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Interaction of *Rhizoctonia solani* Anastomosis Groups and Sugar Beet Cultivars

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Root and crown rot diseases caused by the fungus *Rhizoctonia solani* are increasing in frequency and severity in many sugar beet growing regions worldwide. Due to the many identified *R. solani* anastomosis groups (AGs) and many cultivars (Cs) of sugar beet that are broadly grown, AG x C interactions should be reinvestigated. In this study, the pathogenicity of eight *R. solani* AGs was tested on nine commercial sugar beet cultivars under greenhouse conditions. Five parameters were measured, and the collected data were statistically analyzed. All tested *R. solani* AGs were virulent and capable of injuring sugar beet seedlings and causing different degrees of pre- and post-emergence damping-off diseases. The occurrence of pre-emergence damping-off was dependent upon *R. solani* AGs and the responses of sugar beet cultivars. AG-2-2, AG-6, AG-10, and AG-4HGI were generally the most virulent AGs. These AGs exhibited significant impacts on the emergence, height and survival of the sugar beet seedlings. AG-6 had the greatest effect on seedling fresh weight, followed by AG-10. Differences in the susceptibility of sugar beet cultivars to *R. solani* infections were also observed. Overall, Kawmera was the most tolerant cultivar, while Gazel and Panthera were the most susceptible to *R. solani* post-emergence damping-off.

Key words: Anastomosis groups, Damping-off., Sugar beet, *Rhizoctonia solani*.

Sugar beet (*Beta vulgaris*) is a strategic sugar crop that is widely cultivated around the world. It is the second most common crop in Egyptian sugar production after sugar cane. From the seedling stage to harvesting, sugar beet is vulnerable to different biotic and abiotic injuries[1,2]. Many soil borne fungi, including *Rhizoctonia solani,* affect sugar beet stands and sugar yield in some growing areas[3,4,5]. This fungus causes damping-off and root and crown rot, as well as foliar blight in sugar beet plants[6,7].

Root and crown rot diseases in sugar beets are important biotic stresses that may cause great damages (up to 50%), depending on cropping history and environment[8,9]. Fungal propagules often associated with plant debris are responsible for the initial infection of roots. Rhizoctonia root rot disease is widespread and a significant problem for sugar beets and many other plant species[10, 11].

Up to 14 *Rhizoctonia solani* AGs have been identified, suggesting that a certain degree of host specificity may occur among AGs[12,13]. Of the 14 AGs, AG-2-2 and AG-4 are considered the primary cause of Rhizoctonia root and crown rot in most sugar beet growing regions. Although many *R. solani* AGs are able to colonize sugar beet roots, AG-1, AG-2-2, and AG-4 have been responsible for severely reduced sugar beet stands[14].

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Recent use of many commercial cultivars and/or the presence of wide range of *Rhizoctonia solani* AGs could result in a significant increase in root and crown rot of sugar beets. Thus, continuous selection of resistant varieties is the only reliable tool for the integrated control of such diseases[15, 16]. Still, resistant varieties may not be sufficiently adapted to all growing environments, particularly given the probable existence of different pathogen strains[9]. This study evaluated the interaction potential between eight *Rhizoctonia solani* AGs that cause root disease and nine sugar beet cultivars under greenhouse conditions.

MATERIALS AND METHODS

Pathogenicity of *Rhizoctonia solani* AGs

The virulence of eight *R. solani* anastomosis groups (AGs) was investigated on nine sugar beet cultivars under greenhouse conditions. Sugar beet cultivars were obtained from the Agricultural Research Center, Giza, Egypt. The eight *R. solani* isolates belonging to eight AGs used in this study were provided by Saudi Myco-Bank, Botany and Microbiology Department, College of Science, King Saud University. Inoculum production and artificial inoculation were conducted according to Büttner *et al.* (2004)[9]. The fungus was cultured on potato dextrose broth (PDb) in Erlenmeyer flasks at 24°C. After two weeks, mycelium was separated from the nutrient solution, washed, and then homogenized in 500 ml of sterile water with a Warring Blender into a smooth liquid. Ten milliliters of the suspension per pot (12 X 12 cm) was used as liquid inoculum. The infested soil was kept moist for three days before planting. Ten seeds were sown in plastic pots filled with autoclaved potting soil amended with *R. solani* inoculum (at a rate of 0.1% w/w). Three replicate pots per cultivar were used, and seedlings grown in uninfected soil served as controls. Pre-emergence damping-off was recorded 15 days after planting, and post-emergence damping-off, plant survival, plant height, and plant weight were recorded 45 days after planting.

Table 1. ANOVA of the effect of sugar beet cultivar (C), R. solani anastomosis group (AG), and their interactions on damping-off disease, seedling survival, seedling weight, and seedling height under greenhouse conditions

Parameters	Source of variation	D.F	M.S	F value	P>F
Pre- emergence	C	8	2230.556	17.889	0.000
	AG	8	23848.148	191.257	0.000
	C x AG	64	244.329	1.959	0.000
	Error	162	124.691		
Post- emergence	C	8	18.507	7.292	0.000
	AG	8	48.598	19.148	0.000
	C x AG	64	2.489	0.981	0.525
	Error	162	2.538		
Seedling survival	C	8	8.186	5.525	0.000
	AG	8	273.351	184.510	0.000
	C x AG	64	1.950	1.316	0.086
	Error	162	1.481		
Seedling weight	C	8	0.603	0.463	0.881
	AG	8	17.197	13.197	0.000
	C x AG	64	1.139	0.874	0.728
	Error	162	1.303		
Seedling height	C	8	4.175	1.526	0.152
	AG	8	282.303	103.182	0.000
	C x AG	64	5.963	2.179	0.000
	Error	162	2.736		

Statistical analysis

Obtained data were subjected to analysis of variance using the general linear model (GLM) of the SPSS software package version, 16.0. Data of post-emergence damping-off and seedlings survival were transformed into root square of the %values+0.5 before carrying out the analysis of variance (ANOVA) to normalize and stabilize variance. The least significant difference LSD ($P \leq 0.05$) was used to identify differences and compare mean values.

RESULTS

ANOVA (Table1) showed that the cultivar (C), the *R. solani* anastomosis group (AG) and their interactions (C x AG) were significant sources of variation in pre-emergence damping-off and survival of sugar beet seedlings. Only the C and AG were significant sources of variation in post-emergence damping-off disease. The AG and C x AG interactions were significant sources of variation in the height of sugar beet seedlings, while only AG was significant source of variation in seedlings fresh weight. Relative contribution indicated that AG was the most important source of variation in all studied parameters, while C x AG interactions were the least important for all parameters except fresh weight and height of the sugar beet seedlings (Table 2).

The significant interactions C x AG in pre-emergence damping-off indicated that the virulence of *R. solani* AGs varies depending on the tested cultivars. For example, the highest virulence of *R. solani* AG-2-1 was shown on the Toro cultivar, while its lowest virulence was on the Gazel cultivar. Although both AG-2-2 and AG-4HGI were generally virulent, they exhibited highly and moderately pathogenic reactions, respectively, on the Panthera cultivar. Both AG-2-1 and AG-6 were virulent on the Fareda cultivar but remained significantly different from each other (Table 3).

The significance of C and AG in post-emergence damping-off disease indicates that the virulence of *R. solani* AGs does not vary between different cultivars. Regardless of the tested

Table 2. Relative contribution of sugar beet cultivars, *R. solani* AG, and their interactions (C x AG) to the variation of root disease parameters

Source of variation	Pre-emergency	Post-emergency	Plant survival	Plant weight	Plant height
C	8.47	26.59	2.89	3.18	1.43
AG	90.60	69.83	96.42	90.80	96.53
C x AG	0.93	3.58	0.69	6.01	2.04

Table 3. Effect of the interaction between sugar beet cultivars and *R. solani* AGs on pre-emergence damping-off disease of sugar beet under greenhouse conditions

R. solani	Sugar beet cultivars								
AG s	Carola	Diperspoly	Fareda	Gazel	Hend	Kawmera	Panthera	Top	Toro
AG-1	36.67	56.67	36.67	43.33	36.67	53.33	23.33	33.33	60.00
AG-2-1	76.67	80.00	70.00	46.67	53.33	83.33	36.67	66.67	90.00
AG-2-2	93.33	90.00	90.00	66.67	96.67	96.67	83.33	80.00	93.33
AG-3	30.00	26.67	30.00	46.67	16.67	36.67	40.00	36.67	50.00
AG-5	46.67	43.33	40.00	20.00	33.33	46.67	13.33	20.00	66.67
AG-6	90.00	86.67	93.33	86.67	93.33	100.00	83.33	86.67	100.00
AG-10	100.00	93.33	90.00	80.00	96.67	100.00	70.00	100.00	96.67
AG-4HGI	90.00	93.33	66.67	80.00	83.33	90.00	50.00	80.00	90.00
Control	3.33	13.33	6.67	3.33	16.67	13.33	0.00	13.33	33.33

LSD for interaction (C x AG) = 17.998.

Table 4. Effect of the interaction between sugar beet cultivars and *R. solani* AGs on post-emergence damping-off disease of sugar beet under greenhouse conditions

R. solani	**Sugar beet cultivars**																			
	Carola		Diperspoly		Fareda		Gazel		Hend		Kawmera		Panthera		Top		Toro		Mean	
AGs	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran
AG-1	30.00	5.29	23.33	4.86	20.00	4.43	33.33	5.75	20.00	3.68	33.33	5.61	46.67	6.86	36.67	5.82	30.00	5.39	30.37	5.30
AG-2-1	0.00	0.71	10.00	2.83	16.67	3.59	26.67	4.96	23.33	4.71	6.67	2.40	30.00	5.32	13.33	3.67	6.67	2.40	14.82	3.40
AG-2-2	6.67	2.40	6.67	1.98	10.00	2.83	33.33	5.72	0.00	0.71	3.33	1.55	13.33	3.25	20.00	4.28	6.67	1.98	11.11	2.74
AG-3	0.00	0.71	0.00	0.71	3.33	1.55	10.00	2.31	0.00	0.71	0.00	0.71	10.00	2.31	3.33	1.55	3.33	1.55	3.33	1.35
AG-5	13.33	3.16	10.00	2.83	10.00	2.31	23.33	4.76	26.67	4.11	13.33	3.25	16.67	3.59	33.33	5.72	13.33	3.67	17.78	3.71
AG-6	10.00	2.83	13.33	3.67	6.67	1.98	13.33	3.67	6.67	2.40	0.00	0.71	16.67	4.00	13.33	3.25	0.00	0.71	8.89	2.58
AG-10	0.00	0.71	6.67	2.40	6.67	2.40	20.00	4.43	3.33	1.55	0.00	0.71	23.33	4.86	0.00	0.71	3.33	1.55	7.04	2.15
AG-4HGI	3.33	1.55	0.00	0.71	13.33	3.25	20.00	4.43	10.00	2.31	3.33	1.55	23.33	4.76	13.33	3.25	3.33	1.55	10.00	2.60
Control	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71
Mean	7.04	2.01	7.78	2.30	9.63	2.56	20.00	4.08	10.00	2.32	6.67	1.91	20.00	3.96	14.81	3.22	7.41	2.17	11.48	2.73

Tran = data transformed into root square of % values + 0.5 before ANOVA. LSD for AGs or Cs= 0.856.

Table 5. Effect of the interaction between sugar beet cultivars and *R. solani* AGs on survival of sugar beet seedlings under greenhouse conditions

R. solani	Sugar beet cultivars																	
	Carola		Diperspoly		Fareda		Gazel		Hend		Kawmera		Panthera		Top		Toro	
AGs	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran	%	Tran
AG-1	33.33	5.51	20.00	4.43	43.33	6.61	23.33	4.86	43.33	6.48	13.33	3.67	30.00	5.47	30.00	5.29	10.00	2.83
AG-2-1	23.33	4.86	10.00	2.83	13.33	3.67	26.67	4.96	23.33	4.71	10.00	3.24	33.33	5.39	20.00	4.43	3.33	1.55
AG-2-2	0.00	0.71	3.33	1.55	0.00	0.71	0.00	0.71	3.33	1.55	0.00	0.71	3.33	1.55	0.00	0.71	0.00	0.71
AG-3	70.00	8.36	73.33	8.57	66.67	8.18	43.33	6.25	83.33	9.15	63.33	7.97	50.00	6.66	60.00	7.72	46.67	6.84
AG-5	40.00	6.25	46.67	6.80	50.00	7.08	56.67	7.51	40.00	5.40	40.00	6.33	70.00	8.36	46.67	6.69	20.00	4.43
AG-6	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71	0.00	0.71
AG-10	0.00	0.71	0.00	0.71	3.33	1.55	0.00	0.71	0.00	0.71	0.00	0.71	6.67	2.40	0.00	0.71	0.00	0.71
AG-4HGI	6.67	2.40	6.67	2.40	20.00	4.43	0.00	0.71	6.67	2.40	6.67	1.98	26.67	5.19	6.67	2.40	6.67	2.40
Control	96.67	9.85	86.67	9.32	93.33	9.67	96.67	9.85	83.33	9.15	86.67	9.32	100.0	10.02	86.67	9.32	66.67	8.18

Tran = data transformed into root square of % values + 0.5 before ANOVA. LSD for interaction (C x AG) = 1.961.

cultivars, *R. solani* AG-1 was the most pathogenic group in general, while AG-3 was the least. All tested AGs except AG-3 were significantly different from the control treatment. Overall, responses of a particular cultivar to the different AGs were similar. Gazel was generally the most susceptible cultivar to infection with various *R. solani* AGs, as measured by post-emergence, while Kawmera was the most tolerant (Table 4).

Regarding seedlings survival; cultivars responses were different depending on the various AGs due to the significant interactions C x AG. Although Hend cultivar exhibited the highest survival in both AG-3 and AG-1 treatments and with significant difference, Fareda had the highest survival in both AG-5 and AG-3 treatments but without significant difference (Table 5).

Because AG was the only significant source of variation in seedling fresh weight the mean effects were considerable. AG-6 exhibited the strongest effect on seedling fresh weight, followed by AG-10. There were no significant differences between the tested cultivars regarding seedling fresh weight (Table 6).

Due to significant interactions C x AG, the effect of *R. solani* AGs on seedling height varied between cultivars. Moreover, cultivar responses were also different according to *R. solani* AGs. Carola and Diperspoly had their maximal seedling heights when grown in soil

Table 6. Effect of the interaction between sugar beet cultivars and *R. solani* AGs on sugar beet seedlings fresh weight under greenhouse conditions

R. solani	Sugar beet cultivars									
AG s	Carola	Diperspoly	Fareda	Gazel	Hend	Kawmera	Panthera	Top	Toro	Mean
AG-1	2.42	1.65	0.97	1.72	1.58	2.11	1.31	1.51	1.32	1.62
AG-2-1	1.67	1.74	2.17	2.67	2.08	3.16	1.67	2.20	1.36	2.08
AG-2-2	0.00	1.28	0.00	0.00	1.21	0.00	1.31	0.00	0.00	0.42
AG-3	1.06	1.02	1.00	2.12	1.21	1.18	2.70	1.03	1.26	1.40
AG-5	1.71	1.52	1.57	1.48	0.68	1.54	0.76	1.61	2.11	1.44
AG-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AG-10	0.00	0.00	1.20	0.00	0.00	0.00	2.48	0.00	0.00	0.41
AG-4HGI	3.26	3.13	2.28	1.21	2.58	0.44	2.28	3.48	2.63	2.37
Control	1.05	1.53	1.12	0.96	1.00	0.89	1.22	1.01	0.91	1.08
Mean	1.24	1.32	1.15	1.13	1.15	1.04	1.53	1.20	1.07	

LSD for AGs or Cs = 0.613.

Table 7. Effect of the interaction between sugar beet cultivars and *R. solani* AGs on sugar beet seedlings height under greenhouse conditions

R. solani	Sugar beet cultivars								
AG s	Carola	Diperspoly	Fareda	Gazel	Hend	Kawmera	Panthera	Top	Toro
AG-1	5.59	3.73	6.71	4.07	7.17	5.92	5.90	5.67	4.92
AG-2-1	6.25	3.78	3.67	7.19	7.33	5.83	5.68	9.06	3.00
AG-2-2	0.00	0.67	0.00	7.89	0.67	0.00	0.83	0.00	0.00
AG-3	6.77	6.69	7.21	8.12	6.33	6.09	7.60	6.72	7.34
AG-5	7.13	7.74	6.62	6.86	6.86	7.80	7.37	7.84	5.42
AG-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AG-10	0.00	0.00	1.00	0.00	0.00	0.00	2.00	0.00	0.00
AG-4HGI	5.00	4.67	4.67	0.00	3.83	1.67	5.94	4.67	5.33
Control	8.37	8.87	8.35	9.77	8.53	9.45	9.54	8.18	8.68

LSD for interaction (C x AG) = 2.666.

containing AG-5, but had their minimal ones under the AG-4HGI and AG-1 treatments. The minimal height of the Panthera cultivar was recorded in soil inoculated with AG-2-2, while the maximal height was observed in soil containing AG-3 (Table 7).

DISCUSSION

All tested *R. solani* AGs in this study were virulent and capable of injuring sugar beet seedlings and causing different degrees of pre- and post-emergence damping-off diseases. These results confirm that *R. solani* AGs are important and responsible for root and crown rot diseases in sugar beets and many other crops[17, 18, 19]. The virulence of different *R. solani* AGs on sugar beets and occurrence of damping-off and root rot diseases have frequently been discussed[20, 21, 22]. The occurrence of pre-emergence damping-off was dependent on the AG of *R. solani* and the different sugar beet cultivars[9, 23]. Overall, the most virulent AGs in this study were AG-2-2, AG-6, AG-10, and AG-4HGI, all of which resulted in low seedling emergence, reduced seedling height, and minimal plant survival[14]. In contrast, AG-6 had the greatest effect on seedling fresh weight, followed by AG-10. No significant differences were observed between sugar beet cultivars in terms of seedling fresh weight[24]. Previously, various degrees of virulence have been reported among *R. Solani* AGs[25,26,27,28].

The response of sugar beet cultivars was a second important factor in the occurrence of pre-emergence damping-off. The variable responses of sugar beet cultivars might be attributed to the susceptibility of meristematic tissues to the Polygalacturonase (PG) enzyme produced by *R. solani* AGs, which usually attack seedlings at the hypocotyls and lead to damping-off and root rot[29,30,31]. As plant tissues mature, they become less susceptible to fungal PG[19, 32]. The present study shows that Kawmera was generally the most tolerant cultivar, while Gazel and Panthera were the most susceptible to *R. solani* post-emergence damping-off. Differences in the susceptibility of sugar beet cultivars to *R. solani* infections have also frequently been reported[33,34,35].

CONCLUSSION

R. solani is an economically important pathogen for sugar beet seedlings. Understanding the virulence levels of different *R. solani* AGs and the susceptibility of sugar beet cultivars to AGs is important for successful disease management in any particular growing region. Interactions between cultivars and *R. solani* AGs in specific regions should be examined to minimize stand and yield loss in sugar beets.

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REFERENCES

1. Abada, K.A. Fungi causing damping-off and root-rot on sugar beet and their biological control with *Trichoderma harzianum. Agric. Ecosyst. Environ.*, 2003; **51**: 333–337.
2. Eweis, M., Elkholy, S.S., Elsabee, M.Z. Antifungal efficacy of chitosan and its thiourea derivatives upon the growth of some sugar-beet pathogens. *Int. J. Biol. Macromol.,* 2006; **38**: 1–8.
3. Amein, T. Soil-borne pathogens infecting sugar beet in southern Sweden. *Plant Pathol. J.*, 2006; **5**(3): 356-361.
4. Jacobsen, J.B. Root rot diseases of sugar beet. *Proc. Nat. Sci. Matica. Srpska.*, 2006; **110**: 9-19.
5. Jasni, S., Bagi, F., Stojšin, V. *Rhizoctonia solani* crown and root rot–distribution and significance. *Zb. Inst. Za. Ratar. I. Povrt.*, 2006; **42**: 275-282.
6. Stojsin, V., Bagi, F., Jasni, S., Balaž, F., Budakov, D. Root rot of sugar beet in the Vojvodina Province. *Proc. Nat. Sci. Matica. Srpska.*, 2006; **110**: 103-108.
7. Hanson, L.E. Interaction of *Rhizoctonia solani* and *Rhizopus stolonifer* causing root rot of sugar beet. *Plant Dis.*, 2010; **94**: 504-509.
8. Kiewnick, S., Jacobsen, B. J., Braun-Kiewnick, A., Eckh off, J. L. A., and Bergman, J. W. Integrated control of Rhizoctonia crown and root rot of sugar beet with fungicides and antagonistic bacteria. *Plant Dis.* 2001; **85**: 718-722.

9. Büttner, G., Pfahler, B., Marlander, B. Greenhouse and field techniques for testing sugar beet for resistance to *Rhizoctonia* root and crown rot. *Plant Breed*., 2004; **123:** 158–166.
10. Salazar, O., Julian, M.C., Rubio, V. Primers based on specific rDNA-ITS sequences for PCR detection of *Rhizoctonia solani, R. solani* AG 2 subgroups and ecological types, and binucleate *Rhizoctonia. Mycol. Res.,* 2000; **104** (3):281-285.
11. Fuhrer Ithurrart, M.E. Buttner, G., Petersen, J. Rhizoctonia root rot in sugar beet (*Beta vulgaris* ssp. *altissima*) –Epidemiological aspects in relation to maize (*Zea mays*) as a host plant. *J. Plant Dis. Prot.*, 2004; **111**:302–312.
12. Carling, D.E., Baird, R.E., Gitaitis, R.D., Brainard, K.A., Kuninaga, S. Characterization of AG-13, a newly reported anastomosis group of *Rhizoctonia solani*. *Phytopathol.*, 2002; **92**: 893-899.
13. El-Samawaty, A.M.A., Amal, A., Asran, Omar, M.R., Abd-Elsalam, K.A. Anastomosis Groups, Pathogenicity, and Cellulase Production of *Rhizoctonia solani* from Cotton. *Pest technol.*, 2008; **1**(2):117-124.
14. Bolton, M.D., Panella, L., Campbell, L., Khan, M.F.R. Temperature, moisture, and fungicide effects in managing *Rhizoctonia* root and crown rot of sugar beet. *Phytopathol.*, 2010; **100**: 689-697.
15. Marlander, B., Hoffmann, C., Koch, H.-J., Ladewig, E., Merkes, R., Petersen, J., Stockfisch, N. Environmental situation and yield performance of the sugar beet crop in Germany: heading for sustainable development. *J. Agron. Crop Sci.*, 2003; **189**: 201-226.
16. Buttner, G., Pfahler, B., Petersen, J. *Rhizocotnia* root rot in Europe – incidence, economic importance and concept for integrated control. *Proceedings of the 1st joint IIRB-ASSBT Congress*, February 2003, San Antonio, USA, 897-901.
17. Buddemeyer, J., Pfahler, B., Petersen, J., Marlander, B., Genetic variation in susceptibility of maize to *Rhizoctonia solani* (AG 2-2IIIB) - symptoms and damage under field conditions in Germany. *J. Plant Dis. Protect.*, 2004; **111**: 521-533.
18. Ohkura M., Abawi G.S., Smart C.D., Hodge, K.T. Diversity and aggressiveness of *Rhizoctonia solani* and *Rhizoctonia*-like fungi on vegetables in New York. *Plant Dis.*, 2009; **93**: 615–624.
19. Rashad Y.M., Abdel-Fattah G.M., Hafez E.E., El-Haddad S.A. Diversity among some Egyptian isolates of *Rhizoctonia solani* based on anastomosis grouping, molecular identification and virulence on common bean. *Afric. J. Microbiol. Res.*, 2012; **6**(37): 6661-6667.
20. Buddemeyer, J., Marlander, B. Genotypic reaction of sugar beet to *Rhizoctonia solani* root and crown rot-susceptibility, yield and quality at different levels of infestation. *J. Plant Dis. Protect.*, 2005; **112**:105-117.
21. Vico, I., Krsti, B., Jankovia, D., Krstia, B.B, Bulajia, A.R., Duki, N.D. Mutinucleate *Rhizoctonia* sp. pathogen of sugar beet and susceptibility of cultivars under field conditions. *Roc. Nat. Sci, Matica Srpska Novi Sad.,* 2006; **110**:109-121.
22. Buhre, C., Kluth, C., Burcky, K., Marlander,B., Varrelmann, M. Integrated control of root and crown rot in sugar beet: Combined effects of cultivar, crop rotation, and soil tillage. *Plant Dis.*, 2009; **93**:155-161.
23. El-Samawaty A.M.A., Omar M.R., El-Naggar M.A., Yassin M.A., Amer O.E. Pathological Assessment of Seed Borne Fungi Involved in Cotton Seedlings Damping-off**.** *J. Plant Sci.*, 2012; **7**(3):85-95.
24. Strausbaugh, A.C., Eujayl, A.I, Panella, W.L., Hanson, E.L. Virulence, distribution and diversity of *Rhizoctonia solani* from sugar beet in Idaho and Oregon. *Can. J. Plant Pathol.*, 2011; **33**(2): 210-226.
25. EI-Hussieni, S. First Report on *Rhizoctonia* crown and root rots and powdery mildew diseases of sugar beet in Riyadh region, Saudi Arabia. *Saudi J. Biol. Sci.*, 2003; **10**(2):166-174.
26. Stojsin, V., Budakov, D., Jacobsen, B., Grimme, E., Bagil, F., Jasnial, S. Identification of *Rhizoctonia solani* isolates from sugar beet roots by analyzing the ITS region of ribosomal DNA. *Proc. Nat. Sci., Matica Srpska Novi Sad*, 2007; **113**: 161-171.
27. Nagendran, S., Hammerschmidt, R., Mitchell, McGrath, J. Identification of sugar beet germplasm EL51 as a source of resistance to post-emergence *Rhizoctonia* damping-off. *Eur. J. Plant Pathol.* 2009; **123**:461-471.
28. Stojsin, V., Budakov, D., Jacobsen, B., Bagi, F., Grimme, E., Neher, O. Analysis of *Rhizoctonia solani* isolates associated with sugar beet crown and root rot from Serbia. *Afric. J. of Biotechnol.*, 2011; **10**(82):19049-19055.
29. Fenille, R.C., Izioka-Kuramae, E.E., Souza, N.L. Cytomorphological, molecular and pathogenic characterization of *Rhizoctonia solani* associated with soybean from Brazil. In: Book of Abstracts of the Third International Symposium on *Rhizoctonia* (ISR 2000), 2000, Taichung, pp. 20-20.

30. Kuramae, E.E., Sussel, A.A.B., Fenille, R.C., de Souza, N.L. Isolates of *Rhizoctonia solani* HGII AG4 anastomosis group causing damping-off in seedlings of *Coffea arabica* in Brazil. In: Book of Abstracts of the Third International Symposium on *Rhizoctonia* (ISR 2000), 2000, *Taichung*, pp. 26-26.
31. Gonzalez, D., Cubeta, M.A., Vilgalys, R. Phylogenetic utility of indels within ribosomal DNA and ²-tubulin sequences from fungi in the *Rhizoctonia solani* species complex. *Mol. Phylogenet. Evol.*, 2006; **40**: 459-470.
32. Balali, G.R., Kowsari, M. Pectic zymogram variation and pathogenicity of *Rhizoctonia solani* AG-4 bean (*Phaseolus vulgaris*) isolates in Isfahan, Iran. *Mycopathol.*, 2004; **158**: 377-384.
33. Pfahler, B., Petersen, P. Rapid greenhouse screening of maize for resistance to *Rhizoctonia solani* AG 2-2IIIB. *J. Plant Dis. Protect.*, 2004; **111**: 292–301.
34. Larson, R.L., Hill, A.L., Fenwick, A., Kniss, A.R., Hanson, L.E., Miller, S.D. Influence of glyphosate on Rhizoctonia and Fusarium root rot in sugar beet. *Pest Manag. Sci.*, 2006; **62**: 1182-1192.
35. Nagendran, S., Hammerschmit, R., McGrath, J.M. Identification of sugar beet germplasm EL51 as a source of resistance to post-emergence Rhizoctonia damping-off. *Eur. J. Plant Pathol.*, 2008; **129**:461–471.