

SEEDLING RESISTANCE OF SOME WHEAT LINES AND CULTIVARS TO ROOT AND CROWN ROT CAUSED BY *Fusarium pseudograminearum* O'Donnell & T. Aoki

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Original scientific paper

Abstract

Wheat (*Triticum* spp.), one of the most important crops in human nutrition, is cultivated in large areas around the world. *Fusarium pseudograminearum* O'Donnell & T. Aoki is one of the most destructive pathogens of wheat causing root and crown rot. For soilborne plant pathogens, it is difficult to find resistant genotypes. Finding resistant germplasm is an important goal in plant breeding studies. In this study, 104 bread and durum wheat genotypes were tested for resistance to root and crown rot under greenhouse conditions using a virulent *F. pseudograminearum* isolate. No resistant cultivars or lines were observed among the tested durum wheat cultivars and durum wheat lines. Three of the genotypes used in the bread wheat yield trial exhibited resistant reactions, while 15 exhibited moderately resistant reactions. Three bread wheat advanced lines were classified as moderately resistant. No resistant cultivars were found among the tested bread wheat cultivars, with Ahsen, Dinçer, Altınbaşak, Yakamoz, and Karatopak exhibiting moderately resistant reactions.

Keywords: *Fusarium pseudograminearum*, wheat, disease resistance

INTRODUCTION

Wheat (*Triticum* spp.), one of the most important crops in human nutrition, is cultivated in large areas around the world. An important carbohydrate source, wheat is used in bread, pasta, and bulgur, while its stems and straw are used in animal nutrition. Post-harvest residues enrich the soil's organic matter content (Bockus *et al.*, 2010; Geçit, 2016). There are important diseases that affect wheat yield and quality. Of these, *Fusarium* species cause significant yield losses, with *Fusarium pseudograminearum* O'Donnell & T. Aoki standing out as one of the most destructive species (Bockus *et al.*, 2010, Kazan and Gardiner, 2018).

Fusarium species and other fungal diseases with a necrotrophic phase of their infection cycle causes billions of dollars of losses in cereal crops every year (Savary *et al.*, 2012).

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In many arid and semi-arid cropping regions of the world, such as Australia, the Pacific Northwest of the United States, Canada, New Zealand, South Africa, the Middle East, North Africa, and South America, *Fusarium* crown rot caused by the fungal pathogen *F. pseudograminearum* is an important disease agent lowering both quality and quantity (Kazan and Gardiner, 2018). There is a wide variety of responses to *Fusarium* crown rot in bread wheat, but among cool-season cereals, bread wheat and especially durum wheat are vulnerable to *F. pseudograminearum* (Liu and Ogbonnaya, 2015, Yazıcı Kuzu *et al.*, 2022; Yılmaz *et al.*, 2023). Due to its modest yield losses upon infection, barley is regarded as tolerant. Oats can also be infected by *F. pseudograminearum*, which causes the development of very few or no disease symptoms (Percy *et al.*, 2012). Seedlings infected with *F. pseudograminearum* may suffer from damping-off both before and after emergence (Kazan and Gardiner, 2018). Plants that survive damping-off may show unfulfilled kernels and stunted growth as a result of nutrient and water transfer being blocked. Infected seedlings have dark brown to black crowns as a result of the rot (Boamah *et al.*, 2021). The accumulation of deoxynivalenol (DON), an internationally regulated mycotoxin, is frequently the caused by *F. pseudograminearum* (Bolanos-Carriel *et al.*, 2020).

Balmas (1994) isolated *F. pseudograminearum* in Southern Italy. The pathogen was discovered in a wheat (*Triticum aestivum*) crop in Cordoba, Spain, in 2016 by Agustí-Brisach *et al.* (2018). The crown and basal stems of the affected plants displayed dry rot and necrosis. It appears that in central-southern Spain, *Fusarium* crown rot is a prevalent wheat disease that significantly reduces yield.

The distribution and species of *Fusarium* spp. found in wheat samples taken from 12 areas of Anhui Province, China, in 2020, 2022, and 2024 were examined by He *et al.*, (2025). Based on molecular and morphological identification, nine species of *Fusarium* were found. Over time and in different parts of Anhui Province, the predominant pathogen of *Fusarium* crown rot shifted from *F. graminearum* Schwabe to *F. pseudograminearum*. Pathogenicity tests revealed that all *Fusarium* species caused crown rot in wheat seedlings. He *et al* (2025) also found that *F. culmorum* was the most harmful species followed by *F. pseudograminearum* and *F. graminearum*. Disease control by the application of pyraclostrobin and prothioconazole was also assessed. The results showed that *F. pseudograminearum* was sensitive to prothioconazole and pyraclostrobin, the co-formulation (1:1) was more effective than prothioconazole alone. Gebremariam *et al.* (2018) conducted a comprehensive survey in the summer of 2013 to collect *Fusarium* species that were colonizing the lower stems (crowns) of durum wheat (*Triticum durum*) and bread wheat (*Triticum aestivum*) from various wheat-growing districts of Türkiye. Fungi were identified from symptomatic crowns after samples were taken from 200 fields that represented Türkiye's main wheat-growing regions. Using morphological and molecular methods, the isolates were identified to the species level. A total of seventeen species of *Fusarium* were isolated. With 36% of all isolated *Fusarium* species, *F. equiseti* (Corda) Saccardo was the most frequently isolated species. The most common of the harmful species, *F. culmorum* (W. G. Smith) Saccardo, was recovered from 13.6% of the sites examined, but *F. pseudograminearum*

O'Donnell & T. Aoki and *F. graminearum* were also isolated from 1% and 0.5% of the sites, respectively. Crown rot of varying degrees was produced by six of the seventeen *Fusarium* species that were examined for pathogenicity. On durum wheat, *F. culmorum*, *F. pseudograminearum*, and *F. graminearum* induced severe crown rot disease. Both *F. hostae* Geiser & Juba and *F. avenaceum* (Fr.:Fr.) Sacc. exhibited weak to moderate virulence. The virulence of *F. redolens* Wollenweber was weak. The following, however, were not harmful: *F. oxysporum* Schlechtendahl emend. Synder & Hansen, *F. equiseti* (Corda (Saccardo), *F. solani* (Martius) Appel & Wollenweber emend. Synder & Hansen, *F. incarnatum* Berkeley & Ravene (syn.: *F. semitectum* Berkeley & Ravenel) (Leslie & Summerell, 2006), *F. reticulatum* Montagne (syn.: *F. heterosporium* Nees ex Fries) (Leslie & Summerell, 2006), *F. flocciferum* Corda, *F. tricinctum* (Corda) Saccardo, *F. brachygibbosum* Padwick, *F. torulosum* (Berkeley & Curtis) Nirenberg, *F. acuminatum* Ellis & Everhart, and *F. proliferatum* (Matsushima) Nirenberg. *Fusarium pseudograminearum* was found in Türkiye as a destructive species also by Ölmez and Tunalı (2019). In their study, researchers obtained 143 *Fusarium* isolates from wheat-producing areas in Adıyaman, Diyarbakır, Mardin, and Şanlıurfa provinces of Türkiye. The most isolated species was *F. proliferatum* (17.4%). *Fusarium pseudograminearum* and *F. culmorum* were the most important crown rot pathogens with a 13% isolation rate.

Chemical control is one of the most essential approaches for managing plant diseases. According to Moya-Elizondo and Jacobsen (2016) and Alahmad *et al.* (2018), fungicidal control of *F. pseudograminearum* in wheat is insufficient and does not offer year-round protection against the pathogen, and it may even be harmful to human health (Boamah *et al.*, 2021). It is not well known what causes host resistance to *F. pseudograminearum*. No genotype of wheat has been shown to be completely resistant to this disease. Near maturity, the majority of wheat cultivars infected with *Fusarium* root rot develop similar lesions at the base of the stem, a condition that is aided by drought. However, some wheat cultivars exhibit less yield loss under *Fusarium* root rot infection, suggesting they are tolerant to this disease (Powell *et al.*, 2017).

Identifying sources of resistance to *F. pseudograminearum* is crucial in disease control. In this study, 104 wheat genotypes obtained from the Eastern Mediterranean Agricultural Research Institute, Adana, Türkiye were tested for resistance to root and crown rot under greenhouse conditions using a virulent *F. pseudograminearum* isolate.

MATERIALS AND METHODS

Fifty-five wheat genotypes used in bread wheat yield trials, 6 durum wheat advanced lines, 15 bread wheat advanced lines, 7 durum wheat cultivars and 21 bread wheat cultivars obtained from the Eastern Mediterranean Agricultural Research Institute located in Adana, Türkiye were tested for resistance to root and crown rot under greenhouse conditions using a virulent *F. pseudograminearum* isolate maintained at the Mycology Laboratory of the Ankara University, Türkiye.

Inoculum preparation was carried out by infecting wheat bran with *F. pseudograminearum*, as described in Yılmaz *et al.* (2023). Wheat genotypes were germinated in 9-cm-diameter Petri dishes containing moistened sterile blotting paper for 3-4 days and then placed in 7-cm-diameter pots containing a mixture of sterilized sand: soil: manure (50:40:10 v/v/v) and approximately 1 g of bran-soaked inoculum. These pots were then covered with this mixture. After eight weeks, the roots were washed and the results were evaluated. A 1-5 scale was used to evaluate the results (1: 1-9% (Resistant), 2: 10-29% (Moderately Resistant), 3: 30-69% (Moderately Susceptible), 4: 70-89% (Susceptible) and 5: 90-99% (Very Susceptible) (Wildermuth and McNamara, 1994; Nicol *et al.*, 2001).

RESULTS AND DISCUSSION

In the bread wheat yield trial (EVD) genotypes, out of 55 genotypes tested, 3 genotypes showed resistant reactions, and 15 genotypes exhibited moderately resistant reactions. On the other hand, 20 genotypes were classified as moderately susceptible, while 13 genotypes were classified as susceptible. Four genotypes were classified as very susceptible. (Table 1). In the testing of six durum wheat advanced lines (M-İ-H), no lines were found to be resistant or moderately resistant. Two genotypes exhibited moderate susceptibility, three were susceptible, and one genotype was very susceptible. Out of the 15 advanced bread wheat lines (E-İ-H) tested, three genotypes were classified as moderately resistant. Nine lines were deemed moderately susceptible, while three were categorized as susceptible. Notably, none of the genotypes were identified as either resistant or highly susceptible among the tested lines.

All durum wheat cultivars tested in the experiment exhibited reactions ranging from susceptible to very susceptible. Durum wheat cultivars Sarıbaşak, Fuatbey, and Sham 1 were susceptible to the virulent *F. pseudograminearum* isolate used, while Eker, Günberi, Ayzer, and Avanos 97 showed very susceptible reactions. Bread wheat cultivars Ahsen, Dinçer, Altınbaşak, Yakamoz, and Karatopak showed moderately resistant reactions, while Altınöz, Candaş, Gemini, Ekinoks, Pandas, Osmaniye, Doğankent, Gökkan, Ceyhan 99, Şahika, and Karmen showed moderately susceptible reactions. Yüreğir 89, Simge, Adana 99, Alkim, and Seyhan 99 showed susceptible reactions (Table 1).

In a study conducted in Türkiye, the reactions of 199 durum wheat genotypes obtained from International Maize and Wheat Improvement Center (CIMMYT) to *F. pseudograminearum* were determined under growth chamber and greenhouse conditions. Under growth chamber conditions, 15 genotypes were resistant, 20 genotypes were moderately resistant, 134 genotypes were moderately susceptible, and 30 genotypes showed susceptible reactions. Under greenhouse conditions, 19 genotypes were resistant, 16 genotypes were moderately resistant, 121 genotypes were moderately susceptible, and 43 genotypes showed susceptible reactions. In both seedling resistance trials in the growth chamber and mature plant resistance trials in the greenhouse, 2 genotypes were resistant, 2 genotypes were moderately resistant, 85 genotypes were

moderately susceptible, and 7 genotypes showed susceptible reactions (Yılmaz *et al.*, 2023).

In another study conducted in Türkiye, it was found that of 200 bread wheat lines supplied by CIMMYT, 1 (0.5%) was resistant to *F. pseudograminearum*, 35 (17.5%) were moderately resistant, 112 (56%) were moderately susceptible, 45 (22.5%) were susceptible and 7 (3.5%) were very susceptible (Yazıcı Kuzu *et al.*, 2022).

Table 1. Seedling resistance status of some wheat lines and cultivars obtained from Eastern Mediterranean Agricultural Research Institute, Adana, Türkiye to *F. pseudograminearum*

Lines and cultivars	Scale values			Mean	Resistance status
	2	2	3		
EVD 101	2	2	3	2,33	MR
EVD 103	4	4	4	4	S
EVD 104	3	3	2	2,66	MS
EVD 106	2	2	1	1,66	MR
EVD 107	3	3	2	2,66	MS
EVD 108	2	2	2	2	MR
EVD 111	3	3	3	3	MS
EVD 112	5	5	5	5	HS
EVD 113	4	4	4	4	S
EVD 114	4	4	3	3,66	S
EVD 116	4	4	5	4,33	S
EVD 117	2	2	3	2,33	MR
EVD 118	2	2	3	2,33	MR
EVD 119	5	5	5	5	HS
EVD 121	2	2	3	2,33	MR

EVD 122	4	4	4	4	S
EVD 123	3	3	3	3	MS
EVD 124	2	2	1	1,66	MR
EVD 125	5	5	5	5	HS
EVD 128	4	4	4	4	S
EVD 129	3	3	2	2,66	MS
EVD 131	4	3	3	3,33	MS
EVD 132	3	3	2	2,66	MS
EVD 133	4	4	4	4	S
EVD 134	3	3	2	2,66	MS
EVD 136	3	3	2	2,66	MS
EVD 137	1	1	2	1,33	R
EVD 138	2	2	3	2,33	MR
EVD 139	3	3	4	3,33	MS
EVD 141	2	2	2	2	MR
EVD 142	2	2	3	2,33	MR
EVD 143	3	3	2	2,66	MS
EVD 144	5	5	4	4,66	HS
EVD 146	3	3	3	3	MS
EVD 147	3	3	3	3	MS
EVD 148	3	3	2	2,66	MS
EVD 149	1	1	2	1,33	R

Scale values: 1: % 1-9 (R: Resistant), 2: % 10-29 (MR: Moderately Resistant), 3: % 30-69 (MS: Moderately Susceptible), 4: % 70-89 (S: Susceptible) ve 5: % 90-99 (VS: Very Susceptible) (Wildermuth and McNamara, 1994; Nicol *et al.*, 2001)

Table 1. Seedling resistance status of some wheat lines and cultivars obtained from Eastern Mediterranean Agricultural Research Institute, Adana, Türkiye to *F. pseudograminearum* (continued)

Lines and cultivars	Scale values			Mean	Resistance status
EVD 150	3	3	2	2,66	MS
EVD 151	2	2	3	2,33	MR
EVD 152	3	3	3	3	MS
EVD 153	3	3	4	3,33	MS
EVD 154	4	4	4	4	S
EVD 156	4	4	3	3,66	S

EVD 157	4	4	3	3,66	S
EVD 158	1	1	2	1,33	R
EVD 159	2	2	3	2,33	MR
EVD 163	2	2	3	2,33	MR
EVD 166	4	4	3	3,66	S
EVD 167	3	3	2	2,66	MS
EVD 168	3	3	4	3,33	MS
EVD 169	3	3	3	3	MS
EVD 172	2	2	3	2,33	MR
EVD 173	4	4	3	3,66	S
EVD 174	2	2	2	2	MR
EVD 175	4	4	4	4	S
M-Ĭ-H 1	5	5	5	5	HS
M-Ĭ-H 3	3	3	4	3,33	MS
M-Ĭ-H 4	4	4	5	4,33	S
M-Ĭ-H 5	4	4	4	4	S
M-Ĭ-H 6	3	3	4	3,33	MS
M-Ĭ-H 7	4	4	3	3,66	S
E-Ĭ-H5	4	4	4	4	S
E-Ĭ-H 1	3	3	4	3,33	MS
E-Ĭ-H 2	3	3	3	3	MS
E-Ĭ-H 4	3	3	2	2,66	MS
E-Ĭ-H 6	3	3	3	3	MS
E-Ĭ-H 7	4	4	3	3,66	S
E-Ĭ-H 8	2	2	3	2,33	MR
E-Ĭ-H 9	4	4	4	4	S
E-Ĭ-H 10	3	3	2	2,66	MS
E-Ĭ-H 11	2	2	2	2	MR
E-Ĭ-H 12	3	3	3	3	MS
E-Ĭ-H 13	3	3	3	3	MS
E-Ĭ-H 14	3	3	4	3,33	MS
E-Ĭ-H 15	2	2	2	2	MR
E-Ĭ-H 16	3	3	4	3,33	MS

Scale values: 1: % 1-9 (R: Resistant), 2: % 10-29 (MR: Moderately Resistant), 3: % 30-69 (MS: Moderately Susceptible), 4: % 70-89 (S: Susceptible) ve 5: % 90-99 (VS: Very Susceptible) (Wildermuth and McNamara, 1994; Nicol *et al.*, 2001)

Table 1. Seedling resistance status of some wheat lines and cultivars obtained from Eastern Mediterranean Agricultural Research Institute, Adana, Türkiye to *F. pseudograminearum* (continued)

Lines and cultivars	Scale values			Mean	Resistance status
Sarıbaşak	4	4	5	4,33	S
Eker	5	5	4	4,66	HS
Günberi	5	5	4	4,66	HS
Ayzer	5	5	4	4,66	HS
Fuatbey	4	4	4	4	S
Sham 1	4	4	5	4,33	S
Avanos 97	5	5	5	5	HS
Ahsen	2	2	2	2	MR
Altınöz	3	3	3	3	MS
Diñçer	2	2	1	1,66	MR
Yüreğir 89	4	4	4	4	S
Simge	4	4	5	4,33	S
Candaş	3	3	2	2,66	MS
Gemini	3	3	2	2,66	MS
Ekinoks	3	3	3	3	MS
Altınbaşak	2	2	3	2,33	MR
Yakamoz	2	2	2	2	MR
Adana 99	4	4	4	4	S
Pandas	3	3	2	2,66	MS
Osmaniyem	3	3	2	2,66	MS
Doğankent	3	3	3	3	MS
Alkım	4	4	4	4	S
Karatopak	2	2	3	2,33	MR
Seyhan 95	4	4	5	4,33	S
Gökkan	3	3	3	3	MS
Ceyhan 99	3	3	2	2,66	MS
Şahika	3	3	4	3,33	MS
Karmen	3	3	2	2,66	MS

Scale values: 1: % 1-9 (R: Resistant), 2: % 10-29 (MR: Moderately Resistant), 3: % 30-69 (MS: Moderately Susceptible), 4: % 70-89 (S: Susceptible) ve 5: % 90-99 (VS: Very Susceptible) (Wildermuth and McNamara, 1994; Nicol *et al.*, 2001)

Although a limited number of durum genotypes and varieties were tested in this study, durum genotypes were found to exhibit reactions ranging from moderately susceptible to very susceptible. Other genotypes exhibited a wide range of reactions, ranging from resistant to very susceptible. Genotypes in the resistant and moderately resistant groups can be used in breeding studies, and it would be appropriate to use varieties in these groups in regions where *F. pseudograminearum* is prevalent.

CONCLUSIONS

Finding resistant germplasm is an important goal in plant breeding studies. Managing soilborne plant pathogens, particularly *Fusarium* species, poses significant challenges. While cultural methods and chemical control measures have yielded some success, losses continue to occur. To achieve sustainable control, it is essential to identify disease-resistant genotypes. However, resistance to *F. pseudograminearum* has been limited. Therefore, discovering resistant germplasm is of utmost importance for enhancing disease resistance (Bockus *et al.*, 2010; Kazan and Gardiner 2018). In this study, 104 bread and durum wheat genotypes were tested for resistance to root and crown rot under greenhouse conditions using a virulent *F. pseudograminearum* isolate. Three of the genotypes used in the bread wheat yield trial exhibited resistant reactions, while 15 wheat genotypes exhibited moderately resistant reactions. Three bread wheat advanced lines were classified as moderately resistant. Bread wheat cultivars Ahsen, Dinçer, Altınbaşak, Yakamoz, and Karatopak exhibited moderately resistant reactions.

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OTPORNOST KLIJANACA ODREĐENIH LINIJA I KULTIVARA PŠENICE NA *Fusarium pseudograminearum* O'Donnell & T. Aoki UZROČNIKA TRULEŽI KORIJENA I KORJENOVOG VRATA

Sažetak

Pšenica (*Triticum* spp.), jedna od najvažnijih kultura u ljudskoj ishrani, se uzgaja na velikim površinama širom svijeta. *Fusarium pseudograminearum* O'Donnell & T. Aoki se smatra za najznačajnijeg patogena pšenice, budući da uvjetuje trulež korijena i korjenovog vrata. Za patogene koji se održavaju u zemljištu, poput *F. pseudograminearum*, je iznimno teško pronaći rezistentne genotipove. Budući da je osnovni cilj oplemenjivačkog rada pronalazak rezistentne germplazme odabranih kultura, u sklopu ovog rada su ispitivana 104 genotipa obične i durum pšenice na otpornost na trulež korijena i korjenovog vrata. Genotipovi su uzgajani u zaštićenom prostoru i inokulisane virulentnim izolatom *F. pseudograminearum*. Među testiranim kultivarima i linijama durum pšenice nisu uočene rezistentne sorte ili linije. Tri genotipa koja su korištena u ispitivanju prinosa obične pšenice pokazala su rezistentne reakcije, dok je 15 pokazalo umjereno rezistentne reakcije. Tri napredne linije obične pšenice su klasifikovane kao umjereno rezistentne. Među testiranim kultivarima obične pšenice nisu pronađene rezistentne sorte, a Ahsen, Dinçer, Altınbaşak, Yakamoz i Karatopak pokazali su umjereno rezistentne reakcije.

Ključne riječi: *Fusarium pseudograminearum*, pšenica, otpornost na bolesti