8.5^{a}	6.1^{a}	7.3^{a}	8.8^{a}	11^{a}	32.1^{a}	11.2^{a}	3.9^{ab}	34.3^{a}	40.6^{a}

Values in the same column followed by the same letter are not significantly different at the 5% level (LSD).

Table 8 : Effect of the *R. solani* isolates on fresh weight of the underground parts of the ten plant species tested (Expressed in g).

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	9.3^{b}	9.9^{a}	0.8^{b}	1.6^{c}	1.7^{bc}	2.2^{d}	2^{b}	8.2^{ab}	3^{ab}	4.7^{bc}	5.1^{b}
G1	11^{b}	4.8^{b}	3^{b}	1.6^{c}	4.4^{a}	6.2^{b}	1.9^{b}	6.9^{ab}	2.9^{ab}	4.5^{bc}	4.4^{b}
H1	9.9^{b}	4.1^{b}	1.8^{b}	1^{c}	3.5^{ab}	1.2^{d}	1.8^{b}	2.5^{b}	2.8^{ab}	6.1^{b}	5.9^{ab}
For	9.7^{b}	3.6^{a}	1.1^{b}	1.9^{bc}	3.1^{ab}	3.1^{d}	1.7^{b}	6.8^{ab}	1.8^{b}	3.3^{c}	4.4^{b}
R1	8.3^{b}	5.6^{ab}	1.1^{b}	1.03^{c}	1^{c}	2.1^{d}	2.6^{ab}	2.6^{b}	3.1^{ab}	3.4^{c}	4.3^{b}
R2	8.6^{b}	7.8^{ab}	2^{b}	3.6^{ab}	1^{c}	2.1^{d}	1.5^{b}	10.4^{a}	3.1^{ab}	3.4^{c}	5.1^{b}
Z.A.C	14.4^{b}	5.7^{ab}	0.9^{b}	1.9^{bc}	3.5^{ab}	3.5^{cd}	1.2^{b}	10.4^{a}	1.8^{b}	4.3^{bc}	6.1^{ab}
Control	31.4^{a}	5.6^{ab}	5.8^{a}	4.26^{a}	3.7^{a}	11.9^{a}	4.1^{a}	9.2^{ab}	3.9^{a}	10.7^{a}	10.03^{ab}

Values in the same column followed by the same letter are not significantly different at the 5% level.

Table 9 : Effect the *R. solani* isolates on dry weight of the aerial parts of the ten plant species tested (Expressed in g).

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	4.1^{bc}	6.1^{ab}	0.4^{bcd}	0.7^{bc}	0.6^{f}	0.7^{bc}	0.8^{c}	1.6^{ab}	0.6^{ab}	9.9^{ab}	3.5^{bc}
G1	5.1^{bc}	5.6^{b}	0.5^{bc}	0.7^{bc}	2.2^{d}	1.5^{ab}	1^{bc}	1.5^{ab}	0.7^{a}	6.7^{b}	2.6^{c}
H1	2.8^{c}	3.8^{d}	0.13^{ef}	0.3^{c}	2.6^{c}	0.6^{bc}	1.2^{bc}	0.8^{b}	0.5^{b}	13.5^{a}	3.5^{c}
For	3.3^{c}	4.5^{cd}	0.36^{cde}	1^{b}	3.2^{b}	$1.4a^{b}$	1.6^{ab}	2.03^{a}	0.4^{b}	4.7^{b}	2.3^{c}
R1	3.2^{c}	2.1^{c}	0.1^{f}	0.4^{c}	0.6^{f}	0.3^{c}	1.4^{bc}	0.9^{b}	0.5^{b}	10.2^{ab}	2.6^{c}
R2	5.5^{bc}	7^{a}	0.6^{b}	1^{b}	0.5^{f}	0.3^{c}	1.5^{ab}	0.93^{b}	0.6^{ab}	6.8^{b}	3.9^{b}
Z.A.C	6.8^{b}	4.8^{bc}	0.23^{def}	0.3^{c}	1^{e}	1^{b}	1.4^{bc}	1.46^{ab}	0.7^{a}	8^{b}	3.7^{abc}
Control	12.5^{a}	6^{b}	0.9^{a}	1.4a	6^{a}	1.8^{a}	2.1^{a}	1.56^{ab}	0.7^{a}	9.1^{ab}	4.8^{a}

Values in the same column followed by the same letter are not significantly different at the 5% level.

Table 10 : Effect of the *R. Solani* isolates on dry weight of the underground parts of the ten plant species tested (Expressed in g).

R. solani isolates	Strawberry injury	Strawberry suspension	Lettuce	Green bean	Tomato	Eggplant	Cucumber	Pepper	Rice	Zucchini	Watermelon
M1	2.9^{b}	4.9^{a}	0.2^{cd}	14.6^{b}	0.2^{d}	0.3^{b}	0.1^{c}	0.8^{a}	0.8^{b}	1.6^{c}	0.4^{c}
G1	3.4^{ab}	2.6^{c}	0.16^{cd}	13.6^{b}	0.7^{c}	0.9^{b}	0.26^{bc}	0.5^{a}	0.7^{b}	1^{e}	0.3^{c}
H1	5^{ab}	1.8^{d}	0.23^{bcd}	5.66^{c}	0.8^{c}	0.5^{b}	0.26^{bc}	0.5^{a}	0.6^{b}	1.8^{b}	0.46^{bc}
For	3.5^{ab}	4.7^{a}	0.2^{cd}	19.3^{ab}	0.8^{c}	0.4^{b}	0.33^{b}	0.6^{a}	0.4^{b}	0.9^{e}	0.3^{c}
R1	3^{b}	2.9^{c}	0.1^{d}	4.3^{c}	0.2^{d}	0.5^{b}	0.36^{b}	0.4^{a}	1.2^{ab}	1.4^{d}	0.3^{c}
R2	3.3^{ab}	4.7^{a}	0.36^{bc}	15^{b}	0.2^{d}	0.5^{b}	0.2^{c}	0.4^{a}	1^{ab}	1.4^{d}	0.7^{b}
Z.A.C	4.1^{ab}	3.1^{c}	0.3^{b}	3.33^{c}	1.4^{b}	1.1^{b}	0.30^{bc}	0.6^{a}	0.5^{b}	1.3^{d}	0.5^{bc}
Control	6.7^{a}	3.8^{b}	0.9^{a}	23.6^{a}	3.1^{a}	2.1^{a}	0.6^{a}	0.6^{a}	1.8^{a}	2.5^{a}	1.1^{a}

Values in the same column followed by the same letter are not significantly different at the 5% level.

1976). Thus, simultaneous pathogenicity evaluation of different *Rhizoctonia* isolates and disease ratings made by determining fresh plant and root weight can provide a practical contribution to monitoring seedlings infection against this pathogen. Hence, it's recommended to adopt a cultural practice by crop rotation with non-host crops should be considered.

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