Article

Response of oat genotypes to infection by *Bipolaris victoriae* and *Bipolaris sorokiniana*

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Abstract

The cultivation of oats (*Avena sativa* L.) is affected by a wide range of foliar diseases caused by pathogenic fungi, among these the most important are those induced by *Bipolaris* spp., which cause severe leaf blights, mainly in the area of High Valleys of Mexico. The objective of this study was to molecularly identify the two isolates associated with leaf blight in oats and determine the response of 30 commercial varieties of oats from the National Collection to infection by *B. victoriae* and *B. sorokiniana* under greenhouse conditions. An isolate of *B. victoriae* and an isolate of *B. sorokiniana* were increased to inoculate plants of 30 varieties of oats by spraying a suspension of spores onto the foliage. The experimental design used was in random blocks for each of the isolates, 30 treatments were evaluated, which consisted of the analyzed varieties, each treatment consisted of 20 plants with four repetitions. Leaf damage was measured as a response variable to determine the severity of the disease. It was observed that the varieties AB-177, Cuauhtémoc, Gema, Texas, Nodaway and Pampas behaved as the most susceptible to *B. sorokiniana*, while, the Teporaca and Nuda varieties showed to be moderately resistant to this pathogen. For the case of *B. victoriae*, it was observed that Juchitepec and Ópalo varieties were resistant, meanwhile, Gema, Bachiniva and Cevamex varieties behaved as the most susceptible to infection.

Keywords: *Avena sativa*, brands, resistance, severity.

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Introduction

Oats (*Avena sativa* L.) is the seventh most harvested grain in the world with 25 million tons in grain, positioning Russia (4 million tons), Canada (2.7 million tons), United States of America (2.5 million tons), Poland (1.5 million tons), Australia (1.3 million tons) and Finland (1.1 million tons) as the main producing countries, (FAO, 2014, USDA, 2017, Consejo Internacional de Cereales, 2018).

In Mexico, the production of oats has grown over the past 20 years from approximately 500 000 hectares to one million hectares, planted 80% under seasonal conditions and 85% for forage production. Of the total area sown in 2015 for irrigation and seasonal, about 765 thousand hectares (grain and fodder). The states of Chihuahua, Coahuila, Durango and Zacatecas contributed most of the area sown with yields above 20 t ha^{-1} for forage oats and 2 t ha^{-1} for grain oats (SIAP, 2016).

Likewise, close to 80% of the national production of oats is destined mainly for the livestock sector, either for consumption as green or hay forage, in grain and in the production of balanced feed, while the rest of the production is uses for various sectors among them the food (Villaseñor-Mir *et al*., 2009).

The increase of the sowing area is due to the fact that in Mexico it is considered as an alternative crop in the High Valleys and in the semi-arid region of the North Center, particularly when the beginning of the rainy season is delayed or low temperatures occur which put at risk the planting of traditional crops of corn and beans (Villaseñor-Mir *et al*., 2003).

In Mexico, oats are the most used species for the productive reconversion of low productivity lands where the growth season is short, and climate change requires the extensive planting of rustic species, low water demand and a reduced biological cycle. Likewise, it is necessary to have varieties suitable for the production of forage and grain with agronomic benefits that are resistant or tolerant to the occurrence of early frosts and intermittent water deficits and phytopathological that minimize the negative effect of diseases such as stem rust (*Puccinia graminis* f. sp. *avenae*), crown rust (*Puccinia coronata* f. sp. *avenae*) and the foliar blight complex caused by *Bipolaris* spp.

However, there are reports of a wide variety of fungal species causing foliar diseases such as *Colletotrichum graminicola*, *Curvularia hawaiiensis*, *Drechslera avenacea*, *Passalora graminis*, *Bipolaris victoriae* and *Bipolaris sorokiniana* (Villaseñor-Mir *et al*., 2003; García-León *et al*., 2013; 2015). Among the most important pathogens in the producing areas of Mexico, *Bipolaris* spp. causal agent of leaf blights, due to the wide incidence and distribution of these pathogens in the High Valleys of Mexico (García-León *et al*., 2013).

It has been found that the complex of *Bipolaris* spp. it is more common rainy environments (>700 mm) of the upper parts of the High Valleys of Mexico, and is less frequent in medium rainy environments (500-600 mm), since these diseases require cool temperatures and high relative humidity (Villaseñor-Mir *et al*., 1998). Technological advances, mainly in the use of fungicides have not contributed to the control of these diseases. However, the use of tolerant or resistant

varieties to this foliar pathogen complex is the most appropriate control method from the environmental and ecological point of view (Leyva-Mir *et al*., 2014). Therefore, the objective of this study was to determine the response of 30 commercial varieties of oats to infection by *B. victoriae* and *B. sorokiniana* under greenhouse conditions.

Materials and methods

Study site

The experiment was carried out in the national laboratory of rusts and other wheat diseases located in the Valleys of Mexico Experimental Field (LANAREC-CEVAMEX), belonging to the National Institute of Forestry, Agriculture and Livestock Research (INIFAP).

DNA extraction, PCR and sequencing

It was taken from 50 to 100 g of pure mycelial growth of 8 days in PDA culture medium, which was macerated with liquid nitrogen. The macerate was placed in a 1.5 mL micro centrifuge tube and 500 µL of extraction buffer (0.1 M Tris pH 8, 10 mM EDTA, 2% SDS, 0.2 mg mL^{-1} K protein) was added. This was maintained for 10 min at 38 °C in 'bain-marie'. After this period, 30 µL of 10% CTAB and 70 µL of 5 M NaCl were placed, then kept at 65 °C for 10 min, 100 µL of 5 M potassium acetate was added and incubated on ice for 5 min, then 700 µL of chloroform-isoamyl alcohol (24:1) was added and centrifuged at 13 000 x g for 10 min.

The supernatant was transferred to a new 1.5 mL micro centrifuge tube and 640 µL of cold isopropanol and 60 µL of 3 M sodium acetate pH 5.8 were added, this was mixed by inversion three times in a gentle manner and incubated for 5 min. at -20 °C. After centrifugation at 13 000 x g for 10 min, the supernatant was discarded; 500 µL of 70% ethanol were added and centrifuged at 13 000 x g for 5 min. The supernatant was removed, and the pellet allowed to dry and then resuspended in 100 µL of sterile distilled water free of DNase. The DNA obtained was verified by electrophoresis in 1% agarose using TAE 1X as run buffer at 90 volts. The results were observed in a Gel-Doc mod 2000 transilluminator (Biorad®).

The PCR was carried out in a Biorad® thermocycler with a reaction mixture composed of PCR 1X buffer, 2.5 mM $MgCl_2$, 0.2 0.4 mM dNTP, µM of each primer, 1U of Taq DNA polymerase (Promega®) and 100 ng of DNA, completing a final volume of 25 µL with nuclease-free water. The PCR protocol for ITS primers 5 and 4 consisted of initial denaturation of 95 °C for 3 min, 35 cycles of 95-55-72 °C for 30-30-60 s respectively, final extension of 72 °C for 10 minutes.

The amplified PCR products were verified by electrophoresis at 90 volts on a 1% agarose gel with TAE 1X run buffer. The gel was observed and analyzed with the Gel-Doc mod 2000 transilluminator (Biorad®).

To obtain DNA sequencing it was necessary to purify the fragments amplified by ITS initiators 4 and 5, using the DNA clean and concentratoTM-5 protocol. In a 1.5 mL micro centrifuge tube, the PCR product was placed and 5 volumes of DNA Binding buffer were added and mixed by inversion. The mixture was transferred to a Zymo-Sping column in a 2 mL collection tube and centrifuged for 30 s at 8 000 rpm, discarding the supernatant.

To the result, 200 µL of DNA Wash buffer was added to the column and centrifuged at 8000 rpm for 30 s and the supernatant was discarded, this step was repeated. After adding 60 µL of DNA Elution buffer directly on the column and incubated for 1 min, the column was transferred to a new 1.5 mL tube for micro centrifugation, to dilute the DNA it was centrifuged for 30 s (Zymo Research). The purified DNA was sent to be sequenced to the company Macrogen® in Korea, and then compared with the database of the National Center for Biotechnology Information (NCBI) in the Basic Local Alignment Search Tool (Blast https: //blast.ncbi. nlm.nih.gov/ Blast.cgi).

Inoculum

In this study isolates of *Bipolaris victoriae* (access number of GenBank EF452448) and *Bipolaris sorokiniana* (GenBank EF452447) were used. To favor the production of conidia, the isolates were increased in Petri dishes with V8 culture medium at 25 °C and their morphological characteristics were corroborated by means of semi-permanent assemblies.

The morphological characteristics of the conidia of *B. victoriae* correspond to conidia of light brown color, thin, slightly curved, rounded and narrow towards the ends, with 4-11 septa, although generally of 8 and measuring 40-120 x 12-19 µm. The conidiophores are solitary or in groups, straight, light brown, up to 250 µm long and 6-10 µm thick.

The morphological characteristics of the conidia of *B. sorokiniana* correspond to conidia of black oval color and bright aspect slightly curved and thinned towards its tip, with 5-9 septa, the conidiophores are solitary or in groups, straight, unbranched approximately 40-120 µm long X 18-28 µm wide. The previous morphological description coincides with that mentioned by Leyva and Romero (1982).

Varieties evaluated

The varieties evaluated in this study were: AB-177, Babicora, Bachiniva, Cevamex, Chihuahua, Cuauhtémoc, Cusihuiriachi, Diamante R-31, Gema, Guelatao, Huamantla, Juchitepec, Karma, Menonita, Nodaway, Nuda, Obsidiana, Ópalo, Pampas, Papigochi, Paramo, Perla, Putnam-61, Rarámuri, Saia (belonging to the species *Avena strigosa*), Tarahumara, Teporaca, Texas, Tulancingo and Turquesa, which belong to the National Collection of oat varieties of the National Institute of Forest Research, Agricultural and Livestock (INIFAP), these varieties were selected based on various parameters and characteristics of yield, production cycle, purpose (grain or forage) and frequency of planting in the oat producing regions of Mexico.

Inoculation of oat varieties with *B. victoriae* and *B. sorokiniana*

Once the fungal isolates were increased, the plants of the 30 varieties of oats were inoculated. For this, a suspension of conidia was prepared at a concentration of 1 x 10^6 spores mL^{-1}, added with Tween 20 (Sigma®, USA) of each of the isolates. Subsequently, with the conidia suspensions of the isolates, they were sprinkled on the leaves of 30-day-old oat plants with a manual atomizer. The plants were kept in an incubation chamber with controlled environment for 72 h at a relative humidity >95% for which an ultrasonic humidifier HU-820A (Samsung

Electronic, Korea) and an average temperature of 19 to 21 °C for 48 h were used. Then they moved to the greenhouse where they remained until symptoms appeared at a temperature that ranged from 21 to 30 °C for 10 days.

The inoculated plants were distributed in a randomized block design for each of the isolates, 30 treatments were obtained for each isolation that consisted of the varieties to be evaluated, each treatment consisted of 20 plants with four repetitions, which gave a total of 80 plants for each treatment. The response variable to evaluate was the severity of the disease in each variety, which was determined as the percentage of the surface of the leaf that presented symptoms 10 days after the inoculation. The scale of 8 levels of severity proposed by Mehta (2014) was used.

The severity evaluation experiment was carried out twice under greenhouse conditions. The data obtained from the response of the treatments was determined by means of an analysis of variance and the comparison of means was carried out using the Tukey test ($p< 0.05$) with the SAS® Version 9.1 program.

Results and discussion

In this study isolates molecularly identified and deposited in the GenBank were used as *Bipolaris victoriae* (access number EF452448) and *Bipolaris sorokiniana* (GenBank EF452447). These isolates are deposited in the Phytopathogenic Fungi Collection of the Department of Agricultural Parasitology of the Autonomous University Chapingo.

Severity of *B. victoriae* and *B. sorokiniana*

The severity evaluations were initiated at ten days when symptoms of blinding of the leaf area were observed in addition to generalized chlorosis and apical albinism.

The treatments presented significant differences in the effect of the treatments ($p= 0.0001$) (Table 1), where the varieties with greater susceptibility to *B. sorokiniana* were AB-177, Cuauhtémoc, Gema, Texas, Nodaway and Pampa, while the varieties in which the lowest percentage of severity was observed were Nuda and Teporaca (Figure 1).

Table 1. Comparison of disease severity caused by *Bipolaris victoriae* and *B. sorokiniana* in commercial varieties of oats in Mexico.

Variety	Severity *B. victoriae*	Response to *B. victoriae*	Severity *B. sorokiniana*	Response to *B. sorokiniana*
AB-177	25 ABC*	MS	80.7 A	AS
Babicora	22.5 ABC	MS	50 DEFGHIJ	S
Bachiniva	32.5 AB	S	34.1 GHIJK	MS
Cevamex	30 AB	S	59.1 ABCDEFG	S
Chihuahua	22.5 ABC	MS	59.2 ABCDEFG	S
Cuauhtémoc	25 ABC	MS	78.8 AB	AS
Cusihuiriachi	17.5 BC	MR	57.1 ABCDEFG	S
Diamante R-31	17.5 BC	MR	59.7 ABCDEF	S

Variety	Severity *B. victoriae*	Response to *B. victoriae*	Severity *B. sorokiniana*	Response to *B. sorokiniana*
Gema	37.5 A	S	70.4 ABCD	AS
Guelatao	15 BC	MR	51.2 DEFGHIJ	S
Huamantla	17.5 BC	MR	30.5 HIJK	MS
Juchitepec	10 C	R	47.5 DEFGHIJK	S
Karma	25 ABC	MS	47.4 DEFGHIJK	S
Menonita	17.5 BC	MR	35.8 FGHIJK	MS
Nodaway	15 BC	MR	76.8 ABC	AS
Nuda	15 BC	MR	27.9 JK	MR
Obsidiana	25 ABC	MS	56.3 ABCDEFG	S
Ópalo	10 C	R	39.8 EFGHIJK	MS
Pampas	17.5 BC	MR	72.6 ABCD	AS
Paramo	17.5 BC	MR	62.2 ABCDE	AS
Papigochi	25 ABC	MS	59.3 ABCDEFG	S
Putnam-61	22.5 ABC	MS	57.1 ABCDEFG	S
Perla	27.5 ABC	MS	54 BCDEFGHI	S
Raramuri	30 AB	S	66.4 ABCD	AS
Saia	15 BC	MR	30.1 IJK	MS
Tarahumara	30 AB	S	53.3 CDEFGHI	S
Teporaca	25 ABC	MS	22.7 K	MR
Texas	27.5 ABC	MS	71.5 ABCD	AS
Tulancingo	20 ABC	MR	61.1 ABCDE	AS
Turquesa	15 BC	MR	55.5 ABCDEFGH	S

*= means within each column followed by the same letter do not differ in the Tukey test at 5% probability.

For the case of *B. victoriae*, the most susceptible varieties were Gema, Bachiniva and Cevamex, meanwhile, the Juchitepec and Opalo varieties showed resistance to this phytopathogenic fungus (Figure 2). It should be noted that the ranges of severity caused by each *Bipolaris* species showed great differences, so the categories (resistant, moderately resistant, moderately susceptible and susceptible) were defined based on the minimum and maximum severity for each pathogen.

Bipolaris victoriae

R= resistant (0-10% severity); MR= moderately resistant (10.1-20% severity); MS= moderately susceptible (20.1-30% severity); S= susceptible (> 30% severity).

Bipolaris sorokiniana

R= resistant (0-15% severity); MR= moderately resistant (15.1-30% severity); MS= moderately susceptible (30.1-45% severity); S= susceptible (45.1-60% severity): AS= highly susceptible (>60% severity).

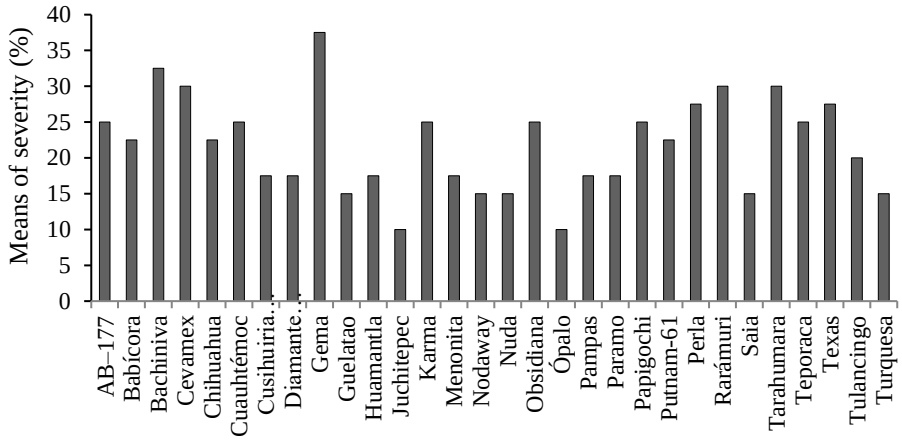

Figure 1. Graphic response of the severity (%) caused by *B. victoriae* in 30 varieties of oats.

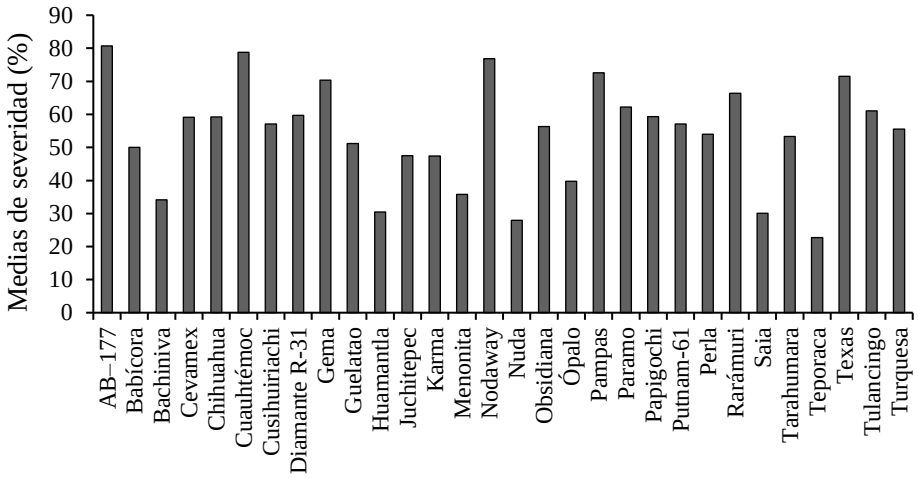

Figure 2. Graphical response of the severity (%) caused by *B. sorokiniana* in 30 varieties of oats.

In the study it was observed that the Cuauhtemoc and Chihuahua varieties were moderately susceptible to *B. victoriae* and susceptible to *B. sorokiniana*. This is confirmed by the results obtained by García-León *et al*. (2013), who report high incidence of both fungal species in oat fields cultivated with these varieties in the State of Mexico, Tlaxcala and Hidalgo.

Also, Leyva-Mir *et al.* (2013), when sampling from seed, they frequently isolated *B. sorokiniana* and *B. victoriae*.

With regard to the Ópalo variety, the data indicated that it was resistant to *B. victoriae* infection and moderately susceptible to *B. sorokiniana* under greenhouse conditions. Villaseñor-Mir *et al*. (2009), obtained the same results and reported that this variety is moderately resistant to the complex of pathogens causing foliar diseases of oats, among which are some species of *Bipolaris*. However, in field conditions, García-León *et al*. (2013), recorded incidences of isolates of *B. sorokiniana* of up to 50% in oat fields cultivated with the Opalo variety in the State of Mexico and Mexico City, but did not register the presence of *B. victoriae* in those samples. It should be

noted that although the Ópalo variety was tolerant to leaf blights in our study, this variety has been reported as highly susceptible to diseases such as stem rust and crown rust (Espitia-Rangel *et al*., 1999).

Regarding the Teporaca variety, it behaved as moderately resistant to infection by *B. sorokiniana* and as moderately susceptible to *B. victoriae*. This is of great relevance, because the Teporaca variety was registered as resistant to stem rust and crown rust in oats (Salmerón-Zamora, 2001) and as moderately resistant to leaf spot by *C. graminicola* (Leyva-Mir *et al*., 2004). What could be an alternative in the areas where these diseases occur.

The Cevamex variety exhibited 30 and 59% severity of symptoms caused by *B. victoriae* and *B. sorokiniana*, respectively. This indicated that it is a variety susceptible to both species of fungi. This variety was considered resistant to the foliar diseases complex when it was released in the late 90's (Villaseñor-Mir *et al*., 1998); nevertheless, 10 years after its release, this variety behaved moderately resistant (Villaseñor-Mir *et al*., 2008).

According to García-León *et al*. (2013), the Cevamex variety presented incidence of *B. victoriae* up to 40% in commercial fields of oats from the State of Mexico during the 2009 and 2010 cycles. Whereas, *B. sorokiniana* was detected in incidences of up to 70% in fields of oats from the State of Mexico, and incidents of up to 40% in oat fields belonging to the area of Mexico City. The increased susceptibility of this variety to leaf blights may be due to the adaptation and wide dispersion of fungal isolates such as *Bipolaris* spp. in the oat producing areas of the Central Valleys of Mexico.

The variety Karma was moderately susceptible to *B. victoriae* and susceptible to *B. sorokiniana*, which differs with that indicated by Villaseñor-Mir *et al*. (2008), who reported that this variety is moderately resistant to foliar disease complex. However, the results obtained coincide with that reported by García-León *et al*. (2013), who registered high incidence (up to 70%) of *B. victoriae* in fields cultivated with the Karma variety in Hidalgo, Tlaxcala and State of Mexico and up to 30% of incidence of *B. sorokiniana*, in oat fields with this variety in the State of Mexico.

On the other hand, Leyva-Mir *et al*. (2004), pointed out that the Karma variety is susceptible to infection by *Colletotrichum graminicola*, which is another pathogen considered within the complex of foliar diseases of oats in Mexico. The greenhouse tests showed that the Turquesa variety was moderately resistant to *B. victoriae* and susceptible to *B. sorokiniana*, similar results were obtained by Villaseñor-Mir *et al*. (2009), who reported this variety as tolerant to the foliar pathogen complex, including anthracnose, caused by *Colletotrichum graminicola*.

In this same sense, García-León *et al.* (2013), detected incidence of *B. sorokiniana* (50%) and *B. victoriae* (90%), in oat fields cultivated with the Turquesa variety in the state of Tlaxcala. Regarding the Obsidiana variety, it behaved moderately susceptible to *B. victoriae* infection and as susceptible to *B. sorokiniana*. Contrary to that indicated by Espitia-Rangel *et al*. (2007) and Villaseñor-Mir *et al*. (2008), who mentioned that this variety is resistant to the foliar disease complex.

Similar results were observed by Leyva-Mir *et al*. (2004), who determined that this variety is moderately resistant to leaf spot caused by *C. graminicola*. On the other hand, García-León *et al*. (2013) did not find the presence of *B. victoriae* and *B. sorokiniana* in fields cultivated with this variety in the states of Tlaxcala and Hidalgo.

All of the above, indicates that the Obsidiana variety has behaved as resistant in field conditions (Espitia-Rangel *et al*., 2007; Villaseñor-Mir *et al*., 2008; García-León *et al*., 2013), but under artificial inoculations has shown susceptibility.

The Menonita and Saia varieties were moderately resistant to *B. victoriae* and moderately susceptible to *B. sorokiniana* in this study. However, Villaseñor-Mir *et al*. (2008) reported these varieties as moderately susceptible to the foliar disease complex in oats.

The Juchitepec variety behaved as resistant to *B. victoriae* and as susceptible to *B. sorokiniana* in our study. This variety has been considered as susceptible to the foliar disease complex (Villaseñor-Mir *et al*., 2009). In addition, according to Leyva-Mir *et al*. (2004), this variety is moderately resistant to the leaf spot of oats caused by *C. graminicola*.

In general, all the varieties of oats evaluated in the present study showed to be more susceptible to infection by *B. sorokiniana* than to *B. victoriae*.

This can be explained because *B. victoriae* affects only the oat crop (Ghabrial *et al*., 2013; Condon *et al*., 2014). Whereas, *B. sorokiniana* is a pathogen of most cereals such as corn, wheat and barley (Leyva-Mir and González-Iñiguez, 2000), which are crops commonly present in the areas where oats are grown in the High Valleys of Mexico. Also, in the case of *B. victoriae*, this pathogen had not been widely studied as a potential problem in oats, until García-León *et al*. (2013); Leyva-Mir *et al*. (2014) detected it in seeds and foliar tissue of oats in the central region of the country, so it was proposed to carry out the present investigation and evaluate the main varieties of oats and their response to *B. victoriae*.

Previously *B. victoriae* as identified and described by García-León *et al*. (2013) is a pathogen that affected only the oat crop due to the detection of victorine toxin by this pathogen, however, today we can verify that *B. victoriae* causes symptoms of late blight, as we can corroborate it in the first report of Tian and Smith (2018) in Georgia.

Mata-Santoyo *et al*. (2018) conducted a study to evaluate the resistance of bread wheat varieties and crystalline wheat to the infection of leaf blight by *Bipolaris sorokiniana*, which according to field and greenhouse evaluations in wheat can occur at any stage of plant development, but the symptoms are more pronounced after gleaning, under a random sampling in the field it was proved that, 100% of the samples that were collected showed symptoms, with this study it was demonstrated that the main agent causing the leaf blight of the wheat. This shows that foliar diseases in cereals such as wheat and oats are present and interact in the same environment and affect both crops with the same repercussions in terms of severity and level of damage in yield and quality of the harvest.

Asad *et al*. (2009), conducted a study to identify *B. sorokiniana* in various agroecological zones of Pakistan and as a result obtained 80 isolates where the species was confirmed causing the symptoms of leaf blight in the wheat crop; that is to say, the disease is strongly disseminated in all the productive areas of cereals in the world, however, little has been studied the resistance of the varieties to this pathogen that for many years was considered as secondary.

Ayana *et al.* (2018) states that *B. sorokiniana* causes losses in wheat cultivation of up to 70% in production, which is why it conducted an experiment to estimate resistance and susceptibility in 294 wheat genotypes and in which it concluded that 10 genotypes showed Resistance, 38 were shown as moderately resistant, 120 classified as intermediate, 111 as moderately susceptible and 15 susceptible genotypes. The study is alarming, because the scientific community focused on the genetic improvement of cereals is focusing its study on a pathogen that historically has coexisted with the cultivation of grasses for a long time.

Finally, it is important to indicate that *B. sorokiniana* is a widespread pathogen in all regions where cereals are cultivated in the world and its range of environments in which it survives practically covers a large part of the habitats, as in stubble from previous harvests, in leaves and seeds of species such as wheat, oats, barley and other grasses (Minotto *et al*., 2014), is why it is important to carry out studies to verify the damage and impact of this phytopathogen on oat varieties in Mexico, as well as to determine possible sources of resistance to include it in the programs of genetic improvement of oats.

Conclusions

The artificial inoculations of *B. sorokiniana* and *B. victoriae* carried out under greenhouse conditions, determined that the oat varieties AB-177, Cuauhtemoc, Gema, Texas, Nodaway and Pampas behaved as the most susceptible to *B. sorokiniana*, whereas, the Teporaca and Nuda varieties showed to be moderately resistant to this pathogen. For the case of *B. victoriae*, it was observed that Juchitepec and Opalo varieties were resistant, meanwhile, Gema, Bachiniva and Cevamex varieties behaved as the most susceptible to infection.

The varieties that showed greater resistance to infection by *B. sorokiniana* and *B. victoriae* could be considered as a source of resistance for the program of genetic improvement of oats in Mexico.

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