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CROP PRODUCTION

Relationship between blast severity on seedlings and panicles of Brazilian oat cultivars

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ABSTRACT: *Blast, caused by Pyricularia oryzae, threats black (Avena strigosa) and white (A. sativa) oats in Brazil. Little is known about the reaction of Brazilian oat cultivars to blast and if there is a relationship between the response of cultivars to the disease at seedling and adult plant stages. The goals of this research were to verify (a) the reaction of black and white Brazilian oat cultivars to infection of P. oryzae and (b) if the response to blast on seedling leaves and panicles was correlated. Seedlings and adult plants of 13 oat cultivars were inoculated with a conidial suspension of one P. oryzae isolate obtained from a black oat cultivar. The cultivars were classified according to blast severity on the leaf seedlings and panicles estimated by visual estimation. Two experiments were conducted for each one of the two evaluated stages. Cultivars with lower value to blast severity on seedling leaves were 'UPFA Gaudéria' (25.82%) and 'UPF 18' (24.88%) and, on panicles, 'BRS Centauro' (31.63%). Coefficients of Pearson, Spearman, and Kendall obtained from correlation analyses between blast severity on seedling leaves and panicles were -0.21232, -0.35714, and -0.30769, respectively (non-significant at 0.05). Lack of correlation between the responses of these oat cultivars to blast on seedling leaves and panicles be considered in the management of the disease in the field and the generation of new oat cultivars.*
Key words: *Pyricularia oryzae, severity, no-tillage.*

Relação entre a severidade de brusone em plântulas e panículas de cultivares brasileiras de aveia

RESUMO: *A brusone, causada por Pyricularia oryzae, ameaça as culturas da aveia preta (Avena strigosa) e branca (A. sativa) no Brasil. Sabe-se pouco sobre a reação das cultivares brasileiras de aveia à brusone e se existe relação entre a resposta destas cultivares à doença nos estádios de plântula e de planta adulta. Os objetivos deste trabalho foram: (a) verificar a reação de cultivares brasileiras de aveia à infecção de P. oryzae e; (b) se existe relação entre a resposta à brusone dessas cultivares nos estádios de plântula e de planta adulta. Plântulas e plantas adultas de 13 cultivares de aveia foram inoculadas com uma suspensão de conídios de um isolado de P. oryzae obtido de uma planta de uma cultivar de aveia preta. As cultivares foram classificadas de acordo com a estimativa visual da severidade da doença nas folhas das plântulas e nas panículas das plantas adultas. Dois experimentos foram conduzidos para cada um dos estádios avaliados. As cultivares com menor severidade de brusone nas plântulas foram a 'Gaudéria UPFA' (25,82%) e a 'UPF 18' (24,88%) e, nas panículas, foi a 'BRS Centauro' (31,63%). Os coeficientes de Pearson, Spearman e Kendall obtidos da análise de correlação entre os dois estádios avaliados foram -0,21232, -0,35714 e -0,30769, respectivamente (todos sem significância estatística à 0,05). A falta de correlação entre as respostas das cultivares de aveia à brusone, em plântulas e panículas, constitui-se em informação a ser considerada no manejo da doença, no campo e na geração de novas cultivares de aveia.*
Palavras-chave: *Pyricularia oryzae, severidade, plantio direto.*

INTRODUCTION

Two oat species are cultivated in Brazil, *Avena strigosa* Schreb and *Avena sativa* L., which are known in the country as black and white oats, respectively. According to IBGE, the Brazilian agency responsible for the collection, organization and availability of information about agricultural production, in 2014, the area for oat grain production in Brazil reached 199,152ha. However, IBGE (2014) does not specify how much of this area corresponded to black or white oats. Black oat production in Brazil is not predominantly intended for grain harvesting but; instead, it is used as forage and dry and/or organic

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matter for the no-tillage soil management widely adopted in the country. Indeed, it is challenging to estimate the area occupied by black oat crop in Brazil, considering that its establishment in most of these areas occurs through natural reseeding in the winter.

In recent years, Brazilian oat crops have also been affected by blast, a disease caused by the fungus *Pyricularia oryzae* Cavara (teleomorph *Magnaporthe oryzae* BC Couch). MEHTA et al. (2006) mentioned that until 2004 the oat cultivars available in Brazil showed resistance to blast under field conditions. During 2004, a serious outbreak in Paraná caused, which may have reached values ranging from 25 to 30% reduction of oat dry matter and yields. In May of 2014, the occurrence of the disease was quite common in the three southern states of Brazil; Paraná, Santa Catarina, and Rio Grande do Sul. Impact of blast on oat crops is not only restricted to reductions in yield and oat grain quality but also in the production of dry and/or organic matter in no-tillage areas.

Despite that, the occurrence of oat blast is relatively recent in Brazil, the potential damage of other blast diseases such as wheat and rice blast, both caused by *P. oryzae*, is already well known in the country (GOULART et al., 2007; PRABHU et al., 2009). In this sense, the development of cultivars with resistance to blast has been one of the leading priorities for most of the Brazilian rice and wheat breeding programs. However, obtaining cultivars with effective and durable resistance to the disease has not been an easy work. So far, a blast resistant wheat cultivar with adequate levels of resistance has not been identified (MACIEL et al., 2014). Besides, the breakdown of resistance to blast has been a relatively common event in rice, especially in highland rice cultivation (ARAÚJO & PRABHU, 2004).

Two important studies on oat blast have been published in Brazil (URASHIMA & SILVA, 2011; MARANGONI et al., 2013). However, many aspects of the oat-*Pyricularia oryzae* pathosystem are still unknown. For example, no reports are assessing the reaction of oat genotypes to blast at the adult plant stage. In this study, we evaluated (a) the reaction of black and white Brazilian oat cultivars to infection of one isolate of *P. oryzae*, and (b) whether the response of these cultivars to blast on seedling leaves and panicles was correlated.

MATERIALS AND METHODS

Thirteen oat cultivars (Tables 2 and 3) were individually sown in 100ml plastic pots containing commercial substrate, and 10 seedlings/pot kept for about 15 days until inoculation. Three seeds of each cultivars were sown in 5-liter plastic pots containing field soil with fertility corrected according to chemical analysis results and kept until reached the adult stage. Periodically, seedlings and adult plants were watered with a nutrient solution containing formulated fertilizer (NPK; 5-25-25) and urea at a concentration of 25 and 5g L^{-1}, respectively. Both seedlings and adult plants were grown in a greenhouse without supplemental light.

The *P. oryzae* monosporic isolate *Py* 12.0.342, obtained from a black oat plant collected in 2012, in Aral Moreira, Mato Grosso do Sul (MS), was grown into Petri dishes containing oatmeal agar medium. These Petri dishes were put inside a growth chamber at 25±2°C under overhead fluorescent lights for 12h per day. Fifteen-day-old colonies were flooded with a solution of distilled water and Tween 80 (1 drop L^{-1}) and gently scraped with a small brush to dislodge conidia from conidiophores. Conidial suspension was filtered through a sieve containing a piece of gauze. The conidial suspension used to inoculate seedlings and adult plants was adjusted to 10^5 conidia mL^{-1}. Conidia count was performed with a Neubauer chamber (Loptik Labor – $0.0025mm^2$) and with the aid of an optical microscope (Nikon Eclipse E-200). Inoculations were performed on seedlings, 15 days after sowing, at growth stage 14 of the Zadoks scale (ZADOKS et al., 1974). Adult plants were inoculated between growth stages 63-71 of the Zadoks scale (ZADOKS et al., 1974)). Inoculations were performed with a 500ml manual plastic atomizer. After inoculation, seedlings and adult plants were kept in a growth chamber at 26±1°C for 24h in the dark and under relative humidity (RH) of 90-100%. This condition of darkness and high humidity was conducted to favor germination of conidia and penetration of the pathogen on the oat tissue. Twenty-four hours after inoculation, conditions in the growth chamber changed to 12 hours of light and 60-70% RH. Seedlings and adult plants remained in the growth chamber until five and seven days after inoculation, respectively, when plants were evaluated for reaction to blast.

Evaluations on seedlings were conducted by visual observation of the type and severity of the lesions present on leaves and in accordance with the diagrammatic scale described by URASHIMA & KATO (1994). On each 100-ml plastic pot, leaf A_2 (HAUN, 1973; CRUZ et al., 2010) of each of ten grown seedlings was evaluated. Type and the severity of the predominant lesion were scored. According to the diagrammatic scale, there are four types of infection, which are classified as 1, 2, 3, and 4. Zero means no infection; 1, dark lesions, pinhead size; 2, minor injuries, brown to black, with no discernible center; 3, round lesions of eyespot type, with gray center; and 4, lesions typical of susceptibility, elliptical and gray center.

Adult plants were evaluated counting the total number of grains and the number of symptomatic grains of each evaluated panicle. Proportion between the two values was transformed in percentage, i.e. the blast severity on the panicles. These procedures were based on the scale stablished by IRRI (1976) to evaluate blast on rice panicles.

Two experiments were conducted for each stage considered in the study, seedling and adult plant. Experiments were arranged in completely randomized design. For each cultivar, two pots, each one with 10 seedlings, were used for each of the two seedling stage experiments. Each of the two adult plant experiments consisted of three pots per cultivar. Five panicles were evaluated per pot. The data obtained from the severity assessments on the leaves and panicles were normalized by transforming them to square root of x+100 prior to analysis of variance (ANOVA). Means were compared by the Tukey`s test at significance level of α = 0.05. Correlation between blast severity on seedlings and panicles was performed based on the severity recorded by each cultivar as mean of the two experiments conducted in each stage. The coefficients of Pearson, Spearman, and Kendall were used for the correlation analysis of the two parameters, blast severity on seedlings and panicles. All statistical analyses conducted in this study were performed using the statistical software SAS, version 9.2 (SAS Institute, 2011).

RESULTS AND DISCUSSION

The ANOVA for the obtained data revealed a significant difference among the cultivars used in the experiments in relation to their reaction to blast on seedling leaves and panicles (Table 1). Moreover, the F-test did not show interaction between the experimental factors cultivar and experiment. All seedlings from all 13 cultivars showed sporulating lesion type 4 on their leaves. Differences among the cultivars in relation to blast severity on leaves are shown in the table 2. The mean severity of lesions on leaves ranged from 24.88 to 56.60%, which were observed in cultivars ‘UPF 18’ and ‘IAPAR 61’, respectively. Blast disease also affected the panicles of all 13 tested cultivars with severity ranging from 31.63 to 55.97% (Table 3). The most resistant and susceptible cultivars to panicle blast were ‘BRS Centauro’ and ‘Embrapa 139 – Neblina’, respectively. Coefficients of Pearson, Spearman, and Kendall obtained for correlation analysis between blast severity on seedling leaves and panicles were -0.21232, -0.35714, and -0.30769, respectively. None of the coefficients were statistically significant at the 0.05 level.

Reaction of the cultivars to *P. oryzae* infection on seedling leaves was quite similar to the results reported by MARANGONI et al. (2013), even though the number of cultivars used on that research

Table 1 - Summary of the analyses of variance (ANOVAs) for the seedling and panicle reaction of oats cultivars to the isolate *Py* 12.0.342 of *Pyricularia oryzae*.

Souces of variation	------------------------Seedling evaluation-----------------------						-------------------------Panicle evaluation-----------------------					
	df	Sum of Squares	F	P value	Pr>F	S[1]	df	Sum of Squares	F	P value	Pr>F	S
Experiment	1	4.75	4.75	26.40	<.0001	***	1	0.001	0.001	0.02	0.8908	NS
Cultivar	12	92.75	7.73	42.98	<.0001	***	12	23.04	1.92	4.54	<.0001	***
Interaction (Exp. X Cultivar)	12	1.26	0.11	0.59	0.8544	NS	12	4.47	0.37	0.88	0.5666	NS
Error	494	88.83					364	153.92				
Total	519	187.58					389	181.44				
CV(%)[2]=	5.43						3.61					

[1]Significance=> NS = nonsignificant. *** = significant at P≤0.001. [2]The data were transformed to square root of x+100 prior to application of the ANOVA tests.

Table 2 - Blast severity on seedlings of *Avena sativa* and *A. strigosa* cultivars submitted to inoculation with conidial suspension of *Pyricularia oryzae*.

Cultivar	Species	Severity[1]
'IAPAR 61'	*Avena strigosa*	56.60 a[2]
'UPFA 21- Moreninha'	*A. strigosa*	54.30 ab
'BRS Madrugada'	*A. strigosa*	47.40 bc
'URS 21'	*A. sativa*	42.55 cd
'BRS Centauro'	*A. strigosa*	41.52 cde
'Embrapa 139 – Neblina'	*A. strigosa*	41.30 cde
'UPF 16 – Jubileu'	*A. sativa*	37.22 def
'IPR – Afrodite'	*A. sativa*	34.52 efg
'FAEM 6 – Dilmasul'	*A. sativa*	30.70 fgh
'UPFA 22 – Temprana'	*A. sativa*	30.12 fgh
'UPF 20 – Teixeirinha'	*A. sativa*	27.60 gh
'UPFA Gaudéria'	*A. sativa*	25.82 h
'UPF 18'	*A. sativa*	24.88 h
CV (%)[3]		3.61

[1]Values were estimated based on the severity of lesions type 4. [2]Means followed by the same letter are not significantly different according to Tukey`s test (0.05). [3]CV was obtained with original data transformed to square root of x+100.

was larger than the number used in the present study. It is also possible to observe in Table 2 that cultivars 'IPR-Aphrodite', 'UPFA Gaudéria', 'UPF 18' and 'UPFA 22-Temprana' demonstrated a relative good performance in relation to leaf blast reaction, situation that was also observed in research conducted by MARANGONI et al. (2013). It is worth mentioning the performance of cultivar 'BRS Centauro', which was the most resistant to panicle blast, even though the severity observed on this cultivar was not significantly different than the rated severity in some other cultivars used in the present study according to Tukey`s test (0.05).

The observed differences in the tested cultivars in relation to leaf response (seedlings) is an indication that the resistance of cultivars to blast can be a

Table 3 - Blast severity on panicles of *Avena sativa* and *A. strigosa* cultivars submitted to inoculation with conidial suspension of *Pyricularia oryzae*.

Cultivar	Species	Severity
'Embrapa 139 – Neblina'	*Avena strigosa*	55.97[1] a
'UPF 18'	*A. sativa*	48.70 ab
'UPFA Gaudéria'	*A. sativa*	48.38 ab
'UPF 20 – Teixeirinha'	*A. sativa*	48.33 ab
'URS 21'	*A. sativa*	47.20 ab
'IAPAR 61'	*A. strigosa*	44.57 abc
'FAEM 6- Dilmasul'	*A. sativa*	43.67 abc
'BRS Madrugada'	*A. strigosa*	43.23 abc
'UPFA 22 – Temprana'	*A. sativa*	42.53 abc
'UPFA 21 – Moreninha'	*A. strigosa*	40.88 bc
'IPR – Afrodite'	*A. sativa*	38.90 bc
'UPF 16 – Jubileu'	*A. sativa*	38.03 bc
'BRS Centauro'	*A. strigosa*	31.63
CV (%)[2]		5.43

[1]Means followed by the same letter are not significantly different according to Tukey`s test (0.05). [2]CV was obtained with original data transformed to square root of x+100.

factor to be considered in the management of the disease in the field. However, the correlation analysis performed on the reaction to isolate *Py* 12.0.342 on seedling leaves and panicles revealed no relationship. Therefore, it would not be appropriate to recommend a specific cultivar based only on its reaction to seedling or adult plant. It would be; therefore, necessary to recommend individual oat cultivars that possess good levels of resistance to blast at both seedling and adult plant stages. Oat breeding programs in Brazil should consider developing blast resistant oat cultivars at both stages.

Any factor affecting grain production is a disadvantage; however, in the case of *A. strigosa* cultivars, which are predominantly used in the no-tillage system for soil cover and sources of dry and organic matter, the infection of the fungus on the leaf, by itself is already a serious problem for the culture. This statement is justified by the fact that leaf infection limits the green mass production, which after becoming dry matter represents the material substrate for the no-tillage system.

This is the first report that shows an analysis of blast on oat panicles. Furthermore, the results presented herein comprise a set of information about methods, criteria and classification patterns that may assist in future research for the identification of oat cultivars resistant to blast.

CONCLUSION

Lack of correlation between the responses of cultivars to blast on seedling leaves and panicles should be considered in the management of the disease in the field and in the generation of new oat cultivars.

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