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COMPARATIVE PATHOGENESITY OF *FUSARIUM* SPECIES ON SOME OF THE POTATO CULTIVARS

ABSTRACT

The fusarium dry rot is one of the most important diseases of potato tubers causing considerable damages during the storage. Resistance sources are one of the fundamental methods in prevention and disease control. This study details the pathogenesity and assessment of susceptibility of commercially acceptable potato Cultivars to dry rot causing by *Fusarium sulphureum* , *F. solani* and *F. oxysporum* under similar conditions includings . inoculum , mehtod of inoculation, temperature , relative humidity and light. The results indicated that though the similar conditions were applied, the tubers of varieties reacted with differing levels of resistance to the species causing the disease. It was found that *F. sulphureum* was the most aggressive one, then fallowed by *F. solani* as far as the disease development is concerned and were independent. *F. oxysporum* did not cause considerable damages. In these exprimments the commerical potato varieties were Seuminar, Rustica, clivastave, Dital, Escort, Monalisa, Marfona, Mondial, Aniona, Deraga, Asta, Hidram, Melisa, Moren, Mariyana, Pashandi, Frasco, Alva, Ceaser, Asva, Aula, Sandara , Marijke, Folva, Tiva, Fregate, Baraka, Aida, Diamant, Arnica, Panda, Atlas, Erigo, Volkano, Famosa, Carlita, Korrigan, Casmos, Assour, Cosima, Ariane, Desiree and saturna, in which started with most susceptible ones fallowed to resistance ones at end to *F.sulphureum*. The variety saturna were the most resistant one to the all tested species in these expriments.

Key words: Fusarium dry rot, *Fusarium* spp., pathogenesity, potato, varieties.

INTRODUCTION

There are several Fusarium species causing dry rot of potato tubers in Iran (Ershad,1995). *F. sulphureum* (syn. .*F. subucinum*) and *F. solani* are the main species (NasrEsfahani,1998), but the relative importance of these two fungi has yet to be assessed.in Britain, however, the most common cause of dry rot has always been considered to be *Fusarium solani* var. coeruleum (Boyd, 1972;

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Adams and Lapwood, 1983). *F.sulphureum* and *F. avenaceum* arealso implicated, though *F. sulphureum* was moreaggressive (Waistie *et al.*, 1989). In contrast, in North America and in mainland Europe, *F. sulphureum* has been considered a major cause of dry rot (Boerema *et al.*,1987) and in certain reports it has appeared to be the dominant species (Tivoli and Jouan, 1981; Gotz and Pett, 1977; Wojciechowska-Kot and Kiszczak, 1981). In SouthAfrica, *F.solani* and *F.oxysporum* are the main causal agents of potato dry rot(Theron and Holz, 1989).Potato cultivars differ in their degree of resistance to *Fusarium* spp. (Horackova,1981; Jellis and Starling, 1983; Waistie *et al.*, 1989) and many cultivars react differ-ently to *F. solani* and to *F. sulphureum*, even though similar methods of inoculationand incubation have been used (Leach and Webb, 1981; Seppanen, 1983; Corsini and Pavek, 1986; Tivoli *et al.*, 1986; Waistie and Bradshaw, 1993). Factors which affect test results, include the incubation temperature and moisture (Seppanen, 1983; Lui and Kushalappa, 2002), the inoculation method (Wellving, 1976; Langerfeld, 1979),the effect of wounding (Tivoli *et al.*, 1986) and the time of year when tests are carried out, were considered in our experiments. In addition, it was suggested that twoyears' testing are necessary to obtain worth while results (Langerfeld, 1979; Waistie *et al.*, 1989).In view of these reports, the reactions of 43 cultivars inoculated with *F. sulphureum*, *F. solani* and *F. oxysporum* were monitored over two successive years, using the same method of inoculation and test conditions throughout.

MATERIALS AND METHODS

The cultures of the three pathogens were obtained as lyophilized cultures from PlantPests and Diseases Research Institute, Evin, Tehran, The three pathogens were main-tained on potato dextrose agar before and between the tests, but were occasionallyinoculated into susceptible potatoes and re-isolated, to ensure that they remainedpathogenic. Fresh isolates were obtained from the same sources for inoculation.Tubers were taken from the plots grown at Roseveh Research Station in Feraydan (Isfahan), and kept in a frost-free store at 6-10°C until mid-January each year.

Three samples of 10 even-sized undamaged tubers were selected from each cultivar.The tubers were washed, allowed to dry overnight, and individually wounded mid-way between the two ends by pressing a rounded-end glass rod 8 mm in diameter in-to the flesh. The rod was flanged to ensure it penetrated 10 mm into the tuber and was sterilized between each wound. The tubers were inoculated immediately by pressing them into a 4-week-old maize-meal + sand culture (maize-meal 5 g + sand 95 g, moisten and autoclaved for 1 to 2 h on 2 successive days) of *F. sulphureum*, *F. solani* or *F. oxysporum* (Langerfeld, 1987).

Ten tubers of each sample were inoculated with each species individually. They were incubated in plastic boxes for 8 weeks at 10°C, the two sub

-samples often being separated by a plastic divider. The incubation chamber was kept at high humidityby blowing steam into the air stream surrounding the boxes.The amount of dry rot was assessed by cutting each tuber transversely in two through the wound, and estimating the fraction of the exposed tissue colonized by the fungus, using the scoring scale 0-24 (Langerfeld, 1987). The number of tubers in each of the six infection classes (0, 1/16, 1/8, 1/4, 1/2, and >l/2) was multiplied by 0, 1, 3, 6, 12 or 24 respectively, the products added, and the sum divided by the total number of tubers. A mean score on the 0-24 scale was calculated for each cultivar.

The data were also subjected to analysis of variance and the mean comparison for the three involving Fusarium species in overall and individually according to Ward's minimum variance method using the cluster procedure of SAS computer software (SAS Institute, 1996).

RESULTS

The common dry rot scores of the potato cultivars are shown in Table 1 and the ranking for *F. sulphureum* and *F. solani* as far as the colonization scores of the cultivars in common are concerned. In fact, the colonization score measures the size of the rot in the tuber, which assesses the within-tuber spread rather than the number of wounds infected. Data obtained for *F. sulphureum*, confirms the high susceptibility of Seuminar followed by Rustica, Clivastava and Dital, and the resistance of Saturna, Desiree and Ariane respectively (P=0.01) (Table 1). However, in case of *F. solani*.

Escort and Monalisa were highly susceptible and Panda, Fregate, Folva, Ariana and Satura were resistant. Many of the cultivars were less resistant in the present studies, and also many with intermediate status differed considerably in rank order (P=0.01) (Table 1).

Observation showed that there are differences in rank order and such differences are apparent when comparing the mean scores. Thus, high susceptibility tends to be associated with high mean scores (Table 1) e.g. the high mean with susceptible cultivars, Seuminar (*F. sulphureum*). Escort and Monalisa (*F. solani*), and low mean with the most resistant cultivars, Saturna, Desiree and Ariana to *F. sulphureum* and Panda, Fregate, Folva, Ariana and Saturna to *F. solani*. Saturna has the lowest and almost similar mean score to the pathogen tests. The differences in susceptibility were clarified by comparing the overall mean score for all cultivars over two years (Table 1 and 2). Cultivars identified as resistant and/or susceptible by the present study showed that when they are subjected to penetration-type tests, the speed at which the pathogen might spread within the tissue could be assessed in spite of a low frequency of infection (Tables 3 and 4).

Table 1

Susceptibility assessment of commercial potato varieties to Fusarium dry rot (means of two years)

Series	Cultivars	Mean of scoring scale and ranking of tuber susceptibility					
		F.sulphureum		*F.solani*		*F.oxysporum*	
		Scoring	Ragnking	Scoring	Ranking	Scoring	Ranking
No.	Varieties	Scale	Order	Scale	Order	Scale	Order
1	Seuminar	24	1	7.8	26	0	37.5
2	Rustica	21.6	3	18	5	0	37.5
3	Clivvastava	21.6	3	13.2	15	1.2	16.5
4	Dital	21.6	3	4.2	35.5	1.4	14
5	Escort	19.2	8.5	24	1.5	2.4	10
6	Monalisa	19.2	8.5	24	1.5	1.2	16.5
7	Marfona	19.2	8.5	16.8	6	0	37.5
8	Mondial	19.2	8.5	16.2	7	0.2	27.5
9	Aniona	19.2	8.5	15.2	10.5	0	37.5
10	Deraga	19.2	8.5	15.2	10.5	0	37.5
11	Asta	19.2	8.5	12	17	0.2	27.5
12	Hidram	19.2	8.5	7.2	28	4.8	4
13	Melisa	16.8	15	11.3	20	2.1	12
14	Moren	16.8	15	15.6	9	1.2	16.5
15	Mariyana	16.8	15	11.4	19	0.2	27.5
16	Pashandi	16.8	15	6.6	29	0	37.5
17	Frasco	16.8	15	4.8	33	10.8	1
18	Alva	16.2	18	7.5	27	7.4	2.5
19	Ceaser	15.9	19	3.3	37	3.9	6
20	Asva	15.6	21	15.2	10.5	0	37.5
21	Aula	15.6	21	13.2	15	1.6	13
22	Sandara	15.6	21	9	23.5	0	37.5
23	Marijke	15.5	23	10.4	21	1.2	16.5

Table 1

Susceptibility assessment of commercial potato varieties to Fusarium dry rot (means of two years) — continued

Series	Cultivars	Mean of scoring scale and ranking of tuber susceptibility					
		F.sulphureum		*F.solani*		*F.oxysporum*	
		Scoring	Ragnking	Scoring	Ranking	Scoring	Ranking
No.	Varieties	Scale	Order	Scale	Order	Scale	Order
24	Flova	15.3	24	2.7	41	0.4	23
25	Tiva	15.1	25	5.2	32	1.1	19
26	Fregate	14.4	26	2.6	42	0.3	24
27	Baraka	13.5	27	11.8	18	7.4	2.5
28	Aida	13.3	28	9.9	22	2.8	9
29	Diamant	13.2	30	9	23.5	0	37.5
30	Arnica	13.2	30	4.8	34	0	37.5
31	Panda	13.2	30	2.4	43	0	37.5
32	Atlas	12.7	31	13.3	13	2.3	11
33	Erigo	12	34.5	6.1	30	3.3	8
34	Volkano	12	34.5	16	8	0.2	27.5
35	Famosa	12	34.5	14.4	12	0.2	27.5
36	Carlita	12	34.5	3	38.5	0.2	27.5
37	Korrigan	11.8	37	21.6	3.5	3.5	7
38	Casmos	10.8	38.5	21.6	3.5	0	37
39	Assour	10.8	38.5	4.2	35.5	0	37
40	Cosima	10.6	40	5.7	31	4	5
41	Ariane	8.7	41.5	2.9	40	0.8	22
42	Desiree	8.7	41.5	8.8	25	0.9	20.5
43	Saturna	2.7	43	3	38.5	0.9	20.5
Mean		15.27		10.21		1.58	
$LSD_{0.05}$		3.12		2.16		2.71	

The tubers in each infection classes (0, 1/16, 1/8, 1/4, 1/2 and >l/2) was multiplied by 0, 1, 3, 6, 12 or 24 respectively. The products added and divided by the total number of tubers. A mean score on a 0-24 scale was calculated for each cultivar

Table 2

Comparison of tested *Fusarium* spp. on dry rot development in potato cultivars

Parameter	*F. sulphureum*	*F. solani*	*F. oxysporu*
Correlation (r)	0.304	-0.242	-0.159
Pair t-test	5.06***	16.37***	8.01***

Table 3

Mean squares from the analysis of variance of the cultivars, to the Fusarium Dry Rot species

Source of variance	*F. sulphureum*			*F. solani*			*F. oxysporum*		
	Df	Ms	P	Df	Ms	P	Df	Ms	P
Years	1	98.88	<0.001	1	79.45	<0.001	1	35.55	<0.001
Cultivars	42	85.32	<0.001	42	70.63	<0.001	42	28.83	<0.001
Years × Cultivars	42	2.38	s	42	1.15	s	42	81	s
Total	85	185.48	85	151.23	85	66.19			

Table 4

Analysis of variance and mean comparison between six groups for three species

Species	Mean of groups					
F.sulphureum	19.07^{a}	18.55^{a}	15.25^{abc}	14.35^{be}	12.82^{c}	2.7^{d}
F.solani	22.80^{a}	15.04^{b}	11.79^{c}	7.22^{d}	4.50^{de}	3.00^{e}
F.oxysporum	9.00^{a}	5.30^{b}	1.77^{c}	1.15^{c}	1.06^{c}	0.31^{c}

DISCUSSION

The rank order of resistance to the two main pathogens differed markedly and the correlation (r=304) is not significant, indicating that resistance to each species is independent. This supports the findings that resistance to these two pathogens is genetically distinct (Corsini and Pavek, 1986; Waistie *et al.*, 1989). Other workers (Seppanen, 1983; Waistie and Bradshaw, 1993; Lui and Kushalappa, 2002) have also reported that cultivars react differently to these and other Fusarium species. In view of the similarity in mode of attack and symptom expression, these differences are surprising. In particular, it is noted that, except foe a few cases, almost all of the varieties highly resistant to *F. sulphureum* are very susceptible to *F. solani* (Table 1).

There are also reports that *F. sulphureum* is more aggressive than *F. solani* (Tivoli and Jouan, 1981; Waistie *et al.*, 1989), which has been confirmed by others (Rousselle-Bourgeois, 1995; Tumburic-lllincci, 1996). Indeed, the authors reported earlier that *F. sulphureum* was the only species (among several which they examined) that infected unwounded tubers.

Comparing the mean ranks gives a different impression, in that both the most resistant and most susceptible cultivars tend to have the lowest variances. However, apart from these generalizations, it is possible to identify certain cultivars that behave erratically (i.e. Moren, Asva, Atlas, Desiree and Saturna).

Waistie *et al.* (1989) also showed that, for correlations of at least 0.89, when the mean of two years' data is considered, the degree of correlation between years is greater than in those quoted for *F. solani* and *F. sulphureum* (Seppanen, 1983) or for *F. solani* (Langerfeld, 1979). These findings therefore support the recommendation, that as a general precaution two years' tests are necessary on account of the large variation in the ranking ofcultivars (Langerfeld, 1979; Waistie *et al.*, 1989). Although, it was pointed out that the rate of spread of the pathogen in tuber tissueis inadequate to assess the likely disease resistance of a cultivar in practice (Langerfeld, 1979; Jellis and Starling, 1983), the results of their inoculation tests with *F. solani* and *F. sulphureum* respectively show that a high colonization score (lesion size) is always associated with high susceptibility to penetration (rotted tubers). Thus a cultivar identified as having a high colonization score is likely to be susceptible to the disease in practice (Waistie and Bradshaw, 1993). On the other hand, these workers have shown that a low colonization score is not always associated with high resistance to penetration. This is in accordance with our symptom observations as far as the rate of spread of lesion size on the surface and in the tuber is concerned. Others comment upon the practical significance of differences in susceptibility or resistance between cultivars.

Adams and Lapwood (1983), found that *F. sulphureum* was more easily transmitted through the soil from mother to daughter tubers of Pentland Crown rather than of Desiree or Maris Piper, which are much less susceptible to *F. sulphureum*. In contrast, they found Maris Piper to be more readily contaminated by *F. solani* than the other two cultivars, which are both much less susceptible to it.These authors and others suggested that differences in sporulating ability might account for differences in the rate of transmission (Theron, 1991). Our work suggests that it may also be related to the inherent susceptibility of the cultivar, which is in agreement with other findings (Waistie and Bradshaw, 1995; Platte, 1995; Lees *et al.*, 1998).

However, the need for a rapid screen for a large number of breeders' clones, primarily to identify those of high susceptibility, appears to be adequately fulfilled by the present test.

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