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Evaluation Reaction of some Wheat Cultivars to take-all Disease (*Gaeumannomyces graminis* var Tritici)

Masoud Khanahmadi*, Fereshteh Bayat* and Fatemeh Jamali**
**Plant Breeding Department of College of Agriculture and Natural Resources, Persian Gulf University, Bushehr, Iran.*
***Plant Protection Department of College of Agriculture and Natural Resources, Persian Gulf University, Bushehr, Iran.*

(Corresponding author: Fereshteh Bayat)
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ABSTRACT: Take-all caused by the soil-borne fungal pathogen *Gaeumannomyces graminis* (Ggt) is one of the most destructive root diseases in wheat and other cereal grain crops in the world. Ten wheat varieties were evaluated for their susceptibility to take-all (Ggt) at the seedling stage in a five week pot test. The dilute artificial inoculum was prepared by mixing the sand/maize-meal inoculums with silver sand. Ten seeds of each variety were placed on the soil surface of a pot and covered with a thin layer of horticultural grit. The factorial experiment with completely randomized design with five replicates was set up. After 5 weeks the plants were removed and their roots washed out with water and the percentage of plants and roots infection was then calculated. Based on the percentage of necrosis roots disease severity was scored. Also root and shoot length, root and shoot fresh/dry weight were measured. Statistical analysis indicated significant differences at 1% level between the wheat species in terms of indices. Mean comparison showed that infection significantly decreased all measured traits in infected plants than control ones. Maximum root length reduction occurred in Koohdasht, Yavaros and Zarrin, in contrast in Vrynak reduction of root length in infected plants was lower than other cultivars. The highest root weight reduction had been seen in Yavaros and Pishtaz, while Karim have been affected less. Infection had biggest reduction of shoot fresh weight in certified Zarrin, while had no effect on SHFW in certified Alvand and low effect on Koohdasht. Root and shoot dry weight decreased by infection compare to control plants. The greatest damage observed in Zarrin and later in Koohdasht and Karim, while certified Alvand, Dehdasht and Pishtaz got less injury.

Keywords: Wheat, take all, *Gaeumannomyces gramini*, germplasm.

INTRODUCTION

In 2014, world production of wheat was 726 million tons/hec, making it the third most-produced cereal after maize (1,016 million tons/hec) (FAOStat, 2015). Many diseases contaminated wheat crop are reducing its yield. Take-all caused by the soilborne fungal pathogen *Gaeumannomyces graminis* var. tritici (Ggt) is one of the most destructive root diseases in wheat and other cereal grain crops in the world (Cook, 2003).

The most conspicuous field symptom of take-all is the occurrence of stunted, yellow plants in circular patches during early stages of growth. The roots of diseased plants are rotted and broken when plants are pulled from the soil. Take-all is usually more severe in lighter soils, with higher pH, and low fertility. Generally, the earlier taking place of infection cause severe disease and the greater yield loss at harvest. Thus, infection of young plants soon after planting results in the most severe yield losses (Asher and Shipton, 1981). Moisture retaining, poorly drained soils or abnormally wet weather, especially in the second half of the growing season, favors the development of the disease (Asher and Shipton, 1981, Trolldenier, 1981).

Gaeumannomyces fungus has seven known species, each of which has a range of different host (Freeman and Ward, 2004 and Rachdowang, 1999). The species known as the G. graminis has four varieties including G. g. var. maydis, G. g. var. avenae, G. g. var. tritici and G. g. var. graminis. Each of these varieties has a different host range. G. g. var. tritici is the major cause of take-all of wheat, barley, triticale and rye, but isn't able to contaminate oat. G. g. var. avenae, in addition to the mentioned host, infects oat as well. G. g. var. maydis often contiminate corn and G. g. var. graminis contaminates some grass weeds like Bermuda grass and rice (Fouly *et al.*,1996). *Gaeumannomyces graminis* var. tritici also infects the cereals like barley, triticale and rye (Asher and Shipton, 1981, Fouly *et al.*,1996, Walker, 1981, and Freeman and Ward, 2004).

Very little progress has been achieved in breeding wheat varieties resistant to root pathogens and also in developing effective systemic fungicides against root diseases (Nilsson, 1969). Current best management practices for controlling root diseases consist of crop rotation, crop residue manipulation, tillage, using different type of nitrogen fertilizer and adding of organic soil amendments (Asher *et al.,* 1981). The identification of resistant germplasm could help provide more durable disease control, significantly reduce yield losses due to take-all and give farmers more freedom in rotational cycles (Scott, 1981). There is extensive literature on evaluation resistance to take-all in wheat. Other related species display differences in their susceptibility to take-all although none so far have been successfully utilized to improve the resistance of wheat. Comparison of above-ground symptoms of take-all and yield of wheat varieties suggests that varieties may also differ in their tolerance to take-all disease. It is hard to compare directly some studies when resistance is scored in different ways. Some measurements such as necrotic root discoloration have been reported as difficult to assess (Foroutan *et al.,* 1989, Huber and McCay-Buis, 1993). The purpose of this study was to identify and characterize some novel sources of resistance to the take-all fungus.

MATERIALS AND METHODS

A. Material

The pot test method was used to evaluate ten wheat germplasm (Koohdasht, Karim, Yavarous, Dehdasht, certified Alvand, Zarrin, certified Zarrin, Pishtaz, Verinak and Chamran) for resistance to take-all at the seedling stage. Fungus inoculum of Gaeumannomyces graminis var. Tritici was prepared by first filling 500 ml conical flasks with 100 g silver sand, 3 g maize-meal (Polenta) and 10 ml of distilled water. Flasks were autoclaved twice, with 48 hours between autoclaving. The flasks were inoculated with agar discs (6-mm diameter, cut with a cork borer) from fungal cultures on PDA, adding three discs per flask. The sand/maize-meal cultures were incubated at room temperature for 5-7 weeks, with shaking once a week for even colonization. Sand/maize-meal inoculums then added in sterilized 1000 ml conical flasks to prepare inoculums for the pot test. Flasks of sand/maize-meal inoculums were stored at 4°C until use. A mixture of 250 g take-all free soil and 50 g dilute artificial sand/maize-meal inoculums (mixed in a plastic bag) was transferred into an 11-cm-tall plastic cup which contains a basal layer of 50 cm^3 damp sand over four 3-mm-diameter drainage holes in the cup. The dilute artificial inoculums was prepared by mixing the sand/maize-meal inoculums with silver sand (normally at ~ 1:250 dilution of sand/maize-meal inoculums to silver sand, exact dilution calculated from soil calibration tests). Ten seeds were then placed on the soil surface and covered with a thin layer of horticultural grit. The factorial experiment with completely randomized design with five replicates was set up. A control treatment without Ggt sand/maize-meal was regarded. All pots were then gently watered and placed in a controlled environment room in a randomized design (16 hour day, 70% RH, day/night temperatures 15/10°C, twice weekly watering). After 5 weeks the plants were removed and their roots washed out with water before disease assessment in a white dish under water. The total number of plants and roots and the number of plants and roots infected with take-all were recorded. The percentage of plants and roots infected was then calculated. Based on the percentage of necrosis roots disease severity was scored from 0 to 5 as follows: 0 = roots and crowns without necrotic spots; 1 = root and crown does not have one or more symptoms of necrotic spots; 2 = root and crown necrotic spots going without symptoms; 3 = more than 50% root necrosis 4 = roots almost black with 75% nigrescence crown development; 5 = root and crown Black and dried plant. Also root and shoot length, root and shoot fresh/dry weight were measured.

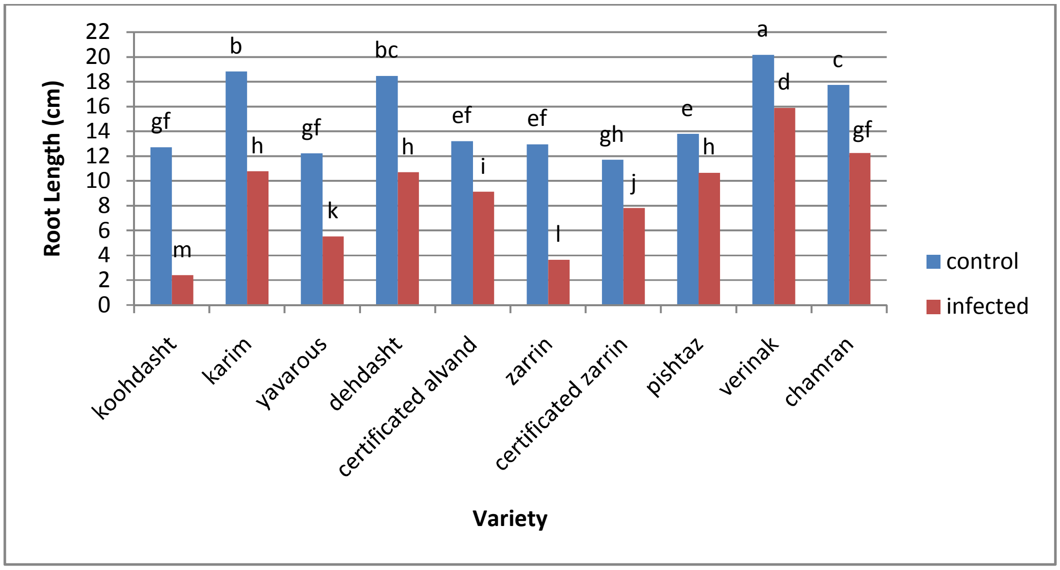
B. Statistical analysis

The analysis of the obtained data was performed using SAS software and mean comparisons were performed using Duncan multiple mean range test at 5% probability level.

RESULTS AND DISCUSSION

Ten wheat varieties were evaluated for their susceptibility to take-all (Ggt) at the seedling stage in a five week pot test. To this end winter wheat and spring wheat were inoculated with Ggt in a greenhouse, after five weeks pathogenecity index, root length, shoot length, root fresh weight, shoot fresh weight, root dry weight and shoot dry weight were measured. Statistical analysis indicated significant differences at 1% level between the wheat species in terms of indices.

Mean comparison of root length showed that compared to control plants, infection decreased root length in all varieties, so that all infected cultivars had significantly shorter root than control ones (Fig. 1 a), but maximum root length reduction occurred in Koohdasht and Zarrin, in contrast, in the Vrynak, Chamran, Pishtaz and Certified Zarrin reduction of root length in infected treatment was lower than other cultivars (Table 2). Infection significantly reduced shoot length as well as root length (Fig. 1 b); reduction in Koohdasht and Karim varieties was greater than others, certified Zarrin and Verynak got least SHL reduction caused by infection than other ones (Table 2).



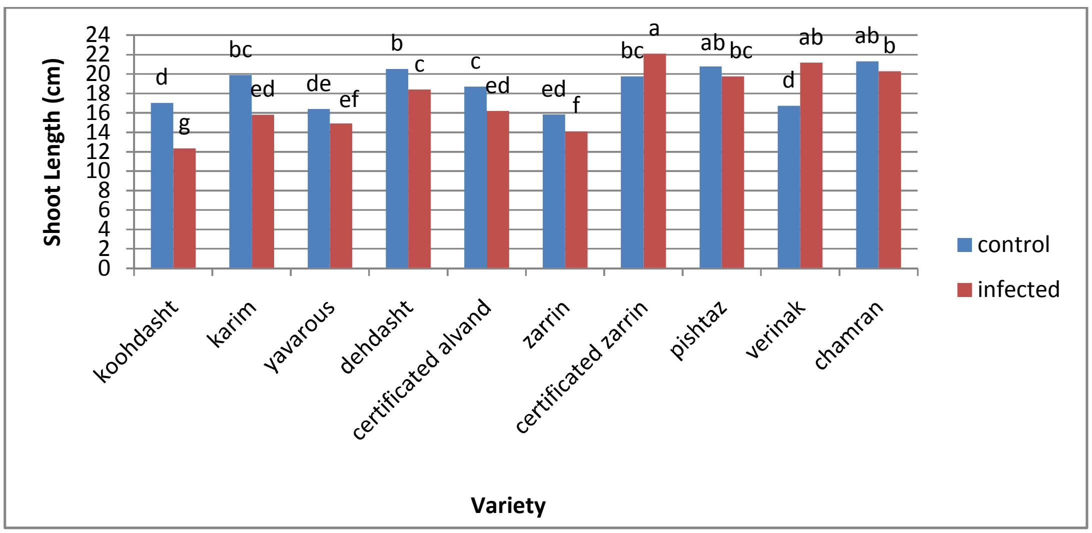


Fig. 1. Mean comparison of (a) R L (b) SHL.

Table 1: Mean square of wheat varieties infected by Ggt for traits including root length, shoot length, root fresh weight, shoot fresh weight, root/shoot dry weight and pathogenecity index.

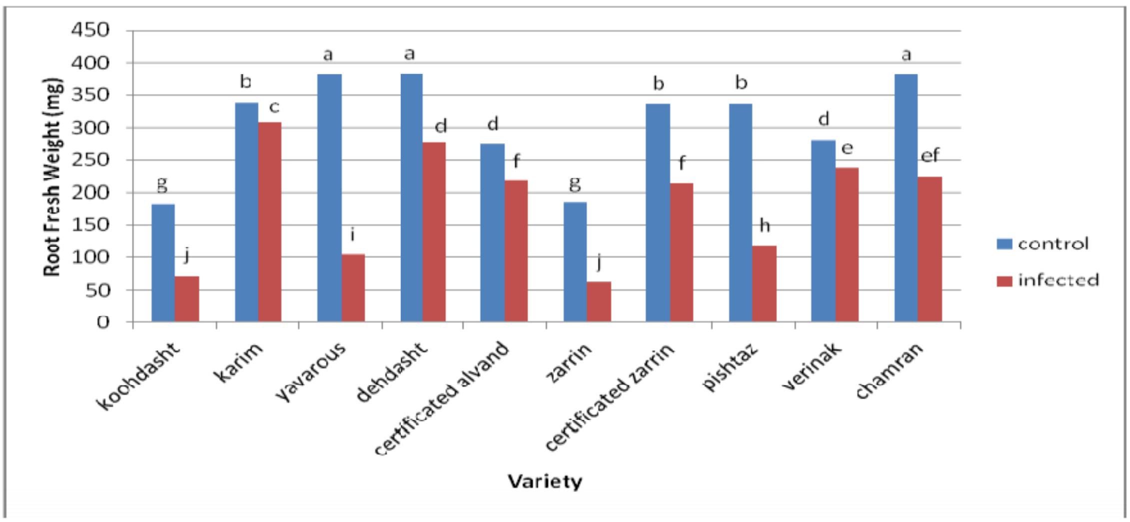
Mean Square							Degres of freedom	Source of changes
PI	SHDW	RDW	SHFW	RFW	SH.L	R.L		
64.07**	8330.82**	6365.40**	160787.27**	232130.40**	21.004**	595.35**	1	Infection
2.193**	1758.01**	1667.27**	25355.51**	31014.45**	33.536**	72.465**	9	Variety
1.363**	254.26**	344.99**	6842.53**	8899.21**	11.239**	9.44**	9	Infection* variety
0.13	5.13	9.72	61.90	57.85	0.669	0.34	40	Error
							59	Total
17.38	4.45	6.18	2.80	3.09	4.52	4.84		C.V

** Significant difference at 1% probability level.

Table 2: Reduction of infected wheat varieties relating to control ones to Ggt for traits including root length, shoot length, root fresh weight, shoot fresh weight, root/shoot dry weight and pathogenecity index.

Variety	RL	SHL	RFW	SHFW	RDW	SHDW	PI
Koohdasht	0.19 d	0.73 d	0.4 e	0.94 a	0.42 e	0.49 d	4 a
Karim	0.57 b	0.8 cd	0.91 a	0.78 bc	0.60 cd	0.55 d	4 a
Yavarous	0.45 c	0.91 bc	0.28 f	0.42 g	0.54 ed	0.54 d	3 ab
Dehdasht	0.58 b	0.89 bc	0.73 c	0.74 bcd	1.22 a	0.77 b	2 bc
certified Alvand	0.69 a	0.87 bc	0.79 b	0.99 a	0.80 b	0.74 b	1.67 c
Zarrin	0.28 d	0.89 bc	0.33 ef	0.64 de	0.41 e	0.65 c	3.9 a
certified Zarrin	0.67 a	1.12 a	0.63 d	0.61 ef	0.75 b	0.55 d	2.67 abc
Pishtaz	0.78 a	0.94 b	0.35 e	0.52 f	0.41 e	0.58 cd	2 bc
Verinak	0.71 a	1.18 a	0.92 a	0.70 ced	0.84 b	0.94 a	3.67 a
Chamran	0.7 a	0.95b	0.59 d	0.81 b	0.71 bc	0.53 d	3.3 a

Root and shoot fresh weight was also decreased by infection; in all varieties infected plants significantly had lower RFW than control treatments (Fig. 1 c and d). The highest root weight reduction had been seen in Yavarous and Pishtaz, while Karim and Verynak affected less. Infection had biggest reduction of shoot fresh weight in Yavarous and had no effect on certified Alvand and Koohdasht and low effect on Chamran (Table 2).



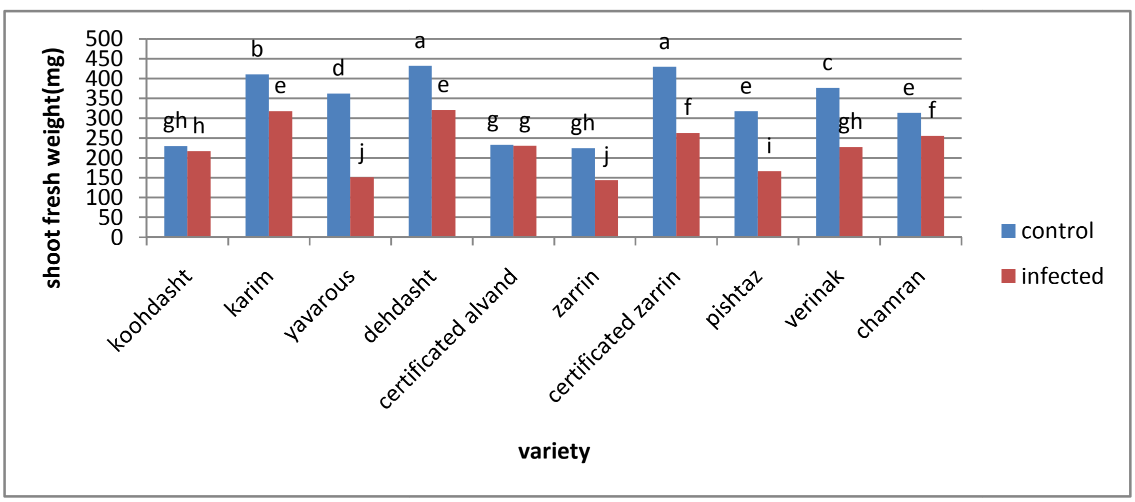


Fig. 1. (c) RFW (d) SHFW (e) RDW (f) SHDW (g) PI in control and infected wheat varieties by Ggt.

Root and shoot dry weight decreased by infection compare to control plants (Fig. 1 e and f), biggest reduction occurred in Koohdasht while Dehdasht got least effect by infection (Table 2).

The greatest reduction in shoot dry weight was observed in Chamran and certified Zarin, while Vrynak had lowest reduction (Table 2).

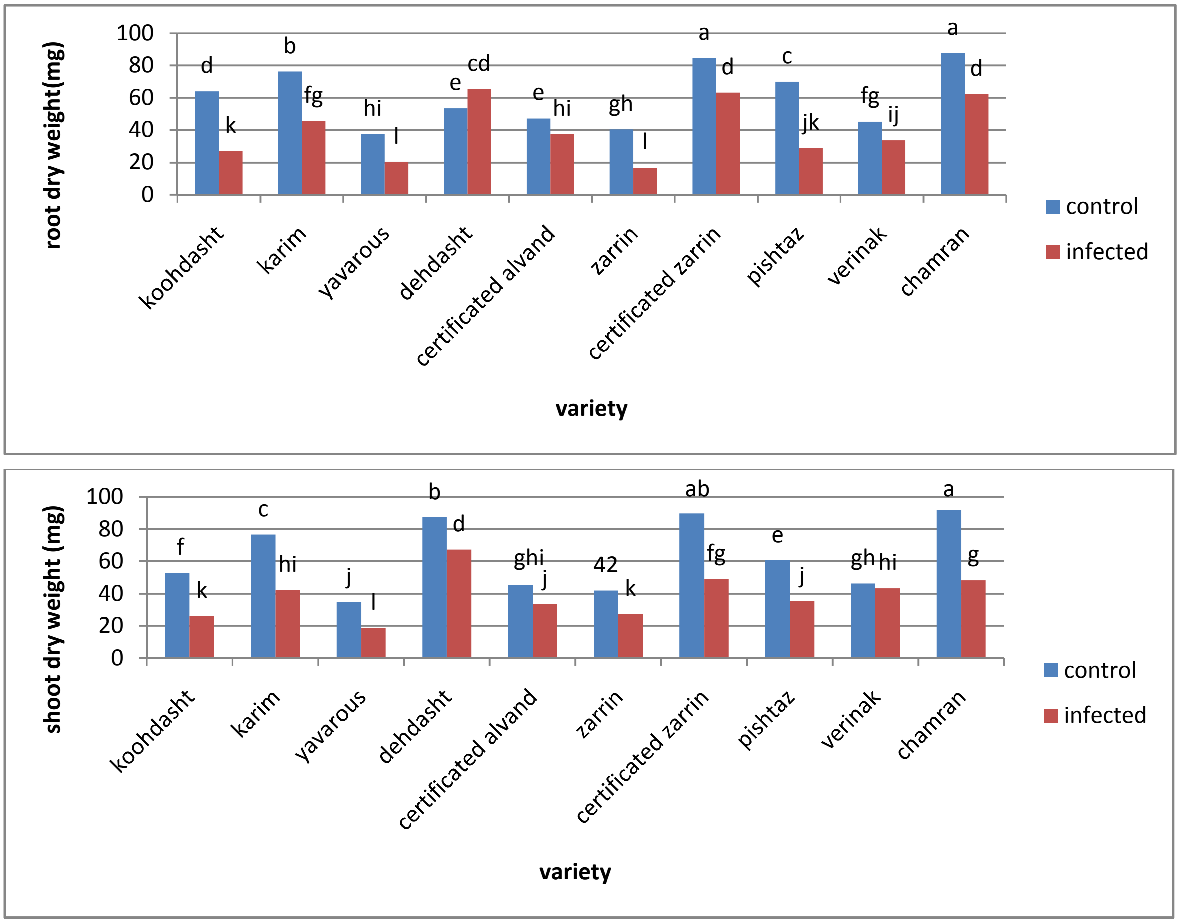


Fig. 1. (e) RDW (f) SHDW.

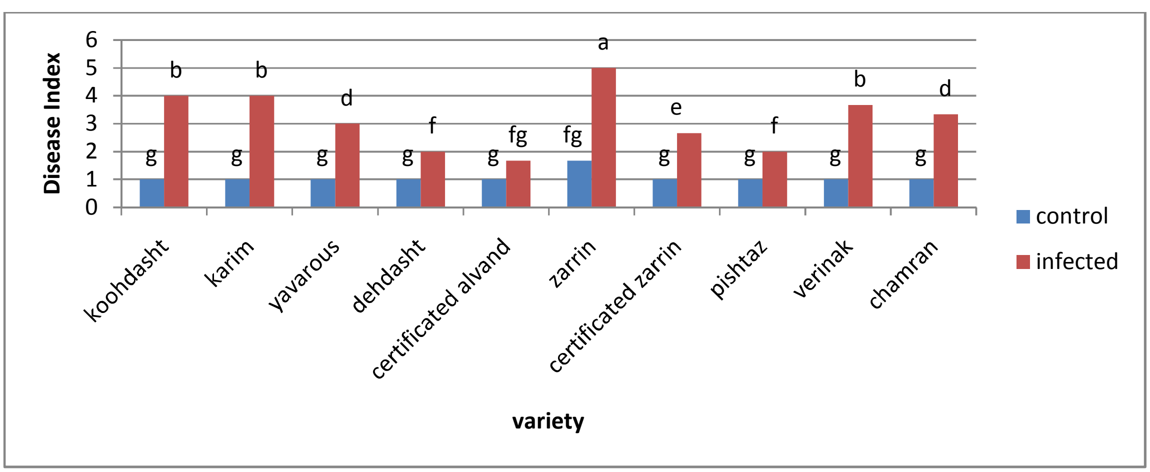


Fig. 1. (g) PI in control and infected wheat varieties by Ggt.

Pathogenicity index in all varieties significantly was greater than control plants (Fig. 1 g), the greatest damage observed in the Zarin and later in Koohdasht and Karim, while certified Alvand, Dehdasht, certified Zarrin and Pishtaz got less injury (Table 2). Reducing the quantity of the product, including reduced plant height, shoot and root dry weight as a result of contamination to impact take-all root disease of wheat. Different varieties of wheat have different reaction manifest to take-all disease. This study was conducted over ten varieties of wheat which contains spring varieties (Karim, Koohdasht and Dehdasht) and winter varieties (Yavaros, certified Alvand, Zarrin, Vrynak, Chamran, and Pishtaz) showed difference between varieties regarding disease severity, root dry weight, root length and pathogenecity index. In this study it was found that Chamran and Zarrin and Koohdasht had the least resistance to wheat take-all. Research has shown that take-all disease have the greatest impact on the roots so that the obvious symptoms of this disease is nigrescence root which is clear on early seedling stage (Rothrock and Langdale, 1989). There are reports on wheat varieties differences to take all, but these differences are too small and wheat regards as the most sensitive host to take all than other cereal (Asher and Shipton, 1981). Previous research also has been shown that winter wheat varieties are more sensitive to take all disease (Liatukas *et al.,* 2010). In general hard red winter wheat varieties had lower yield reduction than high yielding soft white winter varieties under take all (Huber, and McCay-Buis, 1993). In one study, reaction of a number of small grains cereals such as barley, wheat, triticale, rye and oat to take-all disease were evaluated. The results showed that wheat had the greatest sensitivity to wheat, but barley and triticale were moderately sensitive and oat was resistant to fungus (Zaree and Fasihani, 2009). In another experiment, the sensitivity of more than 100 samples of different genotypes of wheat and barley contains 24 varieties of winter wheat, 35 varieties of spring wheat, 55 barley cultivars and hybrids between wheat and rye were estimated in field conditions. The results showed that some wheat cultivars showed lower sensitivity and disease severity was similar to triticale seeds (McMillan, 2012). In another trial in field conditions 15 hybrid lines of triticale and wheat assessed to take-all, a line called Venus with seven pairs chromosomes from rye consistently showed resistance to this disease, on the other words, increase in rye chromosome cause grater resistance to take all (Wallwork,1987).

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