Bozok Journal of Science

V o l u m e 3 , N o 2 , P a g e 6 6 - 7 2 (2 0 2 5)

Research Article D O I : 1 0 . 7 0 5 0 0 / b j s . 1 7 7 9 2 9 5

Screening for Black Point Disease in Spring Bread Wheat Populations

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Received: 06.09.2025	Accepted:17.09.2025	Final Version: 20.09.2025

Abstract

The research was conducted in Yozgat (Yerköy) to determine the incidence and severity of black point disease in 20 segregating populations during the 2023-2024 growing season. The experiment was conducted in a randomized block design with four replications. The segregating populations used as material were at the F_4 level and were of the spring seasonal type. Sowing was done as freezing sowing because the genotypes are of the spring seasonal type. The incidence and severity of black point disease in seeds from segregating populations have been determined. Statistically significant differences were determined among the populations in terms of black point incidence. One segregating population was classified as resistant, eight as hardly susceptible, 10 as moderately susceptible, and one as highly susceptible. No population classified as immune or highly resistant was detected. Segregating populations showed black point incidence values ranging from 3.0 (Ziyabey 98 × Bayram) to 32.3% (Kayra × Koç 2015). The disease severity of segregating populations showed scale values ranging from 1.3 (Candaş × Albachiara and Candaş × Albachiara) to 4.0 (Koç 2015 × Kayra). Black point disease should also be used as a criterion in crossbreeding and selection carried out in plant breeding programs. In this way, the damage of the disease can be kept to a minimum in environmental conditions where black point epidemics occur intensely.

Keywords: Cross breeding, Incidence, Segregating population, Severity, *Triticum aestivum* L.

1. INTRODUCTION

Wheat is one of the most important grains in human nutrition worldwide and in Türkiye. Wheat has the largest share in Türkiye's total grain production of 39 million tons, with 20.8 million tons (TUIK, 2024). Wheat has an important share in human nutrition and meeting daily calorie needs in Türkiye. Türkiye is one of the leading countries in the world in wheat production, as well as in the production of wheat-based food products. It has high production and export values for flour, pasta, bulgur, biscuits, etc. (TUSAF, 2023; TMSD, 2023).

The ecological conditions of Anatolia are among the primary factors contributing to the extensive cultivation of wheat. About 80% of wheat cultivation is carried out under rainfed conditions, particularly in Central Anatolia and the transitional regions of Türkiye (Aydoğan and Soylu, 2017). Climatic conditions are the most important factor in Türkiye's wheat production. In particular, the amount of rainfall and its distribution during the wheat's growing periods affect the yield (Aktaş, 2025). In irrigated fields, high yields can be achieved with intensive fertilizer use compared to production under rainfed conditions. The world's food demand is increasing in parallel with population growth. However, wars, epidemics, climate change, and other factors cause volatility in agricultural production. Changes in Türkiye's total wheat production over the years are primarily due to climatic conditions. While production losses occur during years of drought, significant increases in production are observed during years with high rainfall (Aktas, 2022). In years with excessive rainfall and extreme temperatures, yield and quality losses caused by fungal diseases serious problems. The cultivation techniques used to achieve high grain yields cause diseases such as black point and negatively impact the production of products such as flour, pasta, bulgur, etc.

Black point is a fungal disease that is characterized by brown and black discoloration on the embryo of the wheat kernel (Li et al., 2014). In cases of infection severity, discoloration may progress beyond the embryonic region toward the abdomen and dorsal side of the kernel, showing a tendency to spread throughout the kernel (Tunca et al., 2016). Black point can be caused by pathogens such as

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Alternaria spp., *Cladosporium* spp., *Cochliobolus* spp., *Curvularia* spp., and *Fusarium* spp. (Ünal and Çakır 2017). Some pathogens produce mycotoxins that are harmful to human health, while others affect seed health, causing negative effects on germination percentage, germination strength, and root and shoot development (Toklu et al., 2008; Amatulli et al., 2013; Li et al., 2014; Masiello et al., 2020). Black point disease affects wheat kernels, the final product in food production, and for this reason, many countries have imposed restrictions on the percentage of infected kernels in wheat trade (Li et al., 2019). Biotic and abiotic stress factors influence the incidence and severity of black point disease (Tunca et al., 2016; Endes et al., 2025). Extreme temperatures and high precipitation during the grain filling period increase black point infection. Endes et al. (2025) emphasized that high humidity during the milk stage is more effective in the incidence of black point infection and noted that inoculum density increases the black point incidence in both milk and dough stages.

The most effective and environmentally friendly method in controlling black point is the breeding of resistant varieties (Li et al., 2014; Aktaş and Endes, 2025). Even if environmental conditions are favorable for black point infection to occur, the incidence of disease in resistant genotypes can remain limited (Conner, 1989). In plant breeding programs, the progeny of resistant × susceptible genotype crosses generally shows disease incidence values between those of the parents (Khani et al., 2018). Aktaş & Endes (2025) determined the average incidence of black point disease to be 4.41% in the first growing season and 12.54% in the second growing season in their study conducted at Yerköy location. Environmental conditions can trigger the incidence of black point infection, and therefore it is important to know the genetic resistance or susceptibility characteristics of the cultivated genotype against the disease.

As in the world, the effects of global warming on climate have become more pronounced in Türkiye, and its negative impacts have become more noticeable. Uncertainties in the amount and seasonal distribution of precipitation, along with extreme temperatures, can trigger black point disease in wheat cultivation. This study aimed to determine the reactions of segregating populations to black point in spring bread wheat breeding program.

2. MATERIAL AND METHODS

The experiment was conducted at the Yozgat Bozok University Application and Research Station located in Yerköy district of Yozgat province during the 2023-2024 growing season. Twenty F_4 level segregating populations were used as material. The populations were obtained from the crossing of bread wheat cultivars Albachiara, Ayten Abla, Basri Bey 95, Bayram, Beyazhan, Candaş, Ceyhan 99, Ekinoks, Kayra, Koç 2015, Meltem, Oktan, Polathan, Setan, and Ziyabey 98, and the cross combinations are given in Table 1. The parent cultivars Albachiara, Ayten Abla, Setan, and Kayra have red grain color, while the other cultivars have white grain color. While the parents Ayten Abla and Bayram are of the alternative seasonal type, the other parents are of the spring seasonal type. The Ayten Abla × Albachiara segregating population exhibits characteristics between the spring and alternative seasonal types, while other populations are of the spring seasonal type.

Table 1. Segregating populations used in the experiment

Crosses	Crosses
1. Albachiara × Ceyhan 99	11. Koç 2015 × Albachiara
2. Albachiara × Ziyabey 98	12. Koç 2015 × Kayra
3. Ayten Abla × Albachiara	13. Koç 2015 × Setan
4. Basri Bey 95 × Albachiara	14. Meltem × Setan
5. Beyazhan × Kayra	15. Oktan × Meltem
6. Candaş × Albachiara	16. Setan × Beyazhan
7. Ceyhan 99 × Albachiara	17. Setan × Ekinoks
8. Ceyhan 99 × Setan	18. Setan × Kayra
9. Ekinoks × Beyazhan	19. Setan × Polathan
10. Kayra × Koç 2015	20. Ziyabey 98 × Bayram

When the monthly temperature, precipitation and relative humidity data for the Yerköy district are given in Table 2. The average temperature in May is equivalent to the long-term average, while in all other months it is above the long-term average. Monthly total precipitation was above the long-term average in January and May, and below it in the other months. Relative humidity remained below the long-term average in all months during which the experiment was conducted. The experimental soil has a clay loam texture, is slightly alkaline, salt-free, has a medium lime level and medium organic matter content, and contains sufficient available phosphorus and high amounts of potassium.

Table 2. Meteorological data of Yerköy (TSMS, 2024)

Year	Month	**Temperature (°C)**		**Precipitation (mm)**		**Relative humidity (%)**	
		Average	Long-term average	Total	Long-term average	Average	Long-term average
2023	12	7.1	2.5	18.6	33.3	68.9	77.9
2024	1	4.3	0.6	38.0	34.7	68.8	76.4
	2	7.7	2.9	17.6	24.2	56.8	68.4
	3	8.4	7.2	33.2	41.4	58.8	60.2
	4	17.3	12.3	19.0	26.6	43.7	55.0
	5	16.3	16.2	73.0	48.9	54.5	55.5
	6	24.8	20.9	18.6	37.4	39.1	51.3
	7	25.7	24.3	33.2	8.4	43.1	43.8

The experiment was conducted in a randomized block design with 4 replications. Sowing was carried out in plots sized 3 m x 1.2 m, with 20 cm row spacing and 550 seeds per m^2. Sowing was carried out in the second week of December (freezing sown) to minimize winter damage due to the genotypes were of the spring seasonal type and to minimize winter damage. Diammonium phosphate fertilizer was applied at sowing, calculating 2.3 kg N and 6.0 kg P_2O_5 per decare. Additionally, urea was applied at a calculation of 4.7 kg N da^{-1} before the stem elongation period. Four irrigations were made at the tillering, stem elongation, spike emergence and milk maturity stages. The harvests were made in the first week of July.

The study was conducted under natural epidemic conditions, and the disease was induced by irrigating the plants four times. To determine the incidence of black point, 4 x 100 seeds were randomly counted in the total product obtained after harvest and infected kernels were identified in these samples. Analysis of variance was performed on the data regarding the black point incidence according to the randomized block design and the difference groupings of the means were made according to the Tukey test. The segregating populations were classified according to the incidence of black point as <0.1% (Immune), 0.1-1.9% (Highly resistant), 2.0-4.9% (Resistant), 5.0-14.9% (Hardly susceptible), 15.0-29.9% (Moderately susceptible), and ≥30.0% (Highly susceptible) (Wang et al., 2006). The scale developed by Aktaş & Endes (2025) was used to determine the disease severity in infected grains. Figure 1 shows the appearance of healthy and infected bread wheat kernels according to disease severity.

Figure 1. Appearance of healthy (0) and infected (Grade 1, 2, 3, 4, 5) wheat kernels according to disease severity

3. RESULTS AND DISCUSSION

In the variance analysis performed, the differences between genotypes in terms of the incidence of black point were found to be statistically significant (p<0.01) (Table 1). Although the differences between replicates were found to be significant, the largest share of the total variation is attributable to genotypes.

Table 3. Variance analysis for the incidence of black point disease in bread wheat genotypes

Source of variation	df	SS	MS	F
Model	22	5464.68	248.39	49.64**
Genotype	19	5224.64	274.98	54.96**
Replication	3	240.04	80.01	15.99**
Error	57	285.21	5.00	
Corrected total	79	5749.89		

df: Degrees of freedom, SS: Sum of squares, MS: Mean square **Significant at p<0.01

The incidence rates of black point observed in the 20 spring bread wheat segregating populations used as material in the experiment, along with the incidence classification of populations based on these values and disease severity grades, are presented in Table 4. One segregating population was classified as resistant, eight as hardly susceptible, 10 as moderately susceptible, and one as highly susceptible. No population classified as immune or highly resistant was detected. Segregating populations showed black point incidence values ranging from 3.0 to 32.3% and were grouped into eight statistical groups.

Table 4. Black point incidence and severity grade of spring bread wheat segregating populations at the F_4 level

Crosses	**Incidence (%)**	**Class**	**Average Severity grade**
1. Albachiara × Ceyhan 99	16.8 de	Moderately susceptible	2.50
2. Albachiara × Ziyabey 98	7.8 fgh	Hardly susceptible	1.50
3. Ayten Abla × Albachiara	12.8 ef	Hardly susceptible	2.00
4. Basri Bey 95 × Albachiara	9.0 fg	Hardly susceptible	2.00
5. Beyazhan × Kayra	12.8 ef	Hardly susceptible	2.50
6. Candaş × Albachiara	7.0 fgh	Hardly susceptible	1.25
7. Ceyhan 99 × Albachiara	5.8 gh	Hardly susceptible	1.75
8. Ceyhan 99 × Setan	7.8 fgh	Hardly susceptible	1.50
9. Ekinoks × Beyazhan	16.3 de	Moderately susceptible	2.00
10. Kayra × Koç 2015	32.3 a	Highly susceptible	3.75
11. Koç 2015 × Albachiara	26.0 b	Moderately susceptible	3.25
12. Koç 2015 × Kayra	27.8 ab	Moderately susceptible	4.00
13. Koç 2015 × Setan	19.5 cd	Moderately susceptible	2.50
14. Meltem × Setan	16.0 de	Moderately susceptible	2.00
15. Oktan × Meltem	15.8 de	Moderately susceptible	2.00
16. Setan × Beyazhan	8.8 fgh	Hardly susceptible	2.00
17. Setan × Ekinoks	15.5 de	Moderately susceptible	2.00
18. Setan × Kayra	23.0 bc	Moderately susceptible	2.75
19. Setan × Polathan	27.5 ab	Moderately susceptible	3.00
20. Ziyabey 98 × Bayram	3.0 h	Resistant	1.25

The segregating population of Ziyabey 98 × Bayram was classified as resistant based on the lowest average incidence of black point, but six more segregating populations (Ceyhan 99 × Albachiara, Candaş × Albachiara, Albachiara × Ziyabey 98, Ceyhan 99 × Setan, and Setan × Beyazhan) were in the same statistical group when statistical grouping was considered. The Kayra × Koç 2015 segregating population showed the largest rate of infected kernels with an average of 32.3% and was classified as highly susceptible. Although Setan × Polathan and Koç 2015 × Kayra segregating populations were also in the moderately susceptible class, they were statistically in the same statistical group as the Kayra × Koç 2015 segregating population in the highly susceptible class. The four cross combinations in which the Koç 2015 cultivar was used as the mother in three and as the father in one showed the largest black point incidence. The Albachiara cultivar has been included in 7 cross combinations, one of which is reciprocal with the Ceyhan 99 cultivar. The black point incidence in cross combinations of the Albachiara cultivar ranged from 5.8 to 26.0%. Although Albachiara cross combinations generally were classified as hardly susceptible, the cross combination with the Koç 2015 cultivar was classified as moderately susceptible, with a black point incidence rate of 26.0%. High infection rates have been determined in cross combinations in which the Koç 2015 cultivar is used as either the mother or father. The maximum black point incidence among the 7 cross combinations using the Setan cultivar was observed in the segregating population with the Polathan cultivar.

The study also includes four segregating populations created as a result of reciprocal crosses between the Albachiara&Ceyhan 99 and Koç 2015&Kayra cultivars. The black point incidence rate was determined to be 16.8% in the Albachiara × Ceyhan 99 segregating population and 5.8% in Ceyhan 99 × Albachiara (Figure 2). In the Kayra × Koç 2015 segregating population, the black point incidence was determined to be 32.3%, while in Koç 2015 × Kayra it was 27.8%. One reciprocal cross combination shows that whether the parents are the mother or father is not important in the incidence of black point disease, while the other reciprocal cross combination shows that whether the parents are the mother or father can make a difference in the degree of susceptibility or resistance to the disease.

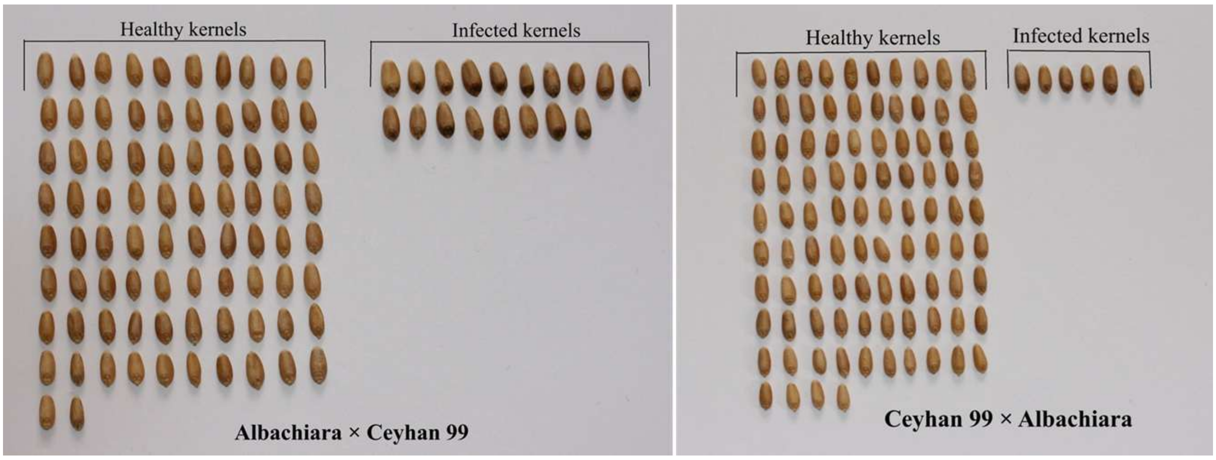

Figure 2. The appearance of black point incidence in segregating populations generated by reciprocal crossing of Albachiara and Ceyhan 99 cultivars

In the study, the mean disease severity values of segregating populations ranged from 1.3 to 4.0 (Table 4). While the Koç 2015 × Kayra segregating population showed the highest disease severity at 4.0, the reciprocal combination of this population, Kayra × Koç 2015, followed with a scale value of 3.8. When Table 4 is shown, it is seen that the general trend is that as the incidence of disease increases, the severity of the disease also increases. Ziyabey 98 × Bayram and Candaş × Albachiara are segregating populations with the lowest disease severity.

Differences in the black point incidence among segregating populations have revealed that genotypes respond differently to the disease. Genetic and environmental factors are important in the occurrence of black point disease (Tunca et al., 2016). Li et al. (2020) reported in their research with many genotypes that no genotype is immune to black point and that climatic conditions are effective in the black point incidence. Aktaş & Endes (2025) determined a very low black point incidence in the first year of their study conducted under Yerköy conditions, while they determined a very high black point incidence in the second growing season. The black point epidemic that occurred during the growing season in which this study was conducted was considered sufficient to determine the reactions of the genotypes, and the genotypes showed different responses. The absence of any genotypes classified as immune and highly resistant may be due to the high severity of the infection or the absence of genotypes with a high level of resistance. Studies by Li et al. (2020) and Aktaş & Endes (2025) support this finding.

Khani et al. (2018) reported that the incidence of black point in progeny obtained through crossbreeding was observed among the parents. Although parents were not used in this study, it shows that segregating populations consisting of cross combinations carry the resistance or susceptibility of the parents. It was determined that they generally possessed compatible traits in terms of susceptibility or resistance When the black point incidence in segregating populations in the study was evaluated according to their pedigrees. Cross combinations using the Koç 2015 cultivar as a parent have shown a high black point incidence. Aktaş & Endes (2025) emphasized that some parents, identified as resistant or susceptible, strongly passed this trait on to their crossbred progenies. In this regard, the results obtained from the study show that parents are effective in the black point incidence.

The black point incidence differed statistically between the Albachiara × Ceyhan 99 and Ceyhan 99×Albachiara populations created as a result of reciprocal crosses. The observed black point incidence between the Kayra × Koç 2015 and Koç 2015 × Kayra populations is not statistically different. McNeal et al. (1968) reported that in reciprocal crosses, the progeny generally showed characteristics between the parents in terms of quality values, and differences were determined in only 2 of the 64 criteria in reciprocal crosses.

4. CONCLUSION

Deviations in rainfall amount and seasonal distribution, which are of great importance in wheat cultivation under rainfed conditions, can lead to an increase in fungal plant diseases such as black point. Additionally, irrigation and excessive fertilizer use for high productivity can also increase the black point epidemic. For these reasons, it would be beneficial to consider black point disease in breeding programs, in addition to the common wheat diseases that are primarily considered in wheat. This study has shown that even during the growing season when black point epidemics are high, the black point incidence can remain limited in some genotypes.

AUTHOR'S CONTRIBUTIONS

The authors contributed equally.

CONFLICTS OF INTEREST

There is no conflict of interest.

RESEARCH AND PUBLICATION ETHICS

The authors declare that this study complies with research and publication ethics.

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