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Potential of transmission of *Pyricularia graminis-tritici* from plant to seed and from seed to seedling in wheat genotypes with different degrees of blast resistance[1]

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ABSTRACT - Transmission studies of *Pyricularia graminis-tritici* by wheat seed can help establishing pathogen tolerance standards in crops. Four genotypes, each one with different responses to blast, were inoculated with five volumes of fungal suspension ($1{,}5x10^5$ spores.mL^{-1}), in order to obtain 0, 5, 10, 20 and 30% of plants inoculated in the experimental unit. The potential of transmission of *P. graminis-tritici* from plant to seed was evaluated by the incidence of the fungus in the seeds produced. Under controlled conditions, the transmission rate of the fungus from seed to seedling was evaluated. Blast incidence in field allowed a high incidence of *P. graminis-tritici* in the seeds, especially in the genotypes considered susceptible. The transmission of fungus from the seeds to seedlings occurred 7, 14 and 21 days after sowing, at low rates. There was a relationship between the presence of blast in field and the incidence of *P. graminis-tritici* in seeds produced by the genotypes BRS 264, VI 98053, CD 116 and CD 104. Inoculation of 5, 10, 20 and 30% of plants with fungus can generate a high incidence of the pathogen in field and in the seeds produced, but it doesn`t guarantee a high transmission rate from seed to seedling, which is low under controlled conditions.

Index terms: *Triticum aestivum*, seed pathology, transmissibility, controlled conditions, tolerance standards.

Potencial de transmissão de *Pyricularia graminis-tritici* planta-semente e semente-plântula em genótipos de trigo com graus diferentes de resistência a brusone

RESUMO - Estudos da transmissão de *Pyricularia graminis-tritici* pela semente de trigo podem auxiliar no estabelecimento de padrões de tolerância do patógeno na cultura. Quatro genótipos diferentes quanto à reação à brusone foram inoculados com cinco volumes da suspensão fúngica ($1{,}5x10^5$ esporos.mL^{-1}), de modo a obter 0, 5, 10, 20 e 30% de plantas inoculadas na unidade experimental. O potencial de transmissão de *P. graminis-tritici* planta-semente foi avaliado pela incidência do fungo nas sementes produzidas. Em condições controladas, avaliou-se a taxa de transmissão do fungo da semente à plântula. A incidência da brusone no campo possibilitou elevada incidência de *P. graminis-tritici* nas sementes, principalmente nos genótipos considerados suscetíveis. Ocorreu transmissão do fungo da semente para plântula aos 7, 14 e 21 dias após a semeadura e as taxas foram baixas. Existe relação entre a presença da brusone no campo e a incidência de *P. graminis-tritici* nas sementes produzidas pelos genótipos BRS 264, VI 98053, CD 116 e CD 104. A inoculação de 5, 10, 20 e 30% de plantas com o fungo pode gerar alta incidência do patógeno no campo e nas sementes produzidas, mas não garante elevada taxa de transmissão da semente para a plântula, que é baixa em condições controladas.

Termos para indexação: *Triticum aestivum*, patologia de sementes, transmissibilidade, condições controladas, padrões de tolerância.

Introduction

Blast is a disease of relatively recent economic importance in wheat cultivation. It is present in different parts of the world, it is difficult to control, and the damage varies according to the genotype and the region. In Brazil, the disease has shown

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great impact in the tropical region, as in the north of the states of *Paraná*, *São Paulo*, *Minas Gerais*, *Mato Grosso do Sul*, *Goiás* and *Distrito Federal*, resulting in reductions in productivity and seed or grain quality (Goulart et al., 2007; Urashima et al., 2009; Cruz and Valent, 2017; Gomes et al., 2017). Researches affirm that blast can be caused by multiple species of *Pyricularia*, and the one that causes disease in wheat has recently obtained new nomenclature – *Pyricularia graminis-tritici* (Castroagudín et al., 2016; Cruz and Valent, 2017).

The seed is one of the most efficient means of dispersion, survival and transmission for several phytopathogens (Machado, 1988; Garcia Junior et al., 2008; Denardin and Agostini et al., 2013; Siqueira et al., 2016; Etebu and Nwauzoma, 2017). Therefore, several aspects of the blast should be investigated, such as the relationship between the presence of the disease in field and the incidence of the fungus in seeds produced (Goulart et al., 1995). It was considered, from the epidemiological point of view, that wheat seed is one of the main sources of primary inoculum of *Pyricularia graminis-tritici* (Goulart and Paiva, 1990; Saharan et al., 2016).

The transmission rate of phytopathogens is strongly influenced by the environment and by the inherent characteristics of the pathogen and of the host (Machado, 1988; Garcia Junior et al., 2008; Siqueira et al., 2016). Due to this, it is not guaranteed that seed-associated pathogens will infect seedlings (Garcia Junior et al., 2008) and, therefore, the simple incidence of pathogens in seeds does not implicate in their transmissibility. Thus, transmission efficiency from seed to seedling should be demonstrated and quantified (Machado, 1988; Garcia Junior et al., 2008).

The transmission can be quantified by detecting the symptoms in the plants, considering that the type of inoculation applied should be the one that resulted exclusively from the association of the pathogen with the seed (Garcia Junior et al., 2008). Studies that evaluate the transmission of pathogens by seeds help in establishing patterns of tolerance (Araújo et al., 2006). However, studies that aim to determine the pathogens transmission by seeds, as it happens in wheat culture, are still insufficient.

Goulart and Paiva (1990) evidenced the transmission of *Pyricularia* from wheat seeds to seedlings, with the lowest incidence in seeds (2%) providing the lowest percentage of transmission; and the highest incidence (21%) providing the highest percentage of transmission. However, literature has not yet reported whether wheat genotypes that are more resistant or susceptible to blast can present different responses to transmission of *P. graminis-tritici*. Goulart et al. (1995) argue that there is a relationship between resistance of the parent plant and transmission of the fungus to wheat seeds.

In this context, this study aimed to determine the relationship between the incidence of blast in field and the incidence of *P. graminis-tritici* in seeds produced from wheat genotypes with different resistance reactions to the disease, inoculated with different quantities of the fungus inoculum, and also to determine the transmission of the fungus from seed to seedling under controlled conditions.

Material and Methods

Four genotypes of wheat were used with the following blast resistance reactions: BRS 264 (susceptible); CD 116 (moderately resistant); VI 98053 and CD 104 (no information on resistance to blast in the state of *Minas Gerais*, Brazil).

The field experiment was carried out in *Viçosa*, state of *Minas Gerais* (MG), Brazil, located at 20º45 ‘LS, and 42º51’ W, and at an altitude of 651 m, in a region where the soil type is Red-Yellow Argisol. The climate type is CWA, and the average relative humidity is 80%. The experimental area had no history of blast, neither on previous wheat crops nor on existing weeds.

Sowing and management of the genotypes were performed according to the technical recommendations for the region (EMBRAPA, 2011). The calculation of the sowing rate was conditioned to seed weight, germination and quantity of seeds per meter, in order to obtain 350 seedlings per square meter. The sowing was carried out in the first half of May 2012, at 19.5 ºC and 83% relative humidity. A conventional sprinkler irrigation system was used.

The experiment used a randomized blocks design, with three replications per treatment, which totalized 60 experimental plots or units. Each plot was composed of five lines of 5.0 m of length, separated by 0.20 m. There was a distance of 1.5 m between plots in the same block. For the purpose of useful area, the three central lines of each plot were considered, discounting 30 cm from both ends of the lines.

The isolate of *Pyricularia graminis-tritici* was obtained from seeds of the cultivar MGS Brilhante, with 11% incidence, produced in *Campos Altos*, MG, Brazil. After the isolation, the fungus was placed in PDA culture medium (potato, dextrose and agar), and maintained under a photoperiod of 12 h of fluorescent light at 26 ºC. After obtaining the pure colony, it was streakedon an oatmeal medium (formulated with 60 g of oat flour, 12 g of agar and 1 L of water) to provide better sporulation. Plates were kept at the previously mentioned temperature, under ambient light for ten days. After this period, superficial mycelium was removed and placed under constant fluorescent light, at room temperature, for four days to sporulate (Urashima et al., 2004). The isolate was inoculated on wheat seedlings, and it showed a large virulence spectrum.

Conidia were collected from the plates that showed sporulation by adding distilled water. Then, the suspension was filtered with sterile gauze and filter paper. The fungal suspension was calibrated using a hemacytometer, with the aid of an optical microscope, and the standard concentration of $1{,}5x10^5$ spores.mL^{-1} was obtained, which was added of Tween 20 (0.01%) as adhesive spreader.

Before inoculation, plants had their leaves and spikes wetted by sprinkler irrigation for ten minutes. The inoculations started when the plants entered the stage of completely emerged spikes, which corresponds to the stages 58-60 in the scale of Zadoks et al. (1974). Due to differences in the cycle of the genotypes, the inoculation was staggered.

In each genotype, treatments were obtained by using five volumes (0; 0.20; 0.35; 0.70 and 1 L) of the conidial suspension of *P. graminis-tritici* (standard concentration of $1{,}5x10^5$ spores.mL^{-1}). These volumes were calculated and tested to inoculate, respectively, five plant percentages from the experimental unit (0, 5, 10, 20 and 30%), i.e., the volumes of 0; 0.20; 0.35; 0.70 and 1 L of the conidial suspension were applied in order to obtain treatments with 0, 5, 10, 20 and 30% of inoculated plants from the experimental unit, respectively.

At the inoculation step, each experimental unit or treatment was physically isolated from the surrounding others by washed plastic sheeting, and this protection was removed 72 h after inoculation. The volume zero (without inoculation) corresponded to the application of water, followed by chemical control based on pyraclostrobin + epoxiconazole at the dose of 0.5 L.ha^{-1} of the commercial product. The treatments were applied with a 2 L sprayer, and pressure of 3.0 bar (43.5 psi), in a homogeneous and uniform way, until the surface was totally wet.

The inoculation schedule was always from 5 p.m., in similar conditions of temperature and relative humidity, with no precipitation, as recommended by Goulart et al. (2007). The temperature and relative humidity conditions were recorded after inoculation (Figure 1). After inoculation, the presence of free water on leaves and spikes was maintained for 12 h, obeying the ideal interval between irrigations, considering the presence of an adequate amount of free water.

Evaluations of incidence were performed at intervals of five days after inoculation (DAI), and the final evaluation was provided 50 DAI (Figure 2), based on the quantification of the symptoms in the spikes. The areas under disease progress curve for incidence (AUDPCI) were calculated for each initial inoculum amount in field.

The harvest was manually done and performed according to the maturation stage of each genotype. For seed threshing, an experimental thresher was used, with manual cleaning, aided by sieves for the removal of impurities. Cleaned seeds were dried at room temperature to approximately 13% moisture. After that, they were packed in Kraft paper, and then sent to the laboratory for the determination of the incidence of *P. graminis-tritici*, in order to verify the potential of transmission of the fungus from the parent plant to seeds.

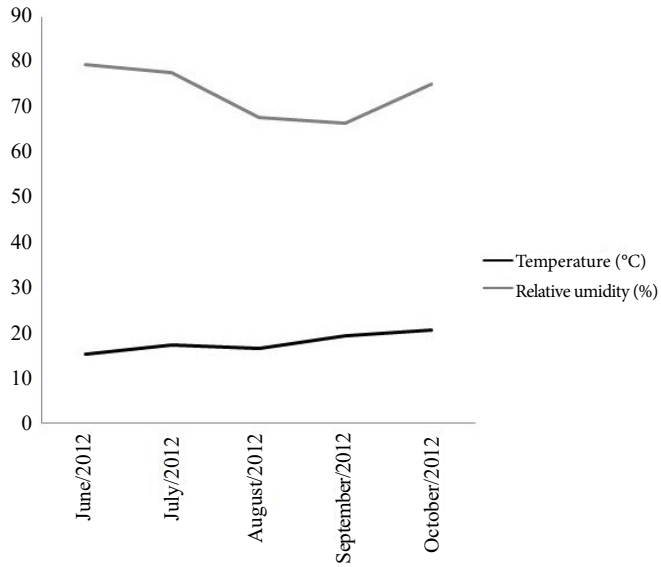

Figure 1. Climatic conditions after inoculation of the genotypes BRS 264, VI 98053, CD 116 e CD 104, during tests in Viçosa – MG, Brazil.

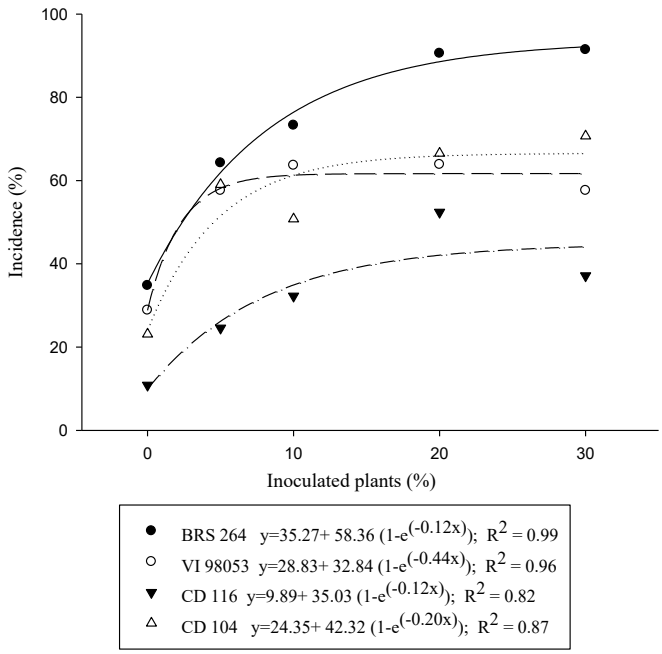

Figure 2. Incidence of blast in wheat genotypes as a function of the quantity of initial inoculum of *P. graminis-tritici* in the plants.

The incidence of *P. graminis-tritici* in seeds produced by the genotypes that were inoculated was determined by freezing-modified blotter test (Machado, 1988), with four replications of 50 seeds each. Three sheets of filter paper were distributed on gerbox plastic plates and moistened with distilled water. The volume of water was 2.5 times the mass of the substrate. Plates were kept in incubation chamber at 25 °C, and photoperiod of 12 h. After 24 h, the plates were transferred to freezer at -20 °C for 24 h. Subsequently, these plates were again maintained in incubation chamber at the same conditions previously described, during seven days. The evaluation was performed by examining the seeds under a stereoscopic microscope, and the incidence of *P. graminis-tritici* was recorded.

After that, it was performed the study of transmission of *P. graminis-tritici* from seeds to seedlings, in a plant growth chamber. The temperature inside the chamber was 26±2 °C, the humidity was 76±6% and the photoperiod was 12 h of light (daylight fluorescent bulbs, 3000 lux) and 12 h of dark.

Seeds harvested in field experiment, from the treatments with 0, 5, 10, 20 and 30% of plants inoculated with *P. graminis-tritici*, were used. Sowing was carried out in sterilized soil in 1.1 L plastic pots, in a completely randomized design, with ten replications. Ten seeds were sown per pot. The soil field capacity (60%) was maintained by frequent irrigations, having the average weight of the pots as reference.

The evaluations were carried out 7, 14 and 21 days after sowing (DAS), determining the emergence, the incidence of *P. graminis-tritici* in the seedlings, and the transmission rate of the fungus from the seeds to the seedlings were determined. The incidence of the fungus in the seedlings was evaluated considering the symptoms in the aerial part: coleoptile, epicotyl, and first leaf. The transmission rate of *P. graminis-tritici* from seeds to seedlings (TR) was determined by the formula proposed by Forcelini (1991), in which: TR (%) = [PS (%) / IS (%)] * 100, in which PS (%) = percentage of seedlings with symptoms of the disease; and IS (%) = percentage of initial seed infection with the fungus.

Fragments of coleoptiles, epicotyls and first leaves tissues from symptomatic and asymptomatic seedlings (control) were washed and disinfested with 70% alcohol, sodium hypochlorite (1% active chlorine) and sterile distilled water for 1 minute, and then dried on sterile filter paper. After that, the fragments were incubated in PDA medium and in oatmeal medium at 25 °C, in photoperiod of 12 h. After 7 and 15 days, the fragments were evaluated under stereoscopic microscope to visualize the morphological structures of *P. graminis-tritici*, and to confirm the potential of transmission. Symptomatic seedlings were also directly analyzed under stereoscopic microscope.

The values of the AUDPCI were calculated using the software PROC GLM, SAS®. With this software, regression analyzes (PROC NLIN), and correlation analyses (PROC CORR) between parameter related to field samples and those evaluated under controlled conditions were performed. The values of the AUDPCI were compared by Tukey's test, $p \leq 0.05$.

Results and Discussion

The incidence of blast in field (Figure 2, Table 1) enabled a variance in the incidences of *P. graminis-tritici* in the seeds of the genotypes tested (incidence ranged from 0 to 30%). The genotypes BRS 264 and CD 104 obtained, in the majority of treatments, values of AUDPCI significantly higher. Therefore, they are considered susceptible to blast (Table 1).

Table 1. The areas under disease progress curve for incidence (AUDPCI) and their respective incidences (%) of *P. graminis-tritici* in seeds produced (means and standard deviation) as a function of the wheat genotype and of the quantity of initial inoculum of the fungus in field.

Wheat genotype	Inoculated plants (%)	AUDPCI	Incidence of *P. graminis-tritici* in the seeds produced (%)[1]
BRS 264	0	6.5 a	10±4.0
VI 98053		5.5 a	5±2.0
CD 116		1.4 b	0±0
CD 104		5.4 a	8±4.6
BRS 264	5	18.7 a	8±4.6
VI 98053		12.0 b	24±9.8
CD 116		3.9 c	11±9.4
CD 104		16.2 ab	30±12.0
BRS 264	10	21.9 a	24±3.3
VI 98053		11.3 b	27±6.0
CD 116		5.8 b	8±4.6
CD 104		18.2 a	24±9.8
BRS 264	20	25.8 a	13±8.2
VI 98053		15.2 bc	24±4.9
CD 116		7.3 c	9±6.0
CD 104		23.6 ab	18±6.9
BRS 264	30	30.0 a	21±6.0
VI 98053		14.8 c	15±6.0
CD 116		6.5 d	11±6.2
CD 104		22.6 b	30±6.9

Means followed by the same letter in the column, for each percentage of inoculated plants, do not differ from each other according to Tukey's test at 5% probability. [1]Incidences obtained in laboratory, by freezing-modified blotter test.

There was no incidence of the pathogen in the seeds coming from the control treatment of the cultivar CD 116 (Table 1). This suggests that the combination of fungicide and the cultivar's moderate resistance to blast was efficient in controlling the pathogen, since the incidence of the fungus in the seeds was null. Besides, the incidence observed in seeds harvested from cultivar CD 116 inoculated treatments was relatively lower when compared to other evaluated genotypes.

Since 1992, the standard tolerance established to *Pyricularia* for certified wheat seeds has been 10% (ABRATES, 1992; Goulart et al., 1995). This implies that most of the incidence values in the wheat seeds genotypes discussed in this study were high, even when only 5% of the plants were inoculated in field. These results point out the potential of transmission of the pathogen from plant to seeds, and reinforce the probability that, the greater the incidence of *Pyricularia* in field, the greater its incidence in seeds (Goulart et al., 1995). Araújo et al. (2009), in studies with cotton, also verified that an increase in the initial inoculum of *Colletotrichum gossypii* South var. *cephalosporioides* A.S. Costa led to an increase in ramulose in field, which augmented the incidence of the pathogen in the seeds.

Faivre-Rampant et al. (2013), when working with the inoculation of rice cultivars with different resistance reactions to *Magnaporthe oryzae*, verified that seeds harvested from progenies inoculated in the mature panicle phase presented a variation in the incidence of the fungus, ranging from 4% in the cultivar Gladio (resistant) to 21% in Maratelli cultivar (susceptible). Therefore, it can be considered that a greater genotype resistance to the pathogen predisposes to a lower rate of transmission of this to the seed (lower incidence), thus confirming the relationship between resistance of the parent plant and transmission of the fungus to the seeds (Goulart et al., 1995). For the genotype CD 116, this level of resistance must have been responsible for the low value of AUDPCI, which resulted in a lower quantification of blast in the plants, and allowed a decrease in the incidence of the fungus in the seeds produced (Table 1).

Satisfactory values of emergence were observed, mainly in the lowest inoculum quantities of *P. graminis-tritici* (0, 5 and 10% of inoculated plants), in all evaluations (Table 2). According to Martins et al. (2004), triticale seeds with *Pyricularia* can provide emergence of healthy seedlings, with no apparent symptoms of blast, as it was observed in the present work for wheat. In general, this pathogen does not affect the emergence (Goulart and Paiva, 1990), considering favorable conditions for the host. This occurs due to the fact that the fungus does not generally affect germination either (Goulart and Paiva, 1990; Urashima et al., 2009; Gomes et al., 2017).

Due to the association of *P. graminis-tritici* with the wheat seeds produced in field experiment, the incidence of the pathogen was observed in the seedlings evaluated under controlled conditions (Table 3). In the evaluation realized 7 DAS, the incidence of the pathogen in the seedlings was not verified in the majority of the treatments, probably due to the little time for establishment of the pathogen, which influenced the pathogen-host relation. The incidence of fungus on seedlings evaluated 14 and 21 DAS varied, but it was low.

Transmission rates of *P. graminis-tritici* from seeds to seedlings 7, 14 and 21 DAS varied to the different amounts of inoculum (Table 4). Although these rates had risen during the evaluations, they were nevertheless considered low, since apparently healthy seedlings had also been originated from seeds proven to be infected by the fungus. Siqueira et al. (2016) also found variability in transmission rates of *Stenocarpella maydis* (Berk.) Sacc by maize seeds, ranging from 25 to 90.5%.

The variability is related mostly to the environment and to inherent characteristics of the pathogen and of the host (Machado, 1988; Garcia Junior et al., 2008; Siqueira et al., 2016), such as the inoculum potential of the pathogen and the degree of resistance of the host.

Table 2. Means and standard deviation of emergence (%) of seedlings from wheat genotypes submitted to different quantities of initial inoculum of *P. graminis-tritici* in field, 7, 14 and 21 days after sowing (DAS).

Inoculated plants (%)	Wheat genotypes			
	BRS 264	VI 98053	CD 116	CD 104
	7 DAS			
0	77±10.6	79±12.0	84±10.7	71±7.4
5	85±5.3	87±10.6	76±11.7	67±22.1
10	92±10.3	67±12.5	16±8.4	82±12.3
20	23±11.6	10±10.5	64±13.5	69±9.9
30	66±9.7	4±7.0	61±20.2	47±18.3
	14 DAS			
0	80±9.4	82±10.3	93±4.8	78±9.2
5	87±4.8	88±10.3	80±14.1	81±12.9
10	95±7.1	70±20.5	17±8.2	78±25.7
20	25±12.7	11±9.9	69±14.5	74±13.5
30	71±12.9	8±10.3	68±14.0	59±22.8
	21 DAS			
0	82±10.3	84±8.4	95±5.3	80±8.2
5	89±5.7	90±10.5	83±10.6	83±14.2
10	97±4.8	73±18.3	28±11.3	90±8.2
20	30±11.5	28±11.3	72±12.3	77±9.5
30	76±8.4	11±8.7	71±12.0	64±19.5

Table 3. Means and standard deviation of incidence (%) of *P. graminis-tritici*, 7, 14 and 21 days after sowing (DAS), in seedlings from wheat genotypes submitted to different quantities of initial inoculum of *P. graminis-tritici* in field.

Inoculated plants (%)	Wheat genotypes			
	BRS 264	VI 98053	CD 116	CD 104
	7 DAS			
0	0±0	0±0	0±0	0±0
5	0±0	0±0	0±0	0±0
10	0±0	0±0	0±0	0±0
20	0±0	0±0	0±0	0±0
30	1±3.16	0±0	0±0	1±3.16
	14 DAS			
0	0.2±0.42	0±0	0±0	0.2±0.42
5	0.6±0.84	0.6±0.51	0±0	0.5±0.70
10	0.4±0.70	0.2±0.42	0.2±0.63	0.1±0.32
20	0.2±0.42	0.8±0.63	0.8±0.79	0.1±0.32
30	1.1±0.73	0.1±0.32	0.4±0.51	1.3±0.48
	21 DAS			
0	0.6±0.84	0±0	0±0	0.4±0.70
5	0.8±0.63	0.7±0.67	0±0	0.6±0.84
10	0.5±0.52	0.4±0.84	0.2±0.42	0.4±0.69
20	0.3±0.48	0.8±0.78	0.8±0.79	0.2±0.42
30	1.2±0.78	0.1±0.32	0.4±0.70	1.5±0.52

Physical and biological factors, the position of the pathogen inside the seed and its intensity are responsible for the great variability in transmission of the pathogen by seed (Siqueira et al., 2014).

When the data of this research are compared to those of Goulart and Paiva (1990), who obtained an average transmission of *Pyricularia* from seed to seedling of 29.2%, among the treatments, it can be inferred once again that rates of transmission found in this work were low, even for seedlings that came from seeds harvested from genotypes submitted to higher amounts of the inoculum of *P. graminis-tritici* in field. The data obtained in the present study also corroborate with other researches that demonstrated the low transmission of this pathogen from seeds to seedlings (Martins et al., 2004).

For genotype VI 98053, there was a positive correlation between the incidence of *P. graminis-tritici* in the parent plant and the incidence of the fungus in the seeds produced (Table 5). This data is important, because information on the relation between the presence of blast in field and the incidence of the fungus in the seeds produced is needed for this and the other genotypes. For cultivar BRS 264, there was a positive correlation between the incidence of *P. graminis-tritici* in the parent plant and the incidence of the fungus in

Table 4. Transmission rates (%) of *P. graminis-tritici* from seeds to seedlings, 7, 14 and 21 days after sowing (DAS), in wheat genotypes submitted to different quantities of initial inoculum of *P. graminis-tritici* in field.

Inoculated Plants (%)	Wheat genotypes				
	BRS 264	VI 98053	CD 116	CD 104	Overall mean
			7 DAS		
0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0
30	4.2	0.0	0.0	3.3	1.8
Overall mean	0.8	0.0	0.0	0.6	-
			14 DAS		
0	2.0	0.0	0.0	2.5	1.1
5	7.5	2.5	0.0	2.1	3.0
10	1.9	0.7	2.5	0.5	1.4
20	1.5	8.3	7.2	0.3	4.3
30	4.5	0.8	3.3	4.3	3.2
Overall mean	3.5	2.4	2.6	1.9	-
			21 DAS		
0	6.0	0.0	0.0	5.0	2.7
5	10.0	2.9	0.0	2.5	3.8
10	2.3	1.4	2.5	2.2	2.1
20	2.3	8.3	7.2	0.6	4.6
30	5.0	0.8	3.3	5.0	3.5
Overall mean	5.1	2.7	2.6	3.1	-

seedlings 21 DAS; and also between the incidence of the pathogen in the parent plant and the transmission rate of the fungus from seeds to seedlings 21 DAS. Thus, the transmission of *P. graminis-tritici* can be verified in two generations: from the parent plant to seeds, and from seeds to seedlings.

It should be emphasized that the incidence of the pathogen in seeds does not guarantee the transmission, as it was observed in cultivar CD 116. This cultivar had 5% of the plants inoculated, and the incidence of *P. graminis-tritici* in the seeds was 11% (Table 1). However, there was no transmission of the fungus from the seeds to the seedlings (the values were equal to zero in all evaluations of this treatment, Table 4).

The literature reports that high or low rates of pathogens transmission by seeds can be efficient, and reflect the same degree of plant damage. Araújo et al. (2016) relate that the transmissibility of *Fusarium oxysporum* f. sp. *vasinfectum* (Atk.) Snyder & Hansen by cotton seeds is efficient and may reflect on high or low rates of infection and transmission to the seedlings, depending on the level of incidence in the seeds.

The present research provides information for pathology and for production of wheat seeds, since, nowadays, there are no studies determining the transmission of *P. graminis-tritici* that can support the establishment of tolerance standards, neither in field nor under controlled conditions. In practice, the importance of these tolerance standards lies in the decision-making process of adopting specific control techniques in field, quarantine measures, forms of treatment, disposal of lots with a certain incidence of pathogens, relevant inspections or even the cancellation of fields of seed production.

Conclusions

There is a relationship between the presence of blast in field and the incidence of *P. graminis-tritici* in the seeds produced by the wheat genotypes BRS 264, VI 98053, CD 116 and CD 104. The transmission of the fungus from seed to seedling occurs, and it is normally low under controlled conditions, both in the genotypes considered susceptible to blast (BRS 264, VI 98053 and CD 104), as well as in the one that is moderately resistant in field (CD 116).

The inoculation of 5, 10, 20 and 30% of the plants with *P. graminis-tritici* can generate high incidence of the pathogen in field and in the seeds produced by the genotypes, but does not guarantee a high transmission rate of the fungus from seeds to seedlings.

Table 5. Pearson correlation coefficients obtained between the parameter evaluated in the field and the parameters evaluated under controlled conditions, in wheat genotypes inoculated with *P. graminis-tritici*.

Wheat genotype		Incidence of *P. graminis-tritici* in seeds produced	Emergence after 7 days	Emergence after 21 days	Incidence of *P. graminis-tritici* in seedlings after 21 days	Transmission rate from seeds to seedlings after 21 days
BRS 264	Incidence of *P. graminis-tritici* in parental plants[1]	0.51^{ns}	-	-	0.86*	0.86*
	Incidence of *P. graminis-tritici* in seeds produced	-	-0.46^{ns}	-0.74^{ns}	0.59^{ns}	0.11^{ns}
VI 98053	Incidence of *P. graminis-tritici* in parental plants[1]	0.92*	-	-	0.25^{ns}	0.19^{ns}
	Incidence of *P. graminis-tritici* in seeds produced	-	-0.22^{ns}	-0.0^{ns}	0.75^{ns}	0.72^{ns}
CD 116	Incidence of *P. graminis-tritici* in parental plants[1]	0.75^{ns}	-	-	-0.2^{ns}	-0.06^{ns}
	Incidence of *P. graminis-tritici* in seeds produced	-	0.78^{ns}	0.76^{ns}	0.02^{ns}	-0.40^{ns}
CD104	Incidence of *P. graminis-tritici* in parental plants[1]	0.68^{ns}	-	-	-0.08^{ns}	-0.06^{ns}
	Incidence of *P. graminis-tritici* in seeds produced	-	0.28^{ns}	0.39^{ns}	0.10^{ns}	-0.24^{ns}

*Significant at 5% probability; ^{ns}– Non-significant at 5% probability according to T-test;
[1]Incidence of blast evaluated in field and quantified 50 days after inoculation.

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