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Determination of the reactions of some bread and durum wheat varieties to the wheat seed gall nematode [*Anguina tritici* (Steinbuch) Filipjev]

Bazı ekmeklik ve makarnalık buğday çeşitlerinin Buğday gal nematodu [*Anguina tritici* (Steinbuch) Filipjev]'na karşı reaksiyonlarının belirlenmesi

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ABSTRACT

This study was conducted to determine the reactions of some bread and durum wheat varieties against wheat seed gall nematode. In the varietal reaction experiment, widely grown in Turkey, 20-bread and 12-durum wheat varieties were used. Total infected grains and healthy grains for each variety were counted and recorded. A statistically significant difference at the level of 0.01 was found among the cultivars in terms of the number of infected grains (pieces / plant), the number of healthy grains (pieces / plant) and the rate of infected grains. Compared to the control, there was a 35.8% decrease in the number of healthy grains in infected plots due to the damage of wheat gall nematodes in wheat varieties. The number of infected grains and the highest rate of infected grains were obtained from a bread wheat variety from cv. Aldane. While different rates of infected grains were obtained from 23 of the varieties included in the experiment, infected grain formation did not occur in the other 9 varieties (durum wheat varieties; Mirzabey 2000, İmren, Şahinbey, Zühre, Yelken 2000, Altıntaş, and bread wheat varieties; Bağcı 2002, Konya 2002, Ahmetağa). According to the number and ratio of infected grains, durum varieties were more tolerant. As with many diseases and pests, using resistant or tolerant varieties is one of the most economical and environmentally friendly method to control wheat gall nematode.

INTRODUCTION

Plant parasitic nematodes are one of the factors that adversely affect the yield and quality of produce in wheat cultivation. Harmful species of wheat are *Heterodera* spp. (Dababat et al. 2015), *Pratylenchus* spp. (Smiley and Nicol 2009), *Anguina tritici* (Tulek et al. 2015), *Ditylenchus dipsaci* and *Meloidogyne* spp., (McDonald and Nicol 2005). Of these species, the wheat seed gall nematode (WSGN) continues to thrive in several countries despite being managed.

The first record of nematodes parasitizing plants in literature is of WSGN [*Anguina tritici* (Steinbuch, 1799) Filipjev 1936] identified by Needham (Needham 1744). He soaked the dark brown hardened wheat grains in water and observed that a white and mobile layer formed on the surface of the water after a certain period. When samples taken from this layer were examined under a microscope, he noted the presence of worm and threadlike creatures. Actually, it was understood that these organisms were the second stage larvae (J2) of the WSGN half century later (Siddiqi 2000, Thorne 1961).

This nematode, which causes significant damage in grains, is responsible for 20-50% yield loss in wheat and 35-65% in rye (Leukel 1924). In Viranşehir district of Turkey, durum wheat (*Triticum durum* Desf.) has been reported to have lost 32% of yield due to *A. tritici* (Özberk et al. 2011). In another study conducted with four bread wheat varieties, *A. tritici*-infected (35%) grains of each variety were seeded together with untreated controls. At harvest time, there was a 55.3% decrease in the grain yield compared to the controls when these infected seeds were sown. The grain yield losses were 59.9% in Gelibolu, 56.6% in Selimiye, 53.2% in Pehlivan and 51.3% in Kate-A variety (Tulek et al. 2015).

This study aimed to determine the reactions of some bread and durum wheat varieties commonly grown in Turkey against the gall nematodes and to compare the differences among the varieties.

MATERIALS AND METHODS

Wheat cultivars and nematode source

In this study, a total of 32 registered and commonly grown wheat cultivars in Turkey that includes 20-bread wheat and 12-durum wheat were evaluated. Infected grains collected from the wheat cultivation areas of Edirne in previous years were used as the source of the inoculum. Accordingly, by using an oblong sieve, grains infected with an average of 11.700 nematodes per infected grain and falling between sieves of ≥2.2 and <2.5 mm width was used in the trials (Tulek et al. 2015).

Seed disinfection and vernalization

The seeds of the varieties used in the experiment selected uniform size. They were soaked in 96% alcohol for 5 min and then their surface sterilized for 10 min in 4.5% sodium hypochlorite. After the seeds were rinsed with sterile distilled water three times, and they were then placed on filter paper in 9 cm diameter plastic Petri dishes, approximately 20 seeds per Petri dish. Afterwards the filter papers were moistened with sterile distilled water and kept in a dark incubator at 20 °C for 48 hours. The seeds taken from the incubator were kept at 2 °C in a refrigerator for 3 weeks because most of them were classified as winter type. Thus, the vernalization requirement of the seeds was satisfied (Tülek and Ökten 2008).

Experimental design and assessment of nematode infection

The experiment was established as split plot in a randomized complete block design with 5 replications. Main plots were applications, infected and uninfected (control) plots, and cultivars were assigned as sub-plots. Plastic pots, 15 cm length and 6 cm in diameter are used for this purpose. Each replication was planted in a pot, and in the first application (infected plots), a healthy germinated, vernalized seed + an infected seed per pot; in the second application (control plots), a healthy germinated, vernalized seed per pot was sown. Before sowing, the infected grains were kept in cold water for about 8 hours to soften. Seed damage caused by nematode was observed regularly during growth periods (From March to July in 2019). Spikes obtained each pot / tube at the harvest maturity were separated from husks using a threshing board and recorded by counting the infected and healthy ones. The percentage of infection was determined according to the formula given below.

$$\text{Percentage of infected seeds (\%)} = \frac{\text{Number of infected seeds per plant}}{\text{Total number of seeds per plant}} \times 100$$

Statistical analysis

Infected seed ratio and measured grain data were subjected to Analysis of Variance (ANOVA) using Jump 5.0.1 statistical program. The means were compared with the least significant difference (LSD $P < 0.05$) if the F value was significant.

RESULTS AND DISCUSSION

The infected grain formation was formed in 23 of the varieties whereas the remaining 9 varieties had no signs of gall formation (Mirzabey 2000, İmren, Şahinbey, Zühre, Yelken 2000, Altıntaş, Bağcı 2002, Konya 2000, Ahmetağa), (Table 1). Some images obtained in field and laboratory studies are given in Figure 1. A negative correlation ($P < 0.01$) was found between the percentage of infected seeds and the number of healthy grains ($r = -0.6544$). Compared to the control, there was a 35.8% decrease in the number of healthy grains in infected parcels due to WSGN in wheat varieties (Table 2).

A statistically significant difference was found among the cultivars in terms of the number of infected grains (pieces / plant), the number of healthy grains (pieces / plant) and the rate of infected grains ($P<0.01$). The highest number of infected grains and the ratio of infected grains were obtained from Aldane bread wheat variety. The infected grain formation was undetected in 9 varieties (durum wheat varieties; Mirzabey 2000, İmren, Şahinbey, Zühre, Yelken 2000, Altıntaş and bread wheat varieties; Bağcı 2002, Konya 2002, Ahmetağa) while different rates of infected grains were obtained from the other 23 varieties included in the experiment. It was observed that durum varieties were

Table 1. Mean number of infected grains (pieces / plant), mean number of healthy grains (pieces / plant), percentage of infected seeds (%) in the infected plots

Varieties	Number of infected grain	Number of healthy grain	Percentage of infected seeds	Cultivars bread/durum
Aldane	57.2 a[x]	2.4 h	97.8 a	Bread wheat
Tosunbey	44.2 ab	3.8 h	92.5 ab	Bread wheat
Gün-91	37.8 bd	11.2 gh	87.4 ac	Bread wheat
Syrena Odeska	44.6 ab	3.6 h	86.4 ac	Bread wheat
Müfitbey	39.0 bc	20.4 fh	79.2 ad	Bread wheat
Flamura-85	24.6 ce	22.6 eh	70.8 ae	Bread wheat
Selimiye	13.4 eg	12.0 gh	70.3 ae	Bread wheat
Kate A-1	11.2 eg	29.2 dh	60.0 af	Bread wheat
Esperia	24.0 ce	10.4 gh	58.2 af	Bread wheat
Demir-2000	20.4 df	18.2 fh	56.7 bf	Bread wheat
İkizce-96	21.6 cf	46.0 ch	48.0 cg	Bread wheat
Nacibey	7.6 eg	14.6 gh	45.6 dg	Bread wheat
Pehlivan	12.0 eg	28.4 dh	40.5 dh	Bread wheat
Sönmez-2001	17.8 eg	44.8 ch	37.9 ei	Bread wheat
Altın 40/98	5.4 fg	68.6 ae	26.2 fi	Durum wheat
Bereket	9.4 eg	21.8 eh	20.7 fi	Bread wheat
Seval	6.8 eg	41.0 ch	20.5 fi	Bread wheat
Eyyubi	4.0 fg	33.8 dh	20.0 fi	Durum wheat
Dumlupınar	2,4 g	20.4 fh	20.0 fi	Durum wheat
Artuklu	4.2 fg	52.8 bg	20.0 fi	Durum wheat
Yakar-99	15.6 eg	84.6 ac	12.4 gi	Bread wheat
Eminbey	0.6 g	31.8 dh	4.7 hi	Durum wheat
Sarıçanak	1.6 g	97.2 ab	2.9 hi	Durum wheat
Altıntaş 95	0.0 g	55.6 bg	0.0 i	Durum wheat
İmren	0.0 g	55.0 bg	0.0 i	Durum wheat
Konya-2002	0.0 g	9,4 gh	0.0 i	Bread wheat
Mirzabey 2000	0.0 g	73.4 ad	0.0 i	Durum wheat
Şahinbey	0.0 g	23.8 eh	0.0 i	Durum wheat
Ahmetağa	0.0 g	34.2 dh	0.0 i	Bread wheat
Bağcı-2002	0.0 g	48.4 ch	0.0 i	Bread wheat
Yelken 2000	0.0 g	106.0 a	0.0 i	Durum wheat
Zühre	0.0 g	63.2 af	0.0 i	Durum wheat
$LSD_{0.05}$:	18.05	47.38	40.7	

X Means not connected by same letter are significantly different at P < 0.05 according to LSD.

more tolerant to WSGN in terms of the number and ratio of infected grains. In the experiment, the highest healthy grain (pieces / plant) obtained from durum cv. Yelken 2000 and Sarıçanak with 106 and 97.2, respectively.

Most of the studies on wheat gall nematode in Turkey were to determine the prevalence of the pest in wheat cultivation areas. According to reports from Turkey, the presence of *A. tritici* was first revealed in the surveys carried out in post-harvest warehouses in the cereal fields of Şanlıurfa, Mardin, Bitlis and Van in 1967 (Öztüzün 1970). In another survey study, wheat samples taken from Tokat and its districts were found to be infected with WSGN (Bora 1970). In a survey study, seed samples collected from 27 provinces were examined and the presence of wheat gall nematodes in samples from 22 provinces was confirmed; it was also determined that the highest contamination rate was found the samples taken from Aksaray by 55.22% (Elmalı 2002). Tülek et al. (2017)'s study examined seed samples taken from farm stores in 2015 to determine the prevalence status of wheat gall nematode in wheat cultivation areas of the Trakya Region. The author reported that out of a total of 685 wheat seed samples examined for gall nematodes; however, 13 samples were infected.

Table 2. Mean number of healthy grains among the treatments

Treatments	Number of grains	
Non-infected plot (Control)	57.87	a[X]
Infected plot	37.14	b

X Means not connected by same letter are significantly different at P < 0.05 according to LSD.

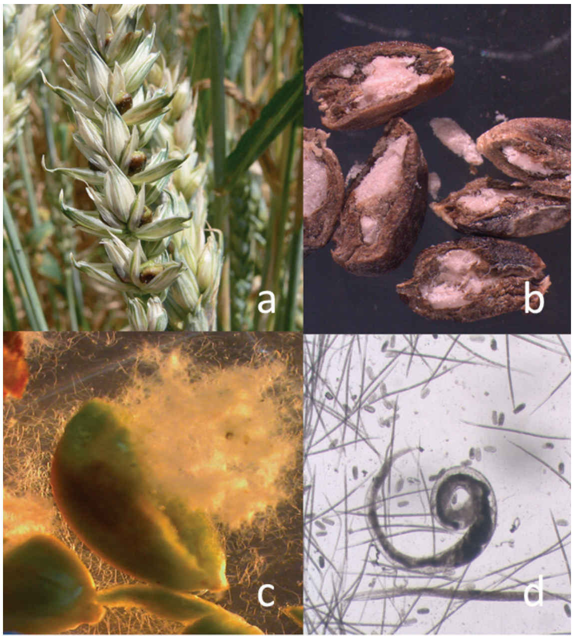

Figure 1. Infected grain in the spike (a), cross-section of the infected grain after harvest (b), view of nematode wools in the early dough stage of grain (c) view of nematodes eggs, second stage (J2) juvenile and adults (d)

Figure 2. Healthy wheat grains and grains converted into galls, bread wheat cv. Aldane and durum wheat cv. Altın 40/98

Wheat damage caused by gall nematodes occurs in the two stages. The first is the formation of infected grains instead of healthy grains; the latter is the reduction in the number of tillers due to the deformation caused by the nematode in the plant, the decrease in the number of grains in the spike, the reduction of 1000-kernel weight and hectoliter weight (Taher 2012). In the experiment, it was observed that growth disorder and deformation more serious in the varieties with high infected grain rate.

The highest grain infection rates in the durum and bread wheat varieties were observed in Altın 40/98 (26.2%) and Aldane (97.8%) varieties, respectively (Figure 2). Ami and Taher (2014), on the other hand, found the highest rate of infected grains in durum and bread wheat was in Arey (37.12%) and Maxipak (65.33%), respectively. Studies have reported that some wheat genotypes are resistant to *A. tritici* and there are differences between varieties. Studies conducted in Iraq have been reported that the Saberbeg wheat variety was highly resistant to WSGN (Al-Beldawi et al. 1977).

Parveen et al. (2003) tested the effects of wheat gall nematode against 7 bread wheat varieties and showed that of these, HD-2009 and WH-542 varieties were resistant to the nematode. Furthermore, they established that even if infected grain formation was not observed in these varieties, curling and twisting were observed in the leaves, which are important signs of nematode damage. From the results of their study conducted in pots and tubes, they proposed that HD-2009 and WH-542 can minimize the effect of wheat gall nematode.

Wheat gall nematode reduces the number of spikes, increases deformation in the plant and causes a decrease in yield. The yield obtained from parcels infected with gall nematode was recorded as 4.13-ton ha^{-1} while the potential yield of Enola bread wheat variety was 6.5-ton ha^{-1}, (Mohamedova and Piperkova 2013). In Tülek et al. (2019)`s study, seeds containing three different densities of infected grain were used to determine the yield loss caused by the wheat gall nematode in the Selimiye bread wheat variety. Compared to the control, in applications containing 10%, 20% and 40% of infected grain resulted in yield losses of 9.7%, 21.5% and 27%, respectively. There was no statistically significant decrease between applications in terms of 1000-grain weight in healthy grains (Tülek et al. 2019).

Results from this study showed that there was a statistically significant decrease of 0.01 levels in the infected parcels in terms of healthy grain number. Compared to the control, there was a 35.8% decrease in the number of healthy grains in infected parcels due to the damage of WSGN in wheat varieties.

In Turkey, WSGN has been noted to cause damage in the fields where certified seed and seed cleaning units are not used. As with many diseases and pests, using resistant varieties is the most economical method to control wheat gall nematode. Therefore, there is a need to develop resistant varieties and screening the genetic resources.

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ÖZET

Bu çalışmada seçilen bazı ekmeklik ve makarnalık buğday çeşitlerinin buğday gal nematoduna (*Anguina tritici*) karşı reaksiyonları tespit edilmiştir. Çeşit reaksiyon denemesinde Türkiye'de yaygın olarak yetiştirilen 20 ekmeklik ve 12 makarnalık buğday çeşidi kullanılmıştır. Her çeşide ilişkin toplam enfekteli ve sağlıklı taneler sayılarak kaydedilmiştir. Çeşitler arasında enfekteli tane sayısı (adet/bitki), sağlıklı tane sayısı (adet/bitki) ve enfekteli tane oranı açısından istatistiki olarak 0.01 düzeyinde önemli farklılık bulunmuştur. Buğday çeşitlerinde kontrolle kıyaslandığında enfekteli parsellerde, sağlıklı tane sayısında buğday gal nematodu zararından kaynaklanan %35.8 azalma olmuştur. Enfekteli tane sayısı ve enfekteli tane oranı en yüksek, ekmeklik buğday çeşidi olan Aldane çeşidinden elde edilmiştir. Denemede yer alan 23 çeşitte farklı oranlarda enfekteli tane elde edilirken diğer 9 çeşitte (makarnalık buğday çeşitleri; Mirzabey 2000, İmren, Şahinbey, Zühre, Yelken 2000, Altıntaş ve ekmeklik buğday çeşitleri; Bağcı 2002, Konya 2002, Ahmetağa) enfekteli tane oluşumu gerçekleşmemiştir. Enfekteli tane sayısı ve oranı dikkate alındığında makarnalık çeşitlerin daha tolerant olduğu tespit edilmiştir. Birçok hastalık ve zararlıda olduğu gibi günümüzde buğday gal nematoduna karşı en ekonomik ve çevreci mücadele yöntemlerinden birisi de, dayanıklı ya da tolerant çeşitlerin kullanılmasıdır.

Anahtar kelimeler: buğday, buğday gal nematodu, *Anguina tritici*, dayanıklılık, verim kaybı

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