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COMPARISON OF SYNTHETIC HEXAPLOID WHEAT LINES FOR RESISTANCE TO ROOT ROT (*Fusarium* spp)

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ABSTRACT

In the study, 58 synthetic bread wheat lines and 6 bread wheat varieties used as standard were used as material. Synthetic bread wheat lines: ZFSN was obtained from the elite 2 synthetic lines of CIMMYT and HRSN was obtained from CIMMYT 14SYNT. In the experiment, Selimiye, Flamura 85, Pehlivan, Aldane, Bereket and Gelibolu bread wheat varieties were used as standard. In the studies carried out in field conditions for two years, only 11 of the 64 genotypes had root rot above the 2.00 scale value. The fact that all of these 11 genotypes are different by years reveals that studies without artificial inoculation should be repeated for more years. In the study carried out with artificial inoculation in laboratory conditions, the root rot values were much higher than the field conditions. The data obtained in two years show higher resistance to root rot of synthetic wheat lines than bread wheat varieties. When the rot root disease is applied artificially to plants, all of the 28 genotypes (2.00-2.33) with the lowest root rot were synthetic bread wheat lines. The highest resistance to root rot was observed in ZFSN 6, HRSN 11-14, HRSN 13-17, HRSN 6-8, ZFSN 8 and ZFSN 3 synthetic bread wheat lines. Data from inoculated and non-inoculated conditions indicate that synthetic bread wheat lines are a valuable source material for plant breeding for root rot resistance.

Keywords: Disease, sensitive, synthetic, tolerance, wheat.

INTRODUCTION

Fusarium root rot is caused by the pathogens *Fusarium pseudograminearum*, *F. culmorum*, *F. avenaceum* and *F. graminearum.* These fungal species cause browning and rot by infecting the coleoptile, leaf sheath and root rot of wheat seedlings. (Kazan and Gardiner, 2018). Breeding studies for variety development have gradually reduced the genetic diversity of culture forms; their susceptibility to pests, environmental stresses and various diseases has also increased (Baloch et al., 2014; Baloch et al., 2017).

Significant yield increases have been achieved with combination breeding in wheat breeding studies. In recent years, the increase in yield has slowed down with the decrease in genetic diversity in the wheat gene pool. Bread wheat (*Triticum aestivum* L.) obtained from natural hybridization between durum wheat (*Triticum turgidum* L. subsp. durum) and *Aegilops tauschii* (Coss.) was developed by backcrossing. The effect of resistance to root rot in the 3 QTL (1BS, 3BS and 5AS) regions in SYN1, a synthetic bread wheat line, is 18.5%, 17.6% and 12.3%, respectively (Zhu et al., 2014). In conclusion, the genetic potential in durum wheat and *Aegilops tauschii* was represented in the bread wheat germplasm (Dreisigacker et al., 2008; Li et al., 2014). In order to add new genetic diversity to the bread wheat gene pool, synthetic hexaploid wheats have been developed and are being used widely (Mujeeb-Kazi et al., 1996).

Root rot disease in wheat is caused by fungi such as *Fusarium culmorum, Fusarium pseudograminearom, Gaumannomyces graminis, Bipolaris sorokiniana, Rhizoctonia cerealis.* Gebremariam et al. (2018) identified 17 different *Fusarium* species in their studies in Aegean, Central Anatolia and Southeastern Anatolia Regions. They stated that the species with the highest isolation rate in the regions was *Fusarium culmorum* with 13.6%. These disease-causing fungi are of soil origin and can be carried by seeds. Therefore, it is important to use certified seeds medicated against diseases in the fight against diseases. In addition to many disease factors affecting yield and quality in wheat and barley, root rot disease is also of great importance (Eken and Demirci, 1998). In wheat, root rot, seedling blight, light brown to black oval spots on the leaves with sharply separated edges, dwarfism in plants, reduction in spike size and grain weight are manifested (Ledingham et al., 1973; Wiese, 1987).

Root rot diseases are seen in almost all grain cultivation areas in the world (Aktas, 2001). Yield loss of 10-40% may occur in wheat and barley due to root rot disease. In the Thrace region, there has been a significant decrease in wheat yield and quality in recent years due to the negative effects of diseases and pests. In the Thrace Region, they stated that the frequency of the disease varied between 73-85%, and the percentage of disease severity was between 29-37%. (Hekimhan and Boyraz, 2011). Although some progress has been made in combating spike and leaf diseases and cultivar resistance, there is not enough data on root rot yet. There has been limited success finding resistance or tolerance in wheat to certain pathogens such as Rhizoctonia species.

Today, synthetic wheat appears to be the strongest candidates to obtain breeding materials that will enable the development of wheat varieties with higher yields and resistance to biotic and abiotic stresses. Beneficial alleles originating from a synthetic-derived CIMMYT line (SPCB-3104) and a landrace (AUS28451) have been identified (Thompson et al., 2017). Mahoney et al. (2016) reported synthetic wheat lines with varying resistance or tolerance to Rhizoctonia species. Recent studies have proven the value of synthetics in breeding for root traits (Becker et al., 2016) and resistance to multiple insect pests and diseases (El Bouhssini et al., 2013; Jighly et al., 2016).

Root rot disease in wheat is seen in different regions of our country at varying rates from year to year and causes significant loss rates. In this study, it was aimed to reveal the potential of synthetic bread wheat lines for root and root rot resistance under field and laboratory conditions.

MATERIALS AND METHODS

Materials

In the study, 58 synthetic bread wheat lines and 6 bread wheat varieties used as standard were used as material. Synthetic bread wheat lines: ZFSN was obtained from the elite 2 synthetic lines of CIMMYT and HRSN was obtained from CIMMYT 14SYNT. In the experiment, Selimiye, Flamura 85, Pehlivan, Aldane, Bereket and Gelibolu bread wheat varieties were used as standard.

Methods

The research was carried out in the experimental area Department of Field Crops in Tekirdag Namik Kemal University Faculty of Agriculture in 2015 and 2016 years, with 58 synthetic wheat genotypes and 6 bread wheat varieties, according to the 8x8 triple lattice trial design with 3 replications. Plants grown in field conditions were removed in the middle of the Stem elongation period and in the heading period, and were evaluated with a 1-5 scale for resistance to root rot (Nicol et al., 2001).

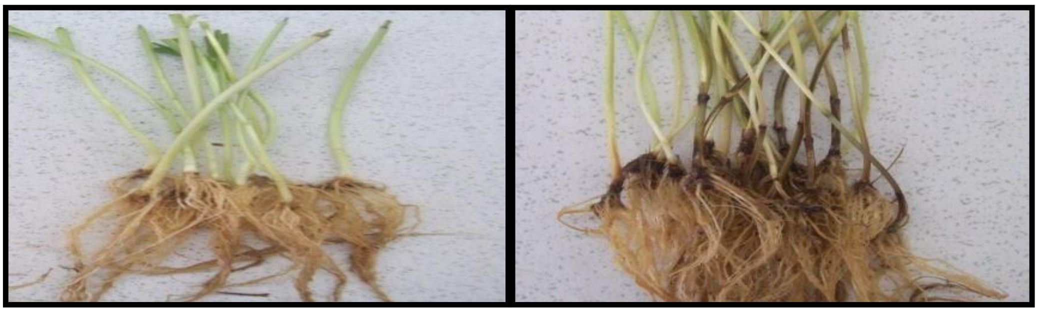
In laboratory conditions, the seeds resistant to root rot were sterilized by soaking in 96% ethanol for 3 minutes, in 4.5% NaOCl for 3 minutes, and washing 5 times with sterile distilled water before sowing. Then, 20 seeds were placed in a sterile petri dish with blotting paper and moistened. The seeds were germinated in the incubator at 20 ºC. The germinated seeds were sown in 10x2.5 cm tubes containing a 40:50:10 (sand, soil, fertilizer) soil mixture sterilized at 110 ºC, one seed per tube. One week after sowing the seed, the disease is inoculated with 1 ml (1x106 spores/ml) to the junction of the stem and soil in each tube has been made. Plants were grown in a growth chamber at 25 ºC with 16 hours of light, at 20 ºC of 8 hours of darkness, under controlled conditions with 70% humidity (Figure 1).

After nine weeks, the plant roots were washed and disease severity was evaluated on a 1-5 scale (Nicol et al., 2001) (Figure 2). With scale 1=Resistant (1-9%), 2=Medium resistant (10-29%), 3=Medium sensitive (30-69%), 4=Sensitive (70-89%), 5=Very sensitive (90-100%) was evaluated.

In the study, the data obtained in field conditions in 2015 and 2016 were carried out according to the 8x8 partially balanced lattice trial design, and the study, which was carried out in the control conditions by inoculation in 2016, was carried out according to the randomized plots trial design. The significance of the differences between the expected and observed root rot values in the data obtained from synthetic bread wheat lines and bread wheat cultivars was determined by the chi-square test (Mather and Jinks, 1971).

Sowing **Inoculation**

Figure 1. Images of sowing seeds and inoculating disease



1-2 Resistant **4-5 Sensitive**

Figure 2. Sample images of disease severity

RESULTS AND DISCUSSION

According to the results of the analysis of variance in the data on root rot under field and inoculation conditions in synthetic and bread wheat genotypes, the differences between the genotypes were found to be statistically significant. In studies conducted by different researchers on wheat, significant differences were observed in wheat genotypes for resistance to root rot (Dreisigacker et al., 2008; Li et al., 2014). In addition, researchers stated that root rot causes significant yield losses in wheat and barley (Aktas, 2001; Hekimhan and Boyraz, 2011). The results of the chi-square test performed to reveal the difference between genotypes are given in Table 1.

Root rot rate of synthetic wheat lines and bread wheat genotypes varies between 1-3 in field conditions and between 2.00-4.67 under inoculation condition. The highest root rot values in the first year were obtained in HRSN 14-10, HRSN 9-15, Pehlivan, HRSN 6-2, while HRSN 8-6, HRSN 7-6, ZFSN 26, ZFSN 14, ZFSN 32 and HRSN 14-2 followed.

Root rot in synthetic and bread wheat genotypes varied between 1.0-3.0 in the second year. The highest root rot value of 3.0 was obtained in Aldane, ZFSN 16, HRSN 15-6 and ZFSN 6 cultivars. ZFSN 31, ZFSN 18, ZFSN 7, HRSN 11-11, HRSN 1-14, HRSN 4-10 and ZFSN 4 lines followed these genotypes with a scale value of 2.00.

The effect of genotypes on root rot was found to be statistically significant according to the results of variance analysis in the data obtained on root rot in the study carried out by infecting fifty-eight synthetic wheat lines and 6 bread wheat genotypes under laboratory conditions. According to the obtained data, when genotypes are examined for root rot, a significant variation is observed between synthetic bread wheat lines in laboratory condition. In laboratory conditions, the highest root rot was obtained in the ZFSN 5 synthetic line with a scale value of 4.67, and the standard variety Aldane, ZFSN 7 and HRSN 15-2 synthetic lines followed this line with a scale value of 4.00. Synthetic lines ZFSN 24, HRSN 12-9, HRSN 13-9, Pehlivan, HRSN 12-11, ZFSN 26, ZFSN 14 and ZFSN 32 with a root rot scale of 3.67 were ranked after these 4 genotypes. In addition, root rot was high in HRSN 15-11, HRSN 8-6, Flamura 85, ZFSN 33, ZFSN 2, HRSN 4-10, HRSN 14-2, Bereket and HRSN 14-17 genotypes with root rot scale values of 3.33. Seventeen of 58 synthetic lines and 4 of 6 standard cultivars showed a root rot scale higher than 3.00.

In the evaluation of the data obtained in the first year in field conditions, 11 of 58 synthetic and 6 standard genotypes had root rot of 2.00 and above, while root rot was at a very low level in 53 genotypes. Root rot values were low due to the absence of any artificial inoculation in field conditions and most of the genotypes were found to be good against root rot. In the study conducted on synthetic wheats, it was revealed that synthetic wheats are superior for resistance to root rot (Zhu et al., 2014; Mujeeb-Kazi et al., 1996). Eleven genotypes with root rot above 2.00 scale were different genotypes in both years. The fact that the genotypes with root rot above 2.00 were different in both years reveals that the results obtained from the studies in which artificial infestation could not be performed under field conditions are not clear. This shows that it should be repeated more in field conditions without artificial inoculation.

In the study, the lowest root rot under inoculation conditions was determined in ZFSN 3, ZFSN 8, HRSN 6-8, HRSN 6-2, HRSN 14-10, HRSN 13-17, HRSN 11-14 and ZFSN 6 synthetic wheat lines with a scale value of 2.00. ZFSN 30, HRSN 2-14, HRSN 15-6, ZFSN 22, Flamura 85, HRSN 11-11, HRSN 4-2, HRSN 1-16, HRSN 11-4, ZFSN 31, HRSN 1-11, HRSN 9- 15 synthetic wheat lines with a root rot value of 2.33 were then ranked for root rot. Data obtained from under field and controlled conditions on root rot in wheat indicated that ZFSN 6, HRSN 11-14, HRSN 13-17, HRSN 6-8, ZFSN 8 and ZFSN 3 synthetic wheat lines with low root rot values are important source materials for plant breeders. As a result, the fact that all 28 genotypes with the lowest root rot value under laboratory conditions are synthetic genotypes shows that synthetic wheat lines can be a useful source for root rot resistance.

Table 1. Average root rot values and importance groups in synthetic wheat lines and bread wheat cultivars

Genotypes	Laboratory condition with artificial inoculation		Laboratory condition with artificial inoculation
	2015	2016	2016
	Average	Average	Average
HRSN 14-10	3.00*	1.00	2.00
HRSN 9-15	3.00*	1.00	2.67
Pehlivan	3.00*	1.00	3.67**
HRSN 6-2	3.00*	1.00	2.00
ZFSN 23	2.00	1.00	3.00*
HRSN 8-6	2.00	1.00	3.33*
HRSN 7-6	2.00	1.00	2.67
ZFSN 26	2.00	1.00	3.67**
ZFSN 14	2.00	1.00	3.67**
ZFSN 32	2.00	1.00	3.67**
HRSN 14-2	2.00	1.00	3.33*
Gelibolu	1.00	1.00	3.00*
HRSN 1-16	1.00	1.00	2.33
HRSN 11-14	1.00	1.00	2.00
HRSN 13-9	1.00	1.00	3.67**
HRSN 12-14	1.00	1.00	3.00*
HRSN 12-11	1.00	1.00	3.67**
ZFSN 18	1.00	2.00	3.00*
Flamura 85	1.00	1.00	3.33*
ZFSN 6	1.00	3.00*	2.00
ZFSN 24	1.00	1.00	3.00*
HRSN 11-4	1.00	1.00	2.33
HRSN 12-9	1.00	1.00	3.67**
ZFSN 15	1.00	1.00	3.00*
HRSN 15-11	1.00	1.00	3.33*
HRSN 1-11	1.00	1.00	2.33
HRSN 13-2	1.00	1.00	3.00*
ZFSN 31	1.00	2.00	2.33
ZFSN 28	1.00	1.00	3.00*
HRSN 13-17	1.00	1.00	2.00
HRSN 4-2	1.00	1.00	2.33
HRSN 15-17	1.00	1.00	2.67
Aldane	1.00	3.00*	4.00**
HRSN 9-7	1.00	1.00	3.00*
ZFSN 8	1.00	1.00	2.00
HRSN 1-6	1.00	1.00	2.67
HRSN 11-11	1.00	2.00	2.33
HRSN 1-14	1.00	2.00	2.33
ZFSN 7	1.00	2.00	4.00**
HRSN 2-16	1.00	1.00	3.00*
ZFSN 3	1.00	1.00	2.00
ZFSN 2	1.00	1.00	3.33*
HRSN 4-11	1.00	1.00	3.00*
ZFSN 21	1.00	1.00	3.00*
ZFSN 5	1.00	1.00	4.67**
HRSN 14-18	1.00	1.00	2.67
HRSN 15-13	1.00	1.00	3.00*
ZFSN 33	1.00	1.00	3.33*
ZFSN 16	1.00	3.00*	2.67
ZFSN 22	1.00	1.00	2.33
HRSN 15-6	1.00	3.00*	2.33
HRSN 6-8	1.00	1.00	2.00
ZFSN 10	1.00	1.00	2.67
ZFSN 4	1.00	2.00	2.67
HRSN 2-14	1.00	1.00	2.33
HRSN 15-2	1.00	1.00	4.00**
ZFSN 30	1.00	1.00	2.33
ZFSN 2	1.00	1.00	3.00*
HRSN 4-10	1.00	2.00	3.33*
Bereket	1.00	1.00	3.33*
HRSN 14-17	1.00	1.00	3.33*
HRSN 7-12	1.00	1.00	3.00*
Selimiye	1.00	1.00	3.00*
HRSN 10-9	1.00	1.00	2.67

CONCLUSION

When genotypes were examined for resistance to root rot under field and inoculation conditions, it was observed that there was a good variation in synthetic wheat lines for resistance to root rot. In the trials carried out for two years under field conditions, the genotypes with root rot above 2.00 in both years were different, indicating that studies without artificial inoculation under field conditions should be repeated in more years.

The results obtained under inoculation and field conditions showed that HRSN 11-14, HRSN 13-17, HRSN 6-8, ZFSN 8 and ZFSN 3 synthetic wheat lines are the most promising genotypes for resistance to root rot. The fact that all of the 28 genotypes that gave the lowest root rot value in the study carried out by artificial inoculation were from synthetic wheat lines, reveals that synthetic wheats can be a good source for resistance to root rot.

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