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Reactions of 11 Potato Cultivars against Some Important Soil-Borne Pathogens

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ABSTRACT

In this study, surveys and the reaction to diseases of some potato (*Solanum tuberosum* L.) cultivars ('Satina', 'Vangogh', 'Marabel', 'Latona', 'Marfona', 'Vericus', 'Jearla', 'Cosmos', 'Granola', 'Hermes', 'Agria') against important soil-borne pathogens were conducted. In surveys, the most isolated genus was *Rhizoctonia* sp., *Fusarium* sp., *Phytophthora* sp. and *Pythium* sp. The isolation ratio of each genus varied between locations. Eleven commercial potato cultivars were evaluated for their reactions to *Rhizoctonia solani* (stem cancer and black scurf), *Fusarium solani* (Fusarium wilt), *Phytophthora erythroseptica* (pink rot) and *Pythium deliense* (root rot). Cultivars exhibited different levels of susceptibility to the pathogens. The most susceptible cultivars were 'Satina' and 'Jearla'. 'Satina', the most sensitive cultivar, had high disease severity ratios to *R. solani*, *F. solani*, *P. erythroseptica* and *P. deliense* (40, 100, 80 and 65%, respectively). 'Hermes' and 'Agria' were resistant to all diseases.

Keywords: disease severity, fungal pathogens, potato cultivars, resistance

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important high-yielding industrial plant in Turkey. Potatoes are extensively produced in many provinces of our country including Niğde, Nevşehir, Bolu and İzmir - Ödemiş. Adana is a known important full-season potato production province (Tuncer and Erdiller 1990). There are many potato cultivars and each cultivar is preferably grown for different purposes of production (industry, cooking, etc.). However, economic loss in a year cannot be predicted because of the disease susceptibility of some cultivars during cultivation.

There are many important fungal and protists causing plant diseases which limits the production of potato causing yield and quality loss. These diseases occur at different stages of plant growth with different symptoms depending on plant phenology and environmental conditions. Major symptoms are encountered including black scurf, sprout infections, dry rot, tuber symptoms, stolon cancer and growth retardation. In addition, some tuber-borne fungal diseases can cause symptoms during the tuber germination or developmental period (Anonymous 1992).

Stem cancer and black scurf caused by *R. solani* is common in all potato-growing areas. The disease forms dark brown or black sclerotia on the surface of the tuber. The sprouting of tubers is delayed under cool and wet conditions. The disease causes stem cancer as sunken necrotic lesions and plant death after severe infections. As the plants continue to grow, the infected part becomes weak and unhealthy so that it causes developmental disorders such as excessive and diseased stolons and the formation of small or superficial tubers (Weinhold *et al.* 1982). *Fusarium* species cause damping-off or decay in the early period of development. Then, the disease infects the plant through the roots that causes vascular obstruction and plant death occurs after a general yellowing and wilting of the leaves (Ayed *et al*. 2006). *Pythium* spp. and *Phytophthora* spp. are known as damping off at an early stage of potato growing. *Pythium* spp. causes tuber decay and tissue becomes soft. *Phytophthora* spp. causes symptoms, particularly in the inner tissue of tubers, pinkish in color and then gets darker.

The control of soil-borne plant diseases is difficult because of the formation of resistant spores that persist in soil for many years. In addition, chemical application to soil is ineffective, difficult to apply and economically unprofitable. The application of fungicides to tubers is important to prevent diseases that may arise in early stages of plant growth. However, the application of fungicides to tubers is partially effective against certain fungal diseases. Therefore, the use of resistant potato varieties is important in preventing diseases. Many researchers reported that some biocontrol agents such as *Gliocladium* spp., *Trichoderma* spp. and *Verticillium biguttatum* have an ability to suppress soil-borne and tuber-borne pathogens including *R. solani* (Van den Boogert and Luttikhold 2004; Demirci *et al*. 2009). Integrated disease management or supportive treatments in addition to traditional methods provide effective control against fungal diseases (Bicici and Erkilic 1986; Powelson *et al.* 1993).

The purpose of this study was to determine the sensitivity of potato cultivars to important soil-borne pathogens, including *Rhizoctonia solani*, *Fusarium solani*, *Pythium deliense* and *Phytophthora erytroseptica*.

MATERIALS AND METHODS

Materials

In this study, pathogens *Rhizoctonia solani* (AG-3), *Fusarium solani*, *Pythium deliense* and *Phytophthora erytroseptica*, isolated from naturally infected potato plants, were used as fungal materials. Potato varieties which were used for resistance reactions were 'Satina', 'Vangogh', 'Marabel', 'Latona', 'Marfona', 'Vericus', 'Jearla', 'Cosmos', 'Granola', 'Hermes', 'Agria'.

Methods

1. Survey and pathogen isolations

Surveys were conducted in different locations including Avşar,

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Derinkuyu, Gedikbaşı, Güneyce, Madala, Center, Tilyazısı and Zile in Nevşehir Province. During observations in survey areas, some information including variety, seed age, area were recorded in diseased fields. Underground parts, including roots and tubers, were observed for the occurrence of symptoms such as necrosis, color changes, soft and dry rots, reproductive structures, vascular discoloration, spots, sclerotia formation. Stem, root and tuber samples which had different symptoms were collected for pathogen isolation.

The roots of infected plants were washed with tap water and then plant tissue was surface sterilized with 2% NaOCl for 2 min. The pieces of infected tissue were cultured on potato dextrose agar (PDA), corn meal agar (CMA) and incubated at 24°C for 1 week. Fungal colonies were subcultured on the same medium then stored at 4°C for further use. Fungal colonies were examined macroscopically and microscopically to identify them (Barnett and Hunter 1998; Carlila *et al*. 2001; Dugan 2006).

2. Preparation of inoculum

For *R. solani* inoculation, sand-corn meal culture (sand: cornmeal: ground corn: distilled water; 70: 5: 5: 20) was prepared (Porter and Merriman 1983). The mixture was autoclaved at 121°C, 1 kPa twice for 20 min. After cooling, mycelial discs of *R. solani* cultures were inoculated into medium and incubated at 24°C for 15 days.

For *F. solani* inoculation, wheat culture was prepared. Wheat was boiled and placed into 500 ml Erlenmayer flask and sterilized at 121°C, 1 kPa. Then cooled media was inoculated with fresh *F. solani* culture and incubated at 24°C for 15 days.

For *P. deliense* and *P. erytroseptica* inoculations, protist microorganisms were cultured on CMA for 1 week. After establishment of cultures, 10 ml of distilled water was added to the cultures and then kept under natural light for 2 days. Then, a spore suspension was prepared by scraping the surface of the media with a spatula. To promote the formation of the zoospores, the suspension was incubated for 1 h at 4°C then 1 h at room temperature (Sunwoo *et al.* 1996). Zoospore concentration was adjusted to 2×10^6 zoospores ml^{-1} using a haemocytometer (OptikLabor).

3. Establishment of the experiment, pathogen inoculations and evaluations

The soil mixture (soil: sand, 3: 1, v/v) used in the experiment was sterilized by heating in oven at 160°C for 3 h filled in black polyethylene bags with 2 kg of soil. The seed-tubers of each potato variety were transferred to growing medium. The inoculations of *R. solani* and *F. solani* were done simultaneously with seed-tuber planting. Previously prepared sand-cornmeal culture of the *R. solani* and wheat culture of *F. solani* were placed in each seed bed as 10 g and then seeds were planted. Spore suspensions of *P. deliense* and *P. erytroseptica* were inoculated after sprouting. 10 ml of spore suspensions of both pathogens were applied around the plants' roots. Meanwhile, control plants for each variety were planted without inoculation. The experiment was conducted according to a completely randomized design with 5 replications. During the experiment, normal cultural practices were applied. The disease symptoms of upper part of plants were evaluated 8 weeks after planting and pathogen inoculations. As the experiment was conducted in a greenhouse, small tubers formed. At the end of the trial periods, disease assessment of the small tubers from plants was made according to a 0-5 scale.

The stem symptoms of *R. solani* were evaluated based on a 0-5 scale (Weinhold *et al*. 1982) where: 0: No visible disease symptoms; 1: Infection on stem was < 5%; 2: Stem infection was 6-25%; 3: Stem infection was 26-50%; 4: Stem infection was 51-75%; 5: Stem infection was > 75%. The tuber symptoms of *R. solani* were evaluated based on a 0-5 scale (Naz *et al.* 2008) where 0: No visible disease symptoms; 1: Infected area of tuber was < 1%; 2: Infected area of tuber was 1-10%; 3: Infected area of tuber was 11-20%; 4: Infected area of tuber was 21-51%; 5: Infected area of tuber was more than 50%.

Evaluation of symptoms of *F. solani* were performed using a 0-4 scale for the upper part, 0: asymptomatic leaf; 1: Leaf wilted; 2: Leaf wilt with hemiplegic yellowing; 3: Leaf with necrosis; dead leaf (Ayed *et al*. 2006) and scale for vascular discoloration, 0: Healthy plants; 1: Plants wilted slightly and vascular discoloration of only main root; 2: Moderate wilting, yellowing of older leaves, spreading of vascular discoloration; 3: severe wilting, yellowing and wilting of leaves except apical leaves, 4: Completely wilted plants or dead plants.

Symptoms *P. erytroseptica* and *P. deliense* evaluation were done according to Sunwoo *et al*. (1996). The scale used was 0: No visible disease symptoms; 1: Leaves slightly wilted with browning lesions beginning to appear on stems; 2: 30-50% of entire plants were diseased; 3: 50-70% of entire plants diseased; 4: 70-90% entire plant were diseased; 5: Plant dead.

Disease severity index was determined using scale values and disease severity percentages were calculated according to the Tawsend and Heuberger Formula (Gomez and Gomez 1983). The data were subjected to analysis of variance (*F*-test). Means were compared using Fisher's least significant differences (LSD) test ($P = 0.05$) (Karman 1971).

RESULTS

Surveys

The results of the isolation from infected plant samples are summarized in **Table 1**. In order to isolate fungal material, plant samples were collected from eight different locations and 1800 da in total. Isolation rates of fungi varied depending on the location and potato variety. The most commonly isolated fungal species were *Rhizoctonia* sp., *Fusarium* sp., *Phytopthora* sp. and *Pythium* sp. However, among them, *Fusarium* sp. was the most commonly isolated fungus, especially in Avşar and Güneyce and the isolation ratio ranged between 19 and 75%. Similarly, the isolation ratio of *Rhizoctonia* sp. lay between 5 and 50%. Oomycetes of *Phytopthora* sp. were not isolated in some locations but was observed in 16% of samples in Güneyce while *Pythium* sp. was isolated in 63% of Derinkuyu samples.

After microscopic and macroscopic identifications, four species were included in disease reaction studies: *R. solani*, *F. solani*, *P. ertyroseptica* and *P. deliense*.

Colletotrichum sp., *Alternaria* sp., *Curvularia* sp. and other saprophytic fungal genera were isolated in addition to some bacterial colonies at 7-22%.

Disease reaction studies

To determine the reactions of cultivars to *R. solani*, two different assessments, including stem and tuber infections, were performed; results are shown in **Table 2**.

Table 1 Isolation ratio (%) of pathogens from diseased plants in some locations.

Location	Area (da)	*Rhizoctonia* sp.	*Fusarium* sp.	*Phytophthora* sp.	*Pythium* sp.	Others
Avşar	245	13	75	0	1	11
Derinkuyu	288	5	19	2	63	11
Gedikbaşı	107	13	49	5	18	15
Güneyce	165	15	56	16	5	8
Madala	270	10	36	4	29	22
Center	278	50	25	0	9	16
Tilyazısı	142	0	31	12	31	27
Zile	304	29	40	9	15	7

Table 2 Stem and tuber infection of *Rhizoctonia solani* in different varieties.

Cultivars	Stem infection		Tuber infection	
	Disease index	Disease severity (%)	Disease index	Disease severity (%)
Satina	1.8 a*	45.0	1.8 b	45.0
Van Gogh	1.0 bc	25.0	1.5 b	37.5
Marabel	1.2 b	30.0	1.3 b	33.5
Latona	0.8 d	20.0	1.0 c	25.0
Marfona	1.2 bc	37.5	1.4 b	35.0
Vericus	0.8 d	20.0	1.0 c	25.0
Jaerla	1.6 a	40.0	2.4 a	60.0
Cosmos	1.0 bc	25.0	1.6 b	40.0
Granola	0.6 d	15.0	1.0 c	25.0
Hermes	1.0 bc	25.0	0.8 c	20.0
Agria	0.3 e	6.3	0.5 cd	12.5

*Means within the column followed by the different levels are significantly different according to the LSD test ($P = 0.05$).

Table 3 Disease severity of *Fusarium solani* in different varieties.

Cultivars	Upper part infection		Vascular discoloration	
	Disease index	Diseases severity (%)	Diseases index	Diseases severity (%)
Satina	3.7 a*	91.6	4.0 a	100.0
Van Gogh	0.6 e	15.0	0.4 e	10.0
Marabel	1.7 d	41.7	2.3 c	58.3
Latona	3.5 a	87.5	3.0 b	75.0
Marfona	0.8 e	20.0	1.2 d	30.0
Vericus	2.3 c	56.3	1.6 d	40.0
Jaerla	3.5 a	87.5	3.3 b	81.3
Cosmos	3.0 ab	75.0	2.2 c	55.0
Granola	2.6 c	65.0	2.0 c	50.0
Hermes	0.8 e	20.0	0.4 e	10.0
Agria	0.4 ef	10.0	0.2 e	5.0

*Means within the column followed by the different levels are significantly different according to the LSD test ($P = 0.05$).

Table 4 Disease severity of *Phytophthora erytroseptica* and *Pythium deliense* in different cultivars.

Cultivars	*Phytophthora erytroseptica*		*Pythium deliense*	
	Disease index	Diseases severity (%)	Diseases index	Diseases severity (%)
Satina	3.2 a*	80.0	2.6 b	65.0
Van Gogh	0.6 d	15.0	0.8 e	20.0
Marabel	2.0 b	50.0	0.8 e	20.0
Latona	1.0 c	25.0	1.6 c	40.0
Marfona	0.0 f	0.0	0.0 f	0.0
Vericus	1.2 c	30.0	1.6 c	40.0
Jaerla	2.4 b	60.0	3.2 a	80.0
Cosmos	1.3 c	31.3	1.8 c	45.0
Granola	1.5 c	37.5	1.2 cd	30.0
Hermes	0.2 e	5.0	0.0 f	0.0
Agria	0.3 e	8.3	0.8 e	20.0

*Means within the column followed by the different levels are significantly different according to the LSD test ($P = 0.05$).

Disease severity of stems and tubers by *R. solani* ranged between 6.3-45.0% and 12.5-60.0%, respectively. The most sensitive varieties were 'Satina' and 'Jaerla' with 45 and 40% stem infections and 45 and 60% tuber infections, respectively. Disease severity of 'Agria' on stems and tubers was 6.3 and 12.5%, respectively.

Disease severity of *F. solani* in the upper part of the plant and vascular tissues was determined using two different scales (**Table 3**).

Disease severity of *F. solani* changed between varieties. 'Satina' was the most sensitive variety and all inoculated plants were diseased: 91.6% in the upper part and 100% in vascular tissues. The other sensitive varieties were 'Latona' and 'Jaerla' with an 87.5% disease severity ratio. 'Agria' was the most resistant and disease severity in the upper part and vascular tissue was 10 and 5%, respectively.

Disease severity of *P. erytroseptica* and *P. deliense* in different varieties is shown in **Table 4**. Reactions to disease varied among the varieties. Disease severity of *P. erytroseptica* and *P. deliense* ranged between 0.0-80.0 and 0.0-80.0%, respectively.

The most sensitive varieties to *Phytophthora* sp. were 'Satina' (80%) and 'Jaerla' (60%). Disease symptoms were not monitored in 'Marfona', while disease severity in 'Hermes' and 'Agria' were determined as 5.0 vs 8.3%, respectively. Again the most sensitive varieties to *Pythium* sp. were 'Satina' and 'Jaerla' with a disease severity ratio of 65 and 80%, respectively. There were no signs of symptoms in 'Hermes' and 'Marfona'.

DISCUSSION

According to the survey, the most commonly isolated fungal species were *Rhizoctonia* sp., *Fusarium* sp., *Phytophthora* sp. and *Pythium* sp. but among them, *Fusarium* sp. was the most commonly isolated fungi. Surveys were carried out in different countries. Tsror *et al.* (1999) surveyed bacterial and fungal seed-borne diseases in Israel indicated that diseases were identified as latent or active infections caused by *Erwinia carotovora*, *Streptomyces scabies*, *R. solani*, *Fusarium* spp. and *Spongospora subterranae*. In addition, *Ralstonia solanacearum*, *Helminthosporium solani*, *Colletotrichum coccodes* and *Verticillium dahliae* were identified. Patel *et al.* (2010) conducted a brief study to determine the plant pathogens affecting potatoes in Degham, India and 15 out of 100 samples analyzed were having late blight disease of potatoes caused by *Phytophthora* sp., 29 samples were stem cancer and black scurf caused by *Rhizoctonia* sp., and 17 samples were suffering from dry rot caused by *Fusarium* spp. Chehri *et al*. (2011), determined the occurrence and pathogenicity of *Fusarium* spp. on potato tubers in Malaysia: 56 *Fusarium* spp. strains were isolated and *F. oxysporum* and *F. solani* were common.

In our study, the extensively grown table cultivars such as 'Granola', 'Marfona' and industrial cultivars such as 'Hermes' and 'Latona' were included. In addition, some other economically important cultivars were 'Agria', 'Cosmos', 'Jaerla', 'Marabel', 'Van Gogh' (Kusman *et al*. 1998).

Potato cultivars differed in their susceptibility to *R. solani* but none of the cultivars exhibited complete resistance to *R. solani*. The most sensitive cultivars were 'Jaerla' and 'Satina' while the lowest disease severity was observed in 'Agria'. Kyritsis and Wale (2002) tested different cultivars or line to the inoculum of *R. solani* and were resulted some differences in their susceptibility to *R. solani* according to the stem cancer and black scurf index. Yanar *et al.* (2005) evaluated the reaction of *R. solani* (AG-3) isolated from potato on 22 commercial and local potato cultivars; 5 cultivars were highly resistant including 'Golkoy', Victoria, 'Aybastı sarısı' and the remaining cultivars exhibited different levels of susceptibility. Naz *et al.* (2008) screened 14 cultivars and advanced lines for resistance to *R. solani*; 'Cardinal' exhibited resistance and 'Desiree' was the most susceptible.

All tested cultivars exhibited a different degree of sensitivity to *F. solani*. The most sensitive cultivars were 'Satina' and 'Jaerla' against *F. solani* while 'Agria' was the most resistant. Similarly, the most sensitive cultivar against *P. deliense* and *P. ertyroseptica* were 'Satina' and 'Jaerla'. 'Marfona' and 'Hermes' showed no symptoms. The presence of disease-resistant cultivars is one of the best disease management measures. In some studies resistance to other potato disease of important cultivars was reported. Christ (1991) ranked potato cultivars for resistance to early blight caused by *Alternaria solani* and concluded that late maturing cultivars 'Katahdin' and 'Kennebec' were more resistant to early blight than early maturing cultivars. Gopal and Singh (2003) screened 270 potato germplasms for resistance to late blight under field conditions and 10 accessions were found to be highly resistant. Osiru *et al.* (2009) evaluate the cultivar reaction to *Alternaria* leaf and stem blight of sweet potato and the range of the disease reaction was 46.3-78.4%. 'Araka red' and 'Tanzania' had the lowest

disease value while 'New kawogo' had the highest disease value. In conclusion, when all diseases were considered together, the most sensitive cultivars were 'Satina' and 'Jaerla' while 'Agria' and 'Hermes' were the most resistant.

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