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Does potassium silicate reduce wheat blast in young and adult wheat plants?

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ABSTRACT

Considering the different levels of efficiency reported in the literature for the use of potassium silicate (PS) on wheat blast, this work investigated whether the foliar spray of PS could reduce blast severity in young and adult wheat cultivars and increase wheat yield indexes. At 28 days after emergence, the 'BR 18', 'BRS 208', and 'BRS Louro' plant cultivars were sprayed with the following PS rates (g/L): 0, 5, 10, 20, and 25. Twenty-four hours after PS application, the plants were inoculated with 10^5 conidia/mL of *P. oryzae*. Seven days after the inoculations the blast severity in the control plants of the 'BRS Louro', 'BR 18', and 'BRS 208' cultivars were 85%, 60% and 35%, respectively. For the 5g/L (PS) dose, severity was reduced more than 60% in the three cultivars. Adult plants of the 'BRS 208' and 'BRS Louro' cultivars were sprayed with water (control) or PS (20g/L) at the tillering, booting, and inflorescence stages. The PS applications were not efficient at reducing blast severity in adult plants and did not affect the wheat yield indexes. PS is only efficient at reducing blast severity in young plants.

Keywords: amineral nutrition; *Pyricularia oryzae*; *Triticum aestivum*

INTRODUCTION

Wheat (*Triticum aestivum L.*) is one of the most cultivated cereals in 2023, and an estimated global production of 788 million tons (USDA, 2023). In Brazil, current national production is estimated around 10.4 million tons, and the estimated production for Rio Grande do Sul is around 4.6 million tons (CONAB, 2023). Although Brazilian states in the tropics have shown increases in their productive potential in recent years, the wheat crop in the Central-West Region of Brazil has suffered great losses due to wheat blast, that limit the production and the crop expansion (Cargnin *et al.*, 2009; Coelho *et al.*, 2016).

Wheat blast is a spike disease; but, the pathogen can cause necrosis in the leaves and culms in warm and humid environments (Saharan *et al.*, 2016). For the leaves, under controlled conditions, the first symptoms of the disease appear after 48 hours and infected tissues are completely dead in 120 hours (Cruz *et al.*, 2016). In addition to this rapid progression, infected crops exhibit reduced yields (from 10% to 100%) and seed quality. Damage varies according to the plant growth stage, plant genotype, aggressiveness of the pathogen isolates, and weather conditions. Beyond that, the greatest losses occur when the fungal infection reaches the base of the rachis, delaying the development of the grains and consequently leading to the death of the spikelets (Kohli *et al.*, 2011; Gomes *et al.*, 2017). Applying fungicides is not very efficient at controlling wheat blast in the field (Cruz & Valent, 2017), the percent control ranged from 43 to 58% influenced by fungicide type, region and

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year (Ascari *et al.*, 2021). Nevertheless, some nutrients have been studied to control wheat blast. The blast severity was reduced from: 64 to 71% to potassium phosphites (Cruz *et al.*, 2011), and 58% to silicate (Oliveira *et al.*, 2019) the calcium, magnesium, and silicon have also reduced blast symptoms in some researches at adult and vegetative growth (Pagani *et al.*, 2014; Debona *et al.*, 2017).

According to Coskun *et al.* (2019), silicon (Si) is not considered an essential element for plant growth, however, the International plant nutrition institute recently recognized silicon as a beneficial element for plants due to its protective function performed in plants under biotic stress. Some studies have shown that Si reduces wheat blast symptoms when it is made available to plants through the roots by supplementing the soil or growing plants in a nutrient solution (Cruz *et al.*, 2015b; Debona *et al.*, 2017). Si can be absorbed by the plants in the form of $Si(OH)_4$ from soil or nutrient solutions at a pH below 9. The solubility of silicic acid is 2 mM at 25 ºC in water, and the polymerization into silica gel occurs when the concentration of the silicic acid exceeds 2 mM. Silicic acid is absorbed by the roots, transported in the shoot, and polymerized to colloidal silicic acid and at the end to silica gel with the increasing silicic acid concentration (Ma *et al.*, 2001). Although there has been an increase in records of the benefits of silicon under different stress conditions in the literature over the past few years, Coskun *et al.* (2019) verified numerous controversies in the roles attributed to Si in plants. The authors proposed a novel model of action of Si in the cell, where Si is considered an extracellular prophylactic agent against sources of stresses. This differs from most studies, which suggest Si plays an active role in the plant's response.

However, it cannot be denied that silicon and its combination in compounds, such as potassium silicate (PS), are beneficial to some plants challenged with biotrophic (Guével *et al.*, 2007; Rodrigues *et al.*, 2009; Lemes *et al.*, 2011; Dallagnol *et al.*, 2020) and hemibiotrophic (Rodrigues *et al.*, 2017; Oliveira *et al.*, 2019) pathogens. Silicates act on the physical resistance of the plant against the fungus through the deposition of amorphous silica on the leaves. This prevents or delays the penetration of the fungus and causes physiological and biochemical changes in the plant, such as increased biosynthesis of flavonoids, phenolic compounds, and lignin-thioglycolic acid derivatives (Xavier Filha *et al.*, 2011). Recently, Dallagnol *et al.* (2023) verified that silicon fertilization had effect on the wheat technological quality under high intensity of disease, it reduce the damage caused by pathogens, and influence positively the flour yield, grain falling number, gluten strength, dough tenacity and tenacity/extensibility ratio, and elasticity index.

Although the benefits of using Si and silicates are widely reported in the international literature (Coskun *et al.*, 2019), their use in the field in Brazil is rare. This is due to the following: a) an inconsistency in the results in the literature, with contrasting responses for the same pathosystem; b) the contradictory results observed when plants are not under stress conditions, which puts in doubt the need for these products; c) doubts about which plant growth stage and how often to apply these products; and d) the little information about the efficiency of products for national wheat cultivars. Thus, the present work is justified by trying to answer some questions about the efficiency of PS on Brazilian wheat cultivars challenged with *Pyricularia oryzae*.

Therefore, the objectives of this work were to assess the efficiency of foliar application of potassium silicate (PS) at reducing blast severity in young and adult wheat cultivars, and to check if PS increases wheat yield indexes. The hypothesis of this work is as follows: if the PS provides constant protection against *P. oryzae*, then similar severity responses will be observed in young and adult plants.

MATERIAL AND METHODS

The investigation was conducted in a greenhouse at the Universidade Federal do Pampa, which is in the city of Itaqui, Rio Grande do Sul State, Brazil (29º09'22"S, 56º33'03"W). The wheat seeds were provided by Empresa Brasileira de Pesquisa Agropecuária - Embrapa Trigo.

Young plants experiment

For the experiment, the 'BRS 208' (susceptible), 'BR 18' (resistant), and 'BRS Louro' (no information about blast resistance) wheat cultivars were selected because of their reaction to blast according to the Technical Information for Wheat and Triticale Crop 2018 (RCBPTT, 2018).

Wheat seeds surface sterilization and sowing conditions were carried out as described by Lorenset *et al.* (2021). Six seedlings per pot were evaluated. The plants were fertilized with nutrient solution according to Xavier Filha *et al.* (2011). Every week the plants received nutrient solution (25 mL) and were watered as needed. The plants were grown in a greenhouse with a temperature of 17 ± 2 °C (day) to 10 ± 2 °C (night), relative humidity of

70 ± 5%, and natural light until inoculation.

Young plants at 28 days after emergence, at growth stage 14 (Zadoks *et al.*, 1974), were sprayed once with PS solutions at the rates of 0, 5, 10, 20 and 25 g/L (Supa Silica, Agrichem ®, containing 20% SiO, combined with humic acid, at pH 12). The PS was applied using a manual atomizer. Each plant was sprayed with 10 mL of PS solution until runoff.

A pathogenic isolate of *P. oryzae* (UFV/DFP Po-01) was used to inoculate the wheat plants. The inoculum was prepared according to the instructions contained in Cruz *et al.* (2016) The plants were inoculated with the conidial suspension (25 mL/plant) of *P. oryzae* (10^5 conidia/mL) 24 hours after the PS application. Non-inoculated plants worked on as the control treatment. The inoculum was sprayed on the adaxial and abaxial leaf surfaces until runoff using a manual atomizer. After inoculation, the plants were maintained in a growth chamber at a temperature of 25 ± 2 °C, relative humidity of 90 ± 5%, and initial 24-h dark. After that, the photoperiod was adjusted to 12 h of light. Seven days after inoculation, the severity of the wheat blast was evaluated in the third leaf from the base of each plant using the diagrammatic scale (Rios *et al.*,2013).

The young plants experiment consisted of a 3 × 5 factorial with three cultivars and five PS rates (0, 5, 10, 20, 25 g/L) in a completely randomized design, and five replications. Each experimental unit corresponded to a plastic pot containing six plants. We evaluated 30 leaves/cultivar/rate of PS. The experiment was repeated twice.

To describe the relationship between the product dose and the severity in the wheat cultivars evaluated, a normal regression model was used. The relationship between dose (x) of PS and severity (y) was analyzed with a quadratic regression model with the following equation:

$$y = a + bx + cx^2 + \varepsilon \qquad (1)$$

where a, b, and c are the model parameters and is the term associated with the residue which is assumed as independent, homogenous and identically distributed according a normal distribution. The model parameters were estimated by least squares method and more details can be seen in Liska *et al.* (2019).

Adult plants experiment

For the adult plants experiment, the 'BRS 208' and 'BRS Louro' cultivars were used (RCBPTT, 2018). Sterilization of the seed surface and substrate preparation followed the instructions carried out in the young plant experiment. Two plants in plastic pots with 4 kg of substrate were fertilized with a nutrient solution following that described by Xavier Filha *et al.* (2011). Nutrient solution (50 mL) was applied to each pot every week,and plants were watered as needed.

Adult plants at the tillering stage (26), booting stage (45), and at the emergence of the completed inflorescence (58), according to Zadoks *et al.* (1974), were sprayed one time with PS at the rate of 20.0 g.L (Supa Silica, Agrichem ®, containing 20% SiO, combined with humic acid, at pH 12). The PS application was made using a handheld manual sprayer until runoff. Each plant was sprayed with 20 mL of PS solution until runoff by stage.

The inoculation procedures were the same as those used for the young plants. Each adult plant at growth stage 58, and 24 hours after the PS application, was inoculated with 50 mL of the conidial suspension of *P. oryzae* (10^5 conidia/mL). The inoculum was sprayed on the spikes and the adaxial and abaxial leaf surfaces, until runoff, using a manual atomizer. The procedures after inoculation were the same as those for the young plants. The inoculated plants were maintained in a growth chamber until the end of the severity assessments. The non-inoculated plants were submitted to an initial 24-h dark period before being transferred to a greenhouse, and. served as the control treatment.

Quantification of incubation period (IP) and blast severity

After inoculation, the incubation period (IP) was assessed daily by observing the presence of blast symptoms on the surface of the spikes; the recording was done in hours (h). The blast severity in the flag leaf and spike was evaluated at 10, 11, 12, 13, 14, and 15 dai (days after inoculation) according to Rios *et al.* (2013) and Maciel *et al.* (2013), respectively. After that, the data for the flag leaf and spikes were used to calculate the area under the blast progress curve (AUBPC) according to Shaner & Finney (1977). The final severity (FS) of the flag leaf and spikes was measured 15 dai. This experiment was in a 2 × 2 factorial arrangement in a completely randomized design with five replications. One plastic pot with two plants and six spikes/plant was considered an experimental unit. Sixty flag leaves and 60 spikes were evaluated/treatment/cultivar. The factors studied were inoculated plants sprayed with PS or not sprayed with PS and cultivars ('BRS Louro' and 'BRS 208'). Non-inoculated plants sprayed with water and PS served as the control treatment.

Quantification of crop yield components

The crop yield components measured were number of tillers and spikes/plant, number of seeds/spike, and weight of 100 seeds.

This experiment was in a 2 × 2 factorial arrangement in a completely randomized design with five replications. One plastic pot with two plants was the experimental unit. The factors studied were non-inoculated plants sprayed with distilled water or PS and cultivars (‘BRS Louro’ and ‘BRS 208’).

The data for IP, blast severity and crop yield components were submitted to an analysis of variance (ANOVA), and the treatment means were compared with Tukey’s test, at a 5% probability level. The residuals of the factorial models were evaluated in terms of homogeneity of variances, independence, and normality. The experiments were repeated twice.

Mycelial growth of P. oryzae in vitro

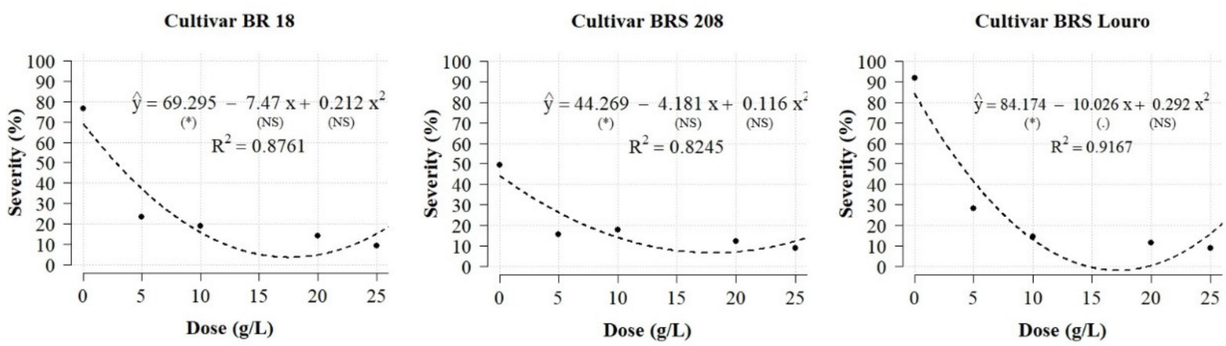
To evaluate the effect of the PS rates on *P. oryzae* mycelial growth, PS (at pH 12) was added to potato dextrose agar (PDA) culture medium at the same concentrations used for spraying the young plants (0, 5, 10, 20, and 25 g/L). A mycelial disk of *P. oryzae* (5 mm diameter) was transferred to each Petri dish. The Petri dishes were maintained in growth chambers at 28 °C. Mycelial growth in millimeters (mm) was evaluated with a digital calipter 72 hours after plating. The mean colony growth was obtained from vertical and horizontal measurements. The experiment was installed in a completely randomized design with six replicates. The Petri dish was considered a repetition. The experiment was repeated twice. The data were submitted to an ANOVA, and the treatment means were compared with Tukey’s test. All the statistical analysis were performed with the statistical software R (R Core Team, 2021)

RESULTS

Young plants experiment

Reduction in blast severity was observed in all cultivars when submitted to the application of PS compared to control plants (Figure 1). The quadratic regression model best described the blast severity-PS rate relationship for the three cultivars: ‘BR 18’ ($\hat{y}$ = 69.295 - 7.47 x + 0.212 x^2, R^2 = 0.8761), ‘BRS 208’ ($\hat{y}$ = 44.269 - 4.181 x + 0.116 x^2, R^2 = 0.8245), and ‘BRS Louro’ ($\hat{y}$ = 84.174 - 10.026 x + 0.292 x^2, R^2 = 0.9167).

The ‘BRS Louro’ cultivar had the highest levels of severity in the control treatment (85%), followed by the ‘BR 18’ cultivar (60%), and ‘BRS 208’ cultivar (35%) (Figure 1). Although there was a reduction in severity for all PS ratios in the three cultivars, the lowest PS rate (5 g/L) reduced the blast severity by more than 60%. PS rates of 18.02 g/L, 17.61 g/L, and 17.18 g/L were estimated to be the most efficient at reducing the blast severity for ‘BRS 208’, ‘BR 18’ and ‘BRS Louro’, respectively. The lowest estimated severity values in the optimal PS rates were 6.6%, 3.53% and 0%, respectively, for ‘BRS 208’, ‘BR 18’, and ‘BRS Louro’.



Symbols in parentheses represent the significance of the model parameters ((**) Significant at 1% probability; (*) Significant at 5% probability; (.) Significant at 10% probability; (NS) Not significant at 10% probability). Dashed line represents the severity predicted by the fitted model.

Figure 1: Wheat blast severity on young plants of cultivars BR 18, BRS 208 and BRS Louro sprayed with different doses of Potassium Silicate (0, 5, 10, 20, 25 g/L). Model fitted to the severity data of the three evaluated cultivars.

Adult plants experiment

Incubation Period (IP)

There were significant differences in the IP between the cultivars (Table 1). The 'BRS Louro' cultivar had a longer IP compared to the 'BRS 208' cultivar, but no significant difference for the PS application occurred in this cultivar. The IP was shorter in plants of the 'BRS 208' cultivar that was not supplied with PS compared to those supplied (Table 1).

AUBPC and FS for the flag leaf

In the present work, there was significant difference for AUBPC data and FS in the flag leaf between the cultivars (Table 2). The 'BRS 208' cultivar had higher AUBPC and FS compared to the 'BRS Louro' cultivar. However, there was no significant difference in the application of PS to the 'BRS 208' cultivar (Table 2). The lowest AUBPC rates for the 'BRS Louro' cultivar occurred in plants not sprayed with PS (Table 2). There was no significant difference in FS in the flag leaf for both cultivars when sprayed or not sprayed with PS (Table 2).

AUBPC and FS for the spikes

There was no significant difference in AUBPC and FS (Table 3) between the PS applications for the 'BRS Louro' and 'BRS 208' cultivars. AUBPC data ranged from 628.54 to 821.21. And FS data ranged from 59.29 to 70.19.

Wheat yield assessment

There was no significant difference between the number of tillers and spikes/plant for the cultivars when submitted or not submitted to PS application (Table 4). The 'BRS Louro' cultivar had the greatest number of spikes/plant compared to the 'BRS 208' cultivar (Table 4). There was no significant difference between the number of tillers/plant to both cultivars. For the average number of grains, there was a significant difference in the response of the BRS Louro cultivar when sprayed or not sprayed with PS (Table 5). The 'BRS Louro' cultivar sprayed with PS had a higher number of grains/spike than the 'BRS 208' cultivar (Table 5). There was no significant difference between the cultivars no sprayed with PS for the variable number of grains/spike (Table 5). The 'BRS 208' cultivar no sprayed with PS had higher grain weight than the 'BRS Louro' cultivar. The 'BRS 208' cultivar no sprayed with PS had higher grain weight than plants sprayed with PS (Table 5). The Correlations between each parameter assessed (severity young plants, severity flag leaf, severity spikes, AUBPC flag leaf, AUBPC spikes) and results of the Student's t-test when population correlation is different from zero were evaluated. However, all correlations were weak, less than 0.69 (unpublished data).

Evaluation of mycelial growth of P. oryzae in vitro

All doses of the PS ($P \leq 0.05$) reduced the mycelial growth *in vitro* compared to the control treatment ($P \leq 0.001$). The mycelial growth of *P. oryzae* was 9.6 mm for the control treatment and 1.5 mm for all PS doses tested (unpublished data).

DISCUSSION

The benefits of silicon in reducing biotic stress in grass plants have been widely discussed by different authors (Liang *et al.*, 2015; Debona *et al.,* 2017). Further, using PS fertilizers is the most practical way for farmers to gain access to these benefits. The present study shows that PS in low doses is efficient at reducing blast symptoms in young plants but is not efficient at the adult plant stage.

All doses of PS caused a reduction of mycelial growth of *P. oryzae in vitro*. Cruz *et al.* (2011) found that at a concentration of 20 g/L PS, the mycelial growth of *P. oryzae* was 3.43 mm at 72 hours, or around 3 times lower than the control treatment (11.14 mm). Recently, Dallagnol *et al.* (2020) found that potassium silicate and polypolyetilene glycol 6000 can reduce the conidia germination of *Podosphaera xanthii* , moreover, the potassium hydroxide, po-

Table 1: Incubation Period (hours) of blast on leaf flag of wheat cultivars inoculated with *P. oryzae*, and sprayed (+) or non-sprayed (-) with potassium silicate (PS)

Cultivars	PS+	PS-
BRS Louro	164.3 Aa	145.2Aa
BRS 208	129.2 Ba	95.8 Bb
CV	12.75	

Means followed by the same letter, lower case in the row and upper case in the column, did not differ significantly by Tukey's test at 5% probability. CV = coefficient of variation.

Table 2: Area under blast progress curve (AUBPC) and final severity (FS) for the flag leaf of wheat cultivars inoculated with *P. oryzae* and sprayed (+) or not sprayed (-) with potassium silicate (PS)

Cultivars	AUBPC		FS*	
	PS+	PS-	PS+	PS-
BRS LOURO	598.59 Ba	422.50 Bb	51.91 Ba	32.50 Ba
BRS 208	2117.65 Aa	2083.89 Aa	88.23 Aa	92.73 Aa
CV	14.89		37.93	

Means followed by the same letter, lower case in the row and upper case in the column, did not differ significantly by Tukey's test at 5% probability. * Data was transformed by $\sqrt{x+1}$. CV = coefficient of variation.

tassium chloride, potassium silicate and PEG 6000 reduced the surface tension on melon leaves. Therefore, the authors suggest that the pH and ionic strength of the PS are not the main chemical properties that affect the fungi, but the modification of the osmotic potential of the leaf surface is caused by PS application (Dallagnol *et al.*, 2020). Thereby, in the present work, in addition to considering the inhibition of the mycelial growth of *P. oryzae* at different doses of PS, the probable decrease in the surface tension of wheat leaves at young growth stages can also be considered to explain the results. Young wheat leaves show less wax deposition on the outer cell walls of the epidermal cells, presenting lower surface tension compared to the leaves of adult plants. Therefore, the reduction in surface tension caused by PS allows for greater homogeneity in the deposition and spread of the product over the surface of the young leaf, delaying and/or reducing the penetration and colonization of the pathogen.

PS has been indicated as a beneficial product both at reducing the rice blast severity (Rodrigues *et al.*, 2004; Cacique *et al.*, 2013), and in the photosynthetic performance of some crops (Kobra *et al.*, 2016; Debona *et al.*, 2017). Inorganic minerals found in soil and food are essential nutrients for the proper body functioning of animals and plants. Minerals are necessary elements for the growth of the plants. Potassium (K^+) for example, regulates water usage and provides disease resistance and stem strength. It is involved in photosynthesis, drought tolerance, winter hardiness, and protein synthesis (Ram, 2020). The second most abundant element in the Earth's crust, silicon (Si), is a tetravalent metalloid considered the main mineral constituent of plants (Epstein, 2009, Debona *et al.*, 2017; Ram, 2020). According to Debona *et al.* (2017), plants with a high Si concentration in the roots or shoots are less prone to suffering from pest attacks and exhibit enhanced tolerance to abiotic stresses, such as drought, low temperature, or metal toxicity. The reduction of disease symptoms was initially related to the formation of a physical barrier formed by the polymerization of Si beneath the cuticle and in the cell walls (Epstein, 2009; Debona *et al.*, 2017). However, some authors have pointed in plants supplied with silicon: the activation of phenylpropanoid pathways, transcription of host defense genes as PAL, and higher activities of defense enzymes (Rodrigues *et al.*, 2004; Brunings *et al.*, 2009; Cruz *et al.*, 2015a; Debona *et al.*, 2017).

In this study, the foliar application of different PS doses was efficient at reducing blast severity in young plants of the three wheat cultivars tested: 'BRS Louro', 'BRS 208', and 'BR 18'. Positive results from PS application were reported by Oliveira *et al.* (2019). The authors verified a 58% reduction in AUPBC in young plants of the 'BRS Guamirim' cultivar sprayed with PS (20 g/L) compared the control plants. For Cacique *et al.* (2013), the supply of silicon in the soil and silicate spraying were efficient at

Table 3: Area under blast progress curve (AUBPC) and final severity (FS) for spikes of wheat cultivars inoculated with *P. oryzae* and sprayed (+) or not sprayed (-) with potassium silicate (PS)

Cultivars	AUBPC*		FS*	
	PS+	PS-	PS+	PS-
BRS LOURO	628.54 Aa	683.44 Aa	56.29 Aa	60.05 Aa
BRS 208	821.21 Aa	693.26 Aa	67.36 Aa	70.19 Aa
CV	33.03		23.11	

Means followed by the same letter, lower case in the row and upper case in the column, did not differ significantly by Tukey's test at 5% probability. * Data was transformed by $\sqrt{x+1}$. CV = coefficient of variation.

Table 4: Number of spikes and tillers /plant for cultivars sprayed (+) or not sprayed (-) with potassium silicate (PS)

Cultivars	Number of spikes		Number of tillers	
	PS+	PS-	PS+	PS-
BRS LOURO	12.70 Aa	12.38 Aa	8,50 Aa	8,23 Aa
BRS 208	9.05 Ba	8.97 Ba	7,00 Aa	6,93 Aa
CV	19.34		16.69	

Means followed by the same letter, lower case in the row and upper case in the column, did not differ significantly by Tukey's test at 5% probability. CV = coefficient of variation.

reducing the size and number of the lesions of leaf area, and the AUBPC in young rice plants. Using an X-ray microanalysis, the authors showed that the deposition of Si was very similar in the epidermis of plants sprayed with soluble Si, plants with roots supplied with soluble Si, or plants cultivated in soil with calcium silicate. Although positive results for the foliar application of PS have been verified in young plants in different pathosystems, Cruz *et al.* (2011) did not observe positive effects of spraying PS before inoculating *P. oryzae* in young 'BR 23', 'BH 1146', and "BRS 208" wheat plants. However, in the present study, PS proved to be efficient at reducing the blast severity in young plants. This may be related to the level of aggressiveness of the isolates used in the different studies, which can be explained by the genetic variability exhibited by the pathogen over time. According to Lorenset *et al.* (2021), it is possible to verify virulence diversity in *P.oryzae* isolates obtained from a single lesion of wheat.

Although there are many doubts about the mode of action of PS via foliar application, the results of this work contradict the suggestion that potassium salts would be responsible for reducing the incidence of some diseases as a result of a direct effect on the pathogen (Liang *et al.*, 2015), since there was variation in the plant severity at different growth stages. Plants at the young stage sprayed with low doses of PS (5 and 10 g/L) had low levels of blast severity, while those at the adult stage sprayed more often with a higher dose of PS (20 g/L) were more susceptible to blast. Thus, the potassium salts in the PS are not the only factors responsible for the results observed in the experiment. According to Cruz *et al.* (2011), the effect of different products applied to reduce blast severity is dependent on the basal level of resistance of the wheat cultivar.

In silicate experiments with BR 18 and BRS 264, Pagani *et al.* (2014) verified the reduction of wheat blast in plants spraying with foliar silicate or supplied with furrow silicate. 'BR 18' cultivar demonstrated lower blast severity levels and it responds less efficiently to silicate treatments. BR 18 is the cultivar that presents the longest resistance to blast in spike. The 'BRS 264' cultivar responded more efficiently to Silicon applications in the field. In adult plants in the present work, the benefits of PS at reducing blast severity were not observed. Both cultivars used in the experiment ('BRS 208' and 'BRS Louro') are classified as susceptible to blast (Cruz *et al.*, 2010), but they did not respond efficiently to the PS application. The cultivars presented different levels of susceptibility to blast. The 'BRS 208' cultivar had a shorter incubation period, a larger AUBPC in leaves and spikes, and a higher FS compared to the 'BRS Louro' cultivar. This is probably evidence of the existence of different genes with a lower effect acting more efficiently on the 'BRS Louro' cultivar than the 'BRS 208' cultivar. Applications of PS at the end of the elongation and inflorescence stages in wheat were not efficient at increasing the concentration of Si in the plant and, consequently, did not cause a reduction of the area below

Table 5: Number of grains/spike and weight of 100 grains (g) for cultivars sprayed (+) or not sprayed (-) with potassium silicate (PS)

Cultivars	Number of grains/spike		Weight of grains	
	PS+	PS-	PS+	PS-
BRS LOURO	29.97 Aa	24.89 Ab	2,93 Aa	3,31 Ba
BRS 208	20.87 Ba	20.71 Aa	3,53 Ab	4,47 Aa
CV	15.55		17.75	

Means followed by the same letter, lower case in the row and upper case in the column, did not differ significantly by Tukey's test at 5% probability. CV = coefficient of variation.

the progress curve of yellow spot and leaf rust (Wordell Filho *et al.*, 2013). The effectiveness of silicate treatments is better when conditions for wheat blast development are less favorable. When blast pressure is high, the observed effects of silicate treatments are less pronounced (Pagani *et al.*, 2014).

In addition to contributing to maintaining resistance in various pathosystems, foliar applications of PS have been shown to benefit crops, such as wheat, maize, soybeans, and sugarcane (Liang *et al.*, 2015). According to Sousa *et al.* (2010), there is a better incidence of light and photosynthetic efficiency in maize plants sprayed with PS, a fact proven by the increase in productivity, the mass of one thousand grains, and weight of the thatch of maize plants. However, in wheat the application of PS doses did not cause changes in yield and quality of the following genotype grains: Quartz, Onyx, Linhagem (Fundacep), Campo Real, and Horizonte (Segalin *et al.*, 2013). Similar results were observed in this study with the 'BRS 208' and 'BRS Louro' cultivars that did not exhibit significant differences regarding the application of PS and yield components, such as the number of tillers and spikes/plant, the mean number of grains/spikes, and the mean weight of 100 grains (g). The benefit of PS seems to occur only in stressful situations (Liang *et al.*, 2015); this explains the results obtained in the experiment on plants that were not challenged with *P. oryzae*.

In this study, we report that different doses of PS were efficient at reducing blast severity in young wheat plants, probably due to the polymerization of the product on the leaves, which prevented the pathogen from penetrating them. Additionally, this was probably due to the effect of the product on *P. oryzae*, the modification of the osmotic potential of the leaf surface, or the activation of defense enzymes (associated with the basal resistance of the genotype) that may have contributed to reducing the colonization of the pathogen, as reported in the literature. Nevertheless, these results did not occur in adult plants, which could be associated with the efficiency of the PS under the climatic conditions, the number of applications and doses, and the response capacity of the cultivar to the product. In this sense, new studies to identify cultivars that are responsive to PS applications at the adult stage, and how this mechanism occurs at the cellular and molecular level, need to be conducted.

CONCLUSION

The results of this work indicate that foliar application of PS no provides constant protection against *P. oryzae.* PS is efficient at reducing blast severity in young wheat plants, but it is not efficient at doing this in adult plants. And, PS does not increase wheat yield indexes. Therefore, the hypothesis proposed by this work was not confirmed.

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