GSC Advanced Research and Reviews
eISSN: 2582-4597 CODEN (USA): GARRC2
Cross Ref DOI: 10.30574/gscarr
Journal homepage: https://gscarr.gsconlinepress.com/

(RESEARCH ARTICLE)

REACTION OF ADVANCED TRITICALE LINES TO BLACK POINT NATURAL INFECTION IN CROP SEASON 2019-2020

Guillermo Fuentes-Dávila [1], Karim Ammar [2], Ivón Alejandra Rosas-Jáuregui [3,*], Pedro Félix-Valencia [4], María Monserrat Torres-Cruz [5] and Alberto Borbón-Gracia [6]

[1] INIFAP, Wheat Pathology, Norman E. Borlaug Experimental Station, P.O. Box 155, km 12 Norman E. Borlaug between 800 and 900 Yaqui Valley, Obregon City, Sonora, Mexico.
[2] International Maize and Wheat Improvement Center, km 45, highway Mexico-Texcoco, El Batan, Texcoco, State of Mexico.
[3] Wheat Biotechnology, Norman E. Borlaug Experimental Station, P.O. Box 155, km 12 Norman E. Borlaug between 800 and 900 Yaqui Valley, Obregon City, Sonora, Mexico.
[4] Agroclimatology, Norman E. Borlaug Experimental Station, P.O. Box 155, km 12 Norman E. Borlaug between 800 and 900 Yaqui Valley, Obregon City, Sonora, Mexico.
[5] Autonomous University of Sinaloa, Faculty of Agronomy of the Fuerte Valley, 16th Street and Japaraqui Av., Juan José Ríos, Sinaloa, Mexico 81110.
[6] Wheat Breeding, Norman E. Borlaug Experimental Station, P.O. Box 155, km 12 Norman E. Borlaug between 800 and 900 Yaqui Valley, Obregon City, Sonora, Mexico.
* Corresponding Author

ORCID Details
Guillermo Fuentes-Dávila: https://orcid.org/0000-0001-8342-5554
Karim Ammar; https://orcid.org/0000-0003-2436-9200
Ivón Alejandra Rosas-Jáuregui; https://orcid.org/0000-0003-3678-5543
Pedro Félix-Valencia; https://orcid.org/0000-0003-3563-5527
María Monserrat Torres-Cruz; https://orcid.org/0000-0002-0827-9937
Alberto Borbón-Gracia: https://orcid.org/0000-0003-3633-3416

GSC Advanced Research and Reviews, 2026, 29(02), 131–138

Publication history: Received on 27 September 2026; revised on 03 November 2026; accepted on 06 November 2026

Article DOI: https://doi.org/10.30574/gscarr.2026.29.2.0318

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0

ABSTRACT

Twenty triticale advanced lines were evaluated for their reaction to black point under natural conditions at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Mexico, during crop season 2019-2020. Sowing dates were November 15 and 26, 2019, using 8 g of seed per 0.7 m long bed with two rows. Harvesting was done by hand, and the evaluation was performed by visual inspection, counting the number of healthy and infected grains on 10 ears per row to determine the percentage of infection. The infection range for the first date was 0 to 8.05 %, with an average of 1.64, and for the second date 0 to 14.24 %, with an average of 2.56. On average for the two dates, 8 lines showed no infected grains, 7 showed infection percentages between 0.1 - 2.5, 2 between 2.6-5.0, 2 between 5.1-10.0 and 1 between 10.1-30 %. Lines that showed the highest percentage of infection were: SN64/EER/3/ERIZO_15/FAHAD_3//POLLMER_2.1 /5/PRESTO//2*TESMO_1/MUSX603/4/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2/9/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DISB5/3/SPHD/PVN

//YOGUI_6/4/KER_3/, SONNI_3*2//FARAS/CMH84.4414/6/RONDO/BANT_5//ANOAS_2/3/RHINO_3/BULL_1-1/5/DAHBI_6/3/ARDI_1/TOPO1419//ERIZO_9/4/2*ZEBRA79/LYNX*2//FAHAD_1/9/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DIS, and 08L129/9/BICEN/8/GAUR_2/HARE_3//JLO97/CIVET/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/150.83//2*TESMO_1/MUSX 603/7/GAUR_2/HARE_3//JLO 97/CIVET with 14.24, 14.15, and 13.37 %, respectively, on the second date.

Keywords: Triticale, *Triticosecale*, Black point, Natural infection.

1 INTRODUCTION

Triticale (x *Triticosecale* Wittmack) is an artificially developed cereal crop derived from intergeneric hybridization between wheat (*Triticum* spp.) and rye (*Secale cereal*e L.) [1]. It combines desirable characteristics of both parental species and has potential for grain production, animal feeding, forage production, and use in the food industry. Its nutritional composition and potential applications in food products have contribute to increasing interest in this crop as an alternative cereal, which also has adaptation to challenging environmental conditions [2,3]. According to FAOSTAT, global triticale world production in 2024 was 12.40 million tons, with Poland, Germany, and France among the leading producers. In comparison, Mexico produced 12,816.86 tons during the same year [4]. Although triticale production in Mexico remains relatively limited, evaluating its agronomic performance and grain health under local environmental conditions may help identify opportunities for expanding its cultivation. Black point (BP) is a seed-associated disease affecting small grain cereals, which has been reported in many cereal-producing regions worldwide [5]. Infected ears which could look normal or exhibit elliptical, brown to dark-brown lesions on the inner surfaces of the glumes. The disease is more commonly characterized by localized brown, dark-brown or blackish discoloration of the grain, typically around the embryo (Figure 1).



Figure 1: Symptoms of black point on triticale grain

Discolored areas may also occur near the brush, along the crease, or elsewhere on the grain, and may range from light to dark in color, with either distinct or indistinct margins. Under severe infection, the entire grain may become discolored and shriveled [6]. Vertical sections may show brown to black spots in the endosperm of infected grain [7]. Many of the fungi that cause BP are saprophytic [8] and *Alternaria alternata* (Fr.:Fr.) Keissl. and *Bipolaris sorokiniana* (Sacc.) Shoemaker are generally considered the primary causal agents of the disease [6]. These fungal species commonly occur under humid field conditions, where seed infection is favored by relative humidity above 90 % and seed moisture content exceeding 20 %. Rainfall during seed maturation, combined with several days of high humidity before harvest, promotes the development of BP. Developing green kernels are particularly susceptible to infection and represent the most vulnerable stage [9,10]. The disease not only causes economic losses due to the degradation in the quality of flour and semolina, but also affects seed germination and inhibits seedling growth [11].

In southern Sonora, Mexico, black point is an endemic disease of durum wheat (*Triticum durum* Desf.) and bread wheat (*Triticum aestivum* L.) [12], but it also affects triticale (X *Triticosecale* Wittmack) [8]. This highlights the need to monitor the disease in cereal germplasm under local production conditions. The identification of genetic variation in BP susceptibility is an important step toward developing cereal cultivars with improved grain health. In wheat, artificial inoculation of germplasm may help breeding programs in identifying resistant genotypes to this disease. It has been demonstrated that inoculation by injection and vacuum infiltration of *Alternaria alternata* [13] and by spraying with *Bipolaris sorokiniana* [14] and with several species that cause BP [11], is useful to identify resistant and susceptible germplasm. The objective of this study was to evaluate the reaction of advanced triticale lines to natural BP infection during the 2019-2020 fall-winter crop season in southern Sonora, Mexico. This evaluation was intended to contribute

to the monitoring of BP in triticale and to identify lines exhibiting comparatively low disease incidence under natural field conditions, providing preliminary information for subsequent germplasm selection and resistance research.

2 MATERIALS AND METHODS

Twenty advanced triticale lines were evaluated for their response to natural black point infection during the 2019-2020 crop season at the Norman E. Borlaug Experimental Station of the National Institute for Forestry, Agriculture, and Livestock Research, located in Block 910 of the Yaqui Valley, Sonora, Mexico (27º22´3.01" N and 109º55´40.22" W, 37 m above sea level) in a clay soil with pH of 7.8. Sowing dates were November 15 and 26, 2019, using 8 g of seed per line in a 0.7-m long bed with two rows, without replications. Fertilization consisted of applying urea at a rate of 150 kg ha^{-1} before sowing. One irrigation was provided for seed germination, followed by three complementary irrigations during the growing season. An additional 100 kg ha^{-1} of urea was applied before the first complementary irrigation. Thirty days after sowing, the herbicide Situi® XL (metsulfuron-methyl) was applied at a rate of 25 g ha^{-1} of the commercial product [15]. Harvest was performed manually, and BP incidence was assessed by visually examining ten spikes per line and counting the healthy and infected grains to determine the percentage of infection. Because BP affects developing kernels and can also develop during seed maturation [9,10], daily relative humidity was recorded from March 1 to 31, 2020, using the CIANO-910 weather station. This station is located in Block 910 of the Yaqui Valley and belongs to the automated weather station network of Sonora [16].

3 RESULTS AND DISCUSSION

The range of infection for the first sowing date was 0 to 8.05 % with an average of 1.64 (Figure 2); 11 lines did not have infected grains, 4 lines fell within the 0.1-2.5 % infection category, 2 lines within 2.6-5.0 %, and 3 lines within 5.1-10 %. The range of infection for the second date was 0 to 14.24 % with an average of 2.56 %; 13 lines did not have infected grains, 3 lines fell within the 0.1-2.5 % infection category, 1 line within 5.1-10 %, and 3 lines within 10.1-30 %.

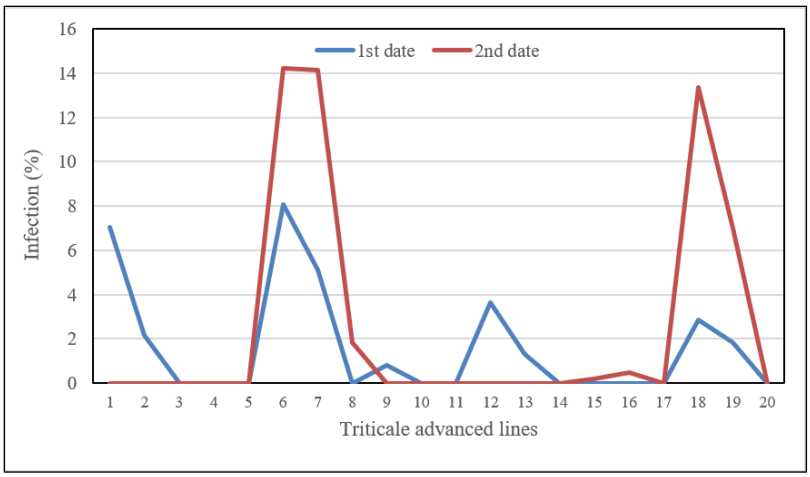

Figure 2: Percentage of infection with black point in two sowing dates, of 20 triticale advanced lines, evaluated under natural infection in the field, during the fall-winter crop season 2019-2020, at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Sonora, Mexico

The only line that showed a contrasting difference in percentage of infection greater than 10 % between the first and second dates was 08L129/9/BICEN/8/GAUR_2/HARE_3//JLO97/CIVET/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/150.83//2*TESMO_1/MUSX 603/7/GAUR_2/HARE_3//JLO 97/CIVET with 10.53 %, while those with a contrasting difference between 5 and 9% were BICENTENARIO TCL2010, SN64/EER/3/ERIZO_15/FAHAD_3//POLLMER_2.1/5/PRESTO//2*TESMO_1/MUSX603/4/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/9/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/, SONNI_3*2//FARAS/CMH84.4414/6/RONDO/BANT_5//ANOAS_2/3/RHINO_3/BULL_1-1/5/DAHBI_6/3/ARDI_1/TOPO1419//ERIZO_9/4/2*ZEBRA79/LYNX*2//FAHAD_1/9/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DIS, and 08L129/8/POPP1_2/TAHARA/4/DAHBI_6/3/ARDI_1/TOPO1419//ERIZO_9/7/CAAL/MANATI_1/5/6TA876/6TB164//PND-T/RHM/3/TESMO_2/4/ 2*ERIZO_12/6/POLLMER_3/FOCA_2-1 with 7.05, 6.19, 9.04, and 5.14 %, respectively.

Lines that showed the highest percentage of infection were: SN64/EER/3/ERIZO_15/FAHAD_3//POLLMER_2.1/5/PRESTO//2*TESMO_1/MUSX603/4/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/9/T1505_WG//ERIZO_10/ BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DIS B5/3/SPHD/PVN

//YOGUI_6/4/KER_3/ (line No. 6) in the second date with 14.24 %, SONNI_3*2//FARAS/CMH84.4414 /6/RONDO/BANT_5//ANOAS_2/3/RHINO_3/BULL_1-1/5/DAHBI_6/3/ARDI_1/TOPO1419//ERIZO_9/4/2* ZEBRA79/LYNX*2//FAHAD_1/9/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/ TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DIS (line No. 7) in the second date with 14.15 %, 08L129/9/BICEN/8/GAUR_2/HARE_3//JLO97/CIVET/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/150.83//2* TESMO_1/ MUSX603/7/GAUR_2/HARE_3//JLO 97/CIVET (line No. 18) also in the second date with 13.37 %, line No. 6 in the first date with 8.05 %, and BICENTENARIO TCL2010 (line No. 1) in the first date with 7.05 %. The average percentage of infection is shown in Figure 3, where lines No. 6, 7, and 18 showed the highest percentage of infection with 11.14, 9.63, and 8.11 %, respectively.

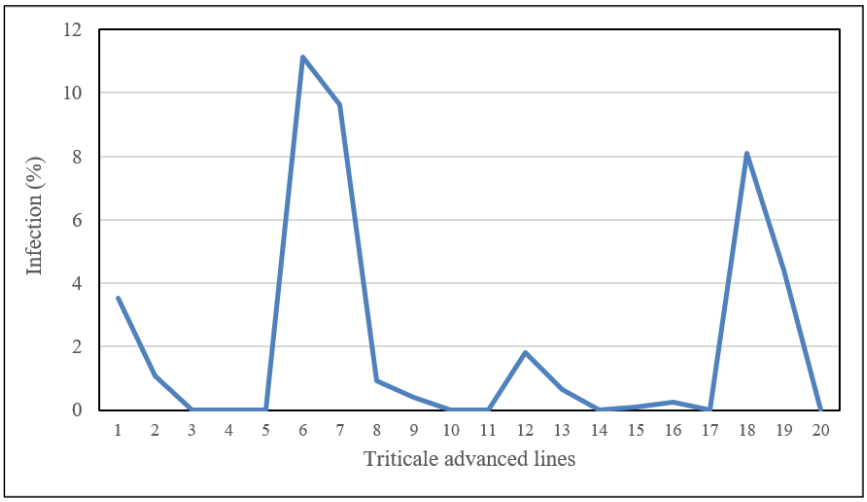

Figure 3: Average percentage of infection with black point in two sowing dates in crop season 2019-2020 of 20 triticale advanced lines, evaluated under natural infection in the field, at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Sonora, Mexico

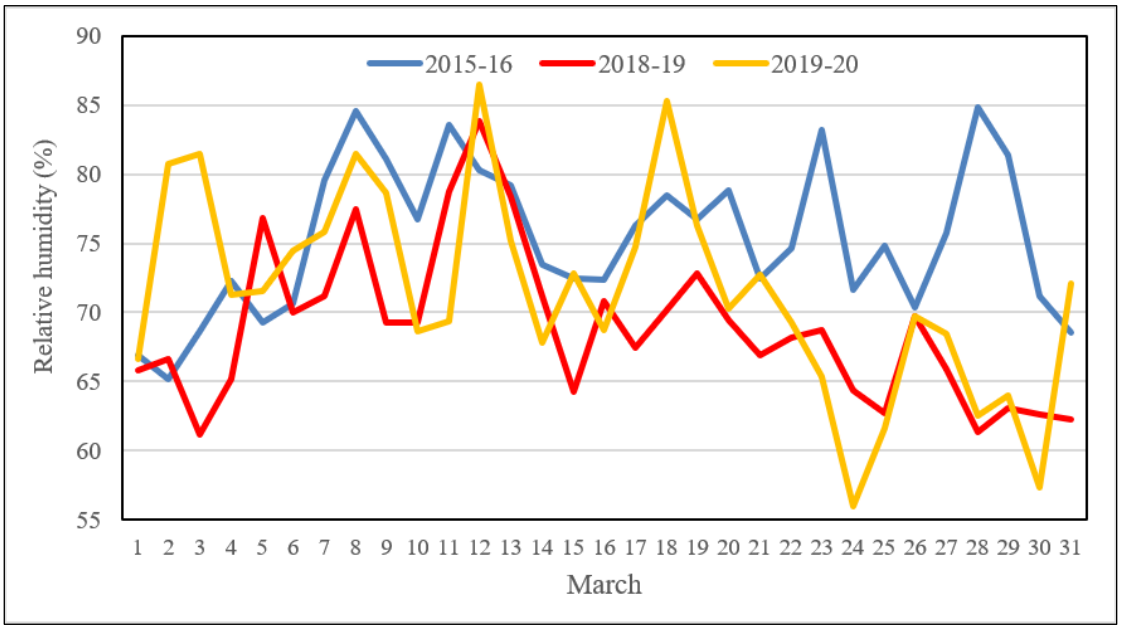

Figure 4: Average relative humidity during March 2020, as compared to March 2016 and 2019, recorded by the weather station CIANO-910, located in Block 910 at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Sonora, Mexico

The daily average relative humidity (RH) for 2019-2020 crop season during March 2020 ranged from 56 to 86.51 % with a mean of 71.51 % (Figure 4), as compared to crop season 2015-2016 where the range of RH was 65.14 to 84.85 % and infection in the first date was 0.31 to 45.59 % and from 0.44 to 42.27 % in the second date [17]. RH in March 2020 had noticeable peaks on March 2, 3, 12, and 18 which surpassed RH in 2016; it was also a little higher on March 5, 6, 15, 21, and 31. However, from March 22 to the 30, RH was much lower than that in 2016, the difference ranging from 0.67 to 22.30 %, which may have accounted for the relatively lower infection in 2020 than in 2016. Except for nine days,

RH was higher in March of 2016 than March 2020 with daily differences ranging from 0.28 to 22.30 % and averaging 7.74 %. It has been also reported that in March 2016, the natural incidence of BP in a group of durum wheat (*Triticum durum* Desf.) cultivars and lines was higher than in March 2017 [18].

Although these findings suggest a strong association between BP development and high humidity, the disease is not exclusively dependent on humid conditions. BP may also occur under hot, dry environments, particularly when wheat maturity is delayed [19], or when plants are subjected to stress factors, such as premature seed senescence and other environmental stresses [20]. Previous studies [9,10] have also demonstrated that rainfall during seed maturation and humid conditions in the days immediately preceding harvest can promote BP development. Within the infection categories of the group based on the average of the two dates, 8 lines did not show any infected grains (Table 1), 7 lines fell within the 0.1-2.5 % infection category, 2 lines within 2.6-5.0 %, 2 lines within 5.1-10.0 %, and 1 line within 10.1-30.0 % (Figure 5). The overall average of the group was 2.10 % with a range of 0 to 11.14 %.

The incidence of BP in wheat-growing areas of southern Sonora during the fall-winter season varies among bread wheat [21], durum wheat, and triticale [12]. This variation may be explained by differences in seasonal weather patterns, as well as by distinct climatic conditions prevailing across the region [22,23]. In addition, the abundance and persistence of primary inoculum may play an important role in disease occurrence. These factors are influenced by environmental conditions and the ability of several fungal pathogens, including *Alternaria triticina* Pras. & Prab., *Helminthosporium sativum* Pamm., King & Bakke, and *Fusarium* spp. to survive as saprophytes on infected plant residues, which serve as potential sources of inoculum for subsequent growing seasons [8].

Table 1: Triticale advanced lines that did not show any infected grains with black point during crop season 2019-2020, evaluated in two sowing dates under natural conditions at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Sonora, Mexico

No.	Pedigree	Selection history
1	TURACO/CENT.SARDEV/7/LIRON_2/5/DISB5/3/SPHD/PVN //YOGUI_6/4/KER_3/6/BULL_10/MANATI_1/8/LIRON_2/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/ MANATI_1/9/BICEN	CTSS08Y00035S-099Y-026M-19Y-099M-2Y-2BMX-4Y-0B
2	FAHAD_8-2*2//PTR/PND-T/3/GAUR_3/ANOAS_2//BANT_1 /4/HARE_7265/YOGUI_1//BULL_2/5/POPP1_1/6/BULL_10/MANATI_1*2//FARAS/CMH84.4414/7/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO 1419//ERIZO_9/3/SUSI_2/6/DAHBI/COATI_1//ONA_1/ ERIZO_	CTSS13Y00040S-14Y-2M-4Y-3M-1Y-0B
3	BW32-1/CENT.SARDEV/7/LIRON_2/5/DISB5/3/SPHD/PVN //YOGUI_6/4/KER_3/6/BULL_10/MANATI_1/8/MERINO/JLO/ /REH/3/HARE_267/4/ARDI_4/5/PTR/CSTO//BGLT/3/RHINO _4-1/4/HARE_7265/YOGUI_3/6/BULL_10/MANATI_1/9/ POLLMER_2.2.1*2//FARAS/CMH84.4414/6/BICEN/5/DAHBI_ 6/3/ARD	CTSS13Y00049S-56Y-1M-2Y-3M-1Y-0B
4	08P166/9/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/ BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/ SUSI_2/8/LIRON_2/5/DISB5/3/SPHD/PVN//YOGUI_6/4/ KER_3/6/BULL_10/MANATI_1/7/83TR1-11/3/150.83 //2*TESMO_1/MUSX 603/4/150.83//2*TESMO_1/MUSX 603	CTSS13Y00100S-24Y-2M-1Y-3M-1Y-0B
5	09P141-INT11/BICEN	CTSS13Y00102S-6Y-2M-2Y-2M-1Y-0B
6	08L129/9/BICEN/8/GAUR_2/HARE_3//JLO97/CIVET/5/ DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/150.83// 2*TESMO_1/MUSX603/7/GAUR_2/HARE_3//JLO97/ CIVET	CTSS14Y00004S-14Y-1M-4Y-2M-0B
7	08L129/4/CAAL/3/T1494_WG//ERIZO_10/2*BULL_1-1	CTSS14Y00022S-8Y-1M-3Y-1M-0B
8	08L132/8/LIRON_2/5/DISB5/3/SPHD/PVN//YOGUI_6/4/ KER_3/6/BULL_10/MANATI_1/7/DAHBI_6/3/ARDI_1/TOPO 1419//ERIZO_9 2*TESMO_1/MUSX 603	CTSS14Y00043S-70Y-1M-2Y-2M-0B

The incidence of BP infection can reach considerable high levels in certain crop seasons. For example, during the 2009-2010 season, the durum wheat line SOMAT_4/INTER_8/4/GODRIN/GUTROS//DUKEM/3/THKNEE_11/5/CNDO/PRIMADUR//HAI-OU_17/3/SNITAN exhibited a BP infection rate of 50.6 % under natural field conditions [21]. During the same season, three bread wheat lines, BABAX/LR42//BABAX/3/ER2000, BABAX/LR42//BABAX*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ, and TC870344/GUI//TEMPORALERAM87/AGR/3/2* WBLL1 showed infection rates of 30.8, 27.3, and 20.5 %, respectively. Similarly, during the 2013-2014 season, the bread wheat lines SOKOLL*2/3/BABAX/LR42//BABAX and KISKADEE#1/CHYAK each exhibited a BP incidence of 31.4 % [24]. In the same season, two triticale lines T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/6/DAHBI/COATI_1//ONA_1/ERIZO_12/4/ERIZO_10/BULL_1-1//MANATI_1/3/SUSI_2 and WIR46058/GNU_1//ERIZO_11/3/SVHT02/STIER_3/4/WIR46058/GNU_1//ERIZO_11/5/NESSER/6/CAGUAN_4-1/FAHAD_5/7/NIMIR_3/ERIZO_12/5/GC.3/733.EB//MPE/3/LAMB_3/4/BUF_2/6/POLLMER_2/8/BAT*2/BCN//CAAL/3/ERIZO_7/BAGAL_2//FARAS_1 recorded infection levels of 34.55 and 48.03 % on the first and second evaluation, respectively [25].

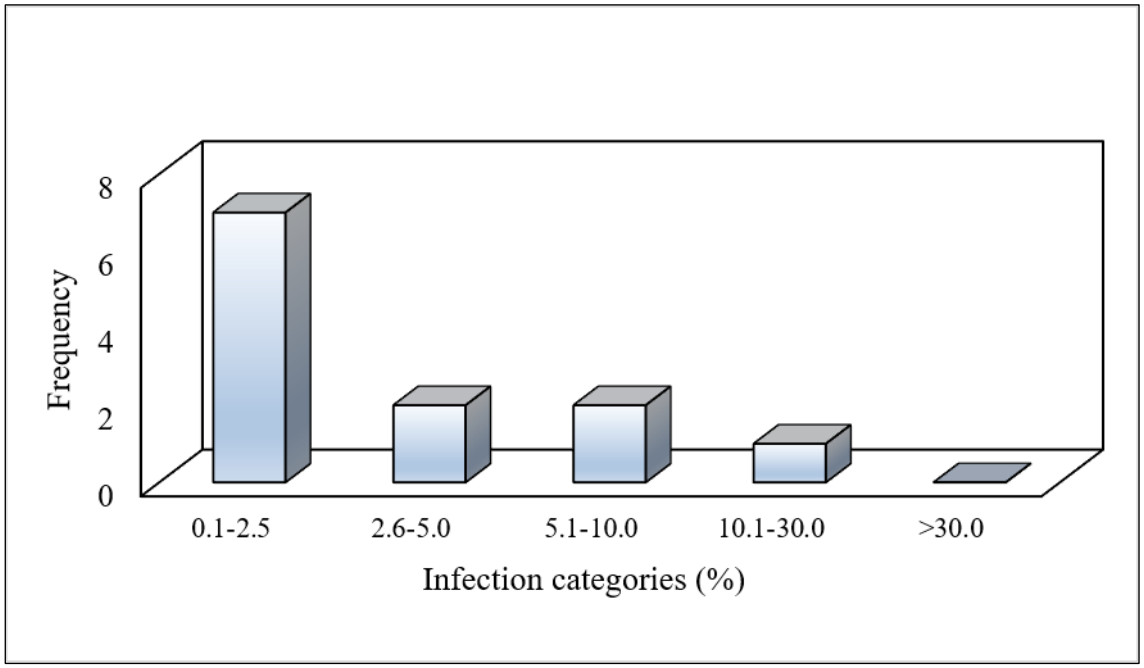

Figure 5: Infection categories (%) with black point in two sowing dates in crop season 2019-2020 of 20 triticale advanced lines, evaluated under natural infection in the field, at the Norman E. Borlaug Experimental Station in the Yaqui Valley, Sonora, Mexico

During the 2015-2016 crop season, triticale line PRESTO//2*TESMO_1/MUSX603/4/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/5/AR/SNP6//TARASCA87_2/C,S10/3/PORSAS_4-1/4/CHACAL_3-2/6/BAT*2/BCN//CAAL/3/ERIZO_7/BAGAL_2//FARAS_1 recorded 45.59 % in the first date, and TURACO/CENT.SARDEV/7/LIRON_2/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/MANATI_1/8/LIRON_2/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/BULL_10/MANATI_1/9/BICEN 42.27 % in the second date [17]; and in 2018-2019, triticale line 804/BAT/3/MUSX/LYNX//STIER_12-3/4/VARSA_3-1/5/FAHAD_8-1*2//HARE_263/CIVET/9/BICEN/8/SUSI_2/5/TAPIR/YOGUI_1//2*MUSX/3/ERIZO_7/4/FARAS_1/6/VARSA_2/7/754.3/IBEX//BUF_2/10/T1505_WG//ERIZO_10/BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO showed 44.73 % in the first date.

Similar to its effects in wheat, severe BP infection in triticale can negatively affect grain quality and reduce the commercial value of grain and its derived products. Moreover, infection may adversely affect seed germination and seedling vigor, thereby diminishing seed quality and potentially compromising crop establishment. In addition to the deployment of resistant cultivars [26], BP incidence may be reduced through appropriate agronomic practices, including decreasing irrigation frequency after heading and lowering nitrogen application rates, without adversely affecting grain yield or quality. Therefore, the systematic evaluation of experimental triticale germplasm for its response to BP infection is essential to identify tolerant or highly resistant genotypes that could be considered for future commercial release.

4 CONCLUSION

In the 2019-2020 crop season, black point infection categories recorded on two evaluation dates among 20 advanced triticale lines showed that eight lines did not have any infected grains, seven lines had infection levels ranging from 0.1 to 2.5 %, two lines from 2.6 to 5.0 %, two lines from 5.1 to 10.0 %, and one line from 10.1 to 30.0 %. Overall, the mean BP infection across the 20 lines was 2.10 %, with individual lines ranging from 0 to 11.14 %.

Lines that showed the highest percentage of infection were: SN64/EER/3/ERIZO_15/FAHAD_3//POLLMER_2.1 /5/PRESTO//2*TESMO_1/MUSX603/4/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/9/T1505_WG//ERIZO_10/ BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DISB5/3/SPHD/ PVN//YOGUI_6/4/KER_3/, SONNI_3*2//FARAS/CMH84.4414/6/RONDO/BANT_5//ANOAS_2/3/RHINO_3/BULL_1-1/5/DAHBI_6/3/ARDI_1/TOPO1419//ERIZO_9/4/2*ZEBRA79/LYNX*2//FAHAD_1/9/T1505_WG//ERIZO_10/ BULL_1-1/3/ERIZO_10/BULL_1-1/4/COPI_1/5/ARDI_1/TOPO1419//ERIZO_9/3/SUSI_2/8/LIRON_2/5/DIS, and 08L129/9/BICEN/8/GAUR_2/HARE_3//JLO97/CIVET/5/DISB5/3/SPHD/PVN//YOGUI_6/4/KER_3/6/150.83//2* TESMO_1/MUSX 603/7/GAUR_2/HARE_3//JLO 97/CIVET with 14.24, 14.15, and 13.37 %, respectively, on the second date.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

Authors express their gratitude to the Mexican National Institute for Forestry, Agriculture, and Livestock Research (INIFAP).

Funding Source

This research was financially supported by the Mexican National Institute for Forestry, Agriculture, and Livestock Research (INIFAP).

Disclosure of conflict of interest

The authors declare that No conflict of interest.

REFERENCES

[1] Müntzing A. 1974. Historical review of the development of triticale. pp.13-30. In: Triticale: proceedings of an international symposium (Eds. R. Macintyre and M. Campbell). El Batan, Mexico. October 1-3, 1973. Int. Develop. Res. Centre Monogr. IDRC-024e. 238 p.

[2] Zhu F. 2018. Triticale: Nutritional composition and food uses. Food Chemistry 241:468–479. https://doi.org/10.1016/j.foodchem.2017.09.009

[3] Rodríguez-Perez G, Cervantes-Ortiz JF, Gámez-Vázquez AJ, Reynaga-Franco FJ, Torres-Velázquez JR, and Ávila-Perches MÁ. 2023. Nutritional value in grains of triticale as an alternative in the food industry. Revista Mexicana de Ciencias Agrícolas 14(3):351-362. https://doi.org/10.29312/remexca.v14i3.2870

[4] FAOSTAT (Food and Agriculture Organization Corporate Statistical Database). 2024. Crops and livestock products. https://www.fao.org/faostat/en/#data/QCL. Accessed on September 25, 2026

[5] Tang H, Tan Z, Wang X, Yang L, Chen G, Yu H, Pu Z, Jiang Q, Li M, Cheng M, Qi P, Li W, Liu Y, Wang J. 2022. Genome-wide association study of kernel black point resistance in Chinese wheat landraces. Plant Disease 106(5):1428-1433. doi: 10.1094/PDIS-09-21-1898-RE.

[6] Mathur SB, and Cunfer BM. 1993. Seed-borne Diseases and Seed Health Testing of Wheat. Danish Government Institute of Seed Pathology for Developing Countries. Hellerup, Denmark. 168 p.

[7] Patel DJ, and Minipara DB. 2015. Symptomatology of black point infected wheat (Triticum aestivum L.) seeds. International Journal of Agriculture Sciences 7(6):533-535. Available at: https://www.researchgate.net/profile/Dipal-Minipara/publication/324675073_SYMPTOMATOLOGY_OF_BLACK_POINT_INFECTED_WHEAT_Triticum_aestivum_L_SEEDS/links/5adacdb40f7e9b28593e67f4/SYMPTOMATOLOGY-OF-BLACK-POINT-INFECTED-WHEAT-Triticum-aestivum-L-SEEDS.pdf.

[8] Wiese MV. 1987. Compendium of Wheat Diseases. APS Press. The American Phytopathological Society. St. Paul, MN, USA. 112 p.

[9] Watkins JE. 2013. Black point disease of wheat. University of Nebraska-Lincoln. http://baylor.agrilife.org/files/2011/06/blackpointnebguide_2.pdf. Accessed on March 23, 2014.

[10] Duveiller E, Singh PK, Mezzalama M, Singh RP, Dababat A, 2012. Wheat Diseases and Pests: A Guide for Field Identification (2nd. Edition). CIMMYT. Mexico, D.F., Mexico. 138 p. available at: https://www.researchgate.net/profile/Abdelfattah-Dababat/publication/259592502_Wheat_Diseases_and_Pests_A_Guide_for_Field_Identification_2nd_Edition/links/02e7e52cd62a0b2d83000000/Wheat-Diseases-and-Pests-A-Guide-for-Field-Identification-2nd-Edition.pdf.

[11] Kai-Ge X, Yu-Mei J, Yang-Kun L, Qiao-Qiao X, Ji-Shan N, Xin-Xin Z, and Qiao-Yun L. 2018. Identification and pathogenicity of fungal pathogens causing black point in wheat on the north China plain. Indian Journal of Microbiology 58(2):159-164. Doi:10.1007/s12088-018-0709-1.

[12] Fuentes Dávila G, Ammar K, Figueroa López P, Camacho Casas MA, Félix Valencia P, Cortés Jiménez JM, Félix Fuentes JL, Chávez Villalba G, and Ortiz Ávalos AA. 2014. Reaction to black point by triticale advanced lines during the agricultural crop season 2011-2012. pp. 345-350. Proceedings of the XVII International Congress of Agricultural Sciences. October 9 and 10, 2014. Mexicali, Baja California, México. 622 p. ISBN: 978-0-9908236-1-290000>9780990823612.

[13] Conner RL, and Thomas JB. 1985. Genetic variation and screening techniques for resistance to black point in soft white spring wheat. Canadian Journal of Plant Pathology 7:402-407. https://doi.org/10.1080/07060668509501669.

[14] Gao C, Song G, Qu K, Li M, Jiang Y, Yin G, Niu J, Tang J, Gao Y, Li Q. 2023. Quantitative trait loci for resistance to black point caused by Bipolaris sorokiniana in bread wheat. Molecular Breeding 43(2):10. doi: 10.1007/s11032-023-01356-6.

[15] FMC. 2022. Situi XP, agricultural herbicide. Data sheet. https://fmcagroquimica.com.mx/wp-content/uploads/2021/08/FT-Situi-181220.pdf.

[16] REMAS (Network of Automatic Meteorological Stations of Sonora). 2022. Download data. http://www.siafeson.com/remas/. Accessed on July 24, 2022.

[17] Fuentes-Dávila G, Ammar K, Rosas-Jáuregui IA, Félix-Valencia P, and Torres-Cruz MM. 2026. Natural infection by black point in advanced triticale lines across thre crop seasons. World Journal of Advanced Research and Reviews 32(01):1013-1022. https://doi.org/ 10.30574/wjarr.2026.32.1.2640.

[18] Fuentes-Dávila G, Rosas-Jáuregui IA, Ayón-Ibarra CA, Félix-Valencia P, and Torres-Cruz MM. 2024. Performance of durum wheat cultivars and advanced lines to black point under natural conditions in two crop seasons. Open Access Research Journal of Science and Technology 12(01):052-059. https://doi.org/10.53022/oarjst.2024.12.1.0113.

[19] CPN (Crop Protection Network). 2019. Black Point of wheat. Available at: https://cropprotectionnetwork.org/encyclopedia/black-point-of-wheat.

[20] UC-IPM (University of California, Agriculture and Natural Resources – Statewide Integrated Pest Management Program). 2019. Agriculture: small grains pest management guidelines. Black Point of wheat. Available at: https://ipm.ucanr.edu/agriculture/small-grains/black-point-of-wheat/?utm#gsc.tab=0.

[21] Fuentes-Dávila G, Figueroa-López P, Cortés-Jiménez JM, Félix-Valencia P, Camacho-Casas MA, Félix-Fuentes JL, Chávez-Villalba G, and Ortiz-Ávalos AA. 2013. Reaction of selected cultivars and lines of durum and bread wheat to black point. Annual Wheat Newsletter 59:48-52. Available at: https://wheat.pw.usda.gov/ggpages/awn/59/TEXTFILES/MEXICO.pdf.

[22] Torres-Cruz MM, Castro-Quiroa LA, Fuentes-Dávila G, and Félix-Valencia P. 2021a. Determination of climatic zones of influence in the Yaqui and Mayo Valleys, Mexico. International Journal of Agriculture, Environment and Bioresearch 6:44-56. https://doi.org/10.35410/IJAEB.2021.5650.

[23] Torres-Cruz MM, Fuentes-Dávila G, and Félix-Valencia P. 2021b. Prevailing temperatures, cold and heat units in the Yaqui and Mayo Valleys, Mexico, during the 2019-2020 wheat season. International Journal of Agriculture, Environment and Bioresearch 6:1-6. https://doi.org/10.35410/IJAEB.2021.5647.

[24] Fuentes-Dávila G, Ayón-Ibarra CA, Félix-Valencia P, Figueroa-López P, Camacho-Casas MA, Félix-Fuentes JL, Chávez-Villalba G, and Rosas-Jáuregui IA. 2016. Reaction of advanced bread wheat lines to black point (Alternaria spp.) during the crop season 2013-2014. pp. 817-823. Proceedings of the XIX International Congress of Agricultural Sciences. Mexicali, Baja California, México. October 27 and 28, 2016. 980 p.

[25] Fuentes-Dávila G, Ammar K, Félix-Valencia P, Ayón-Ibarra CA, Figueroa-López P, Camacho-Casas MA, Félix-Fuentes JL, Chávez-Villalba G, and Castillo-Torres N. 2016. Reaction of triticale lines to black point (Alternaria spp.) under natural infection during the 2013–14 season. XVIII International Congress and XLIII National Congress of the Mexican Phytopathological Society. Western University, Mazatlan Campus. July 3-7, 2016. Mazatlan, Sinaloa, Mexico. Resumen 173, S104.

[26] Davis RM, and Jackson LF. 2007 Black point of wheat. Agriculture: Small grains pest management guidelines. University of California, Agriculture and Natural Resources. https://www2.ipm.ucanr.edu/agriculture/small-grains/black-point-of-wheat/#COMMENTS. Accessed on March 5, 2022.