Occurrence of rice blast on and grain quality of irrigated rice fertilized with nitrogen and silicates

Abstract – The objective of this work was to evaluate the effects of fertilization with nitrogen topdressing and silicates, as well as of the use of fungicides, on the occurrence of rice blast on panicles, milling yield, and whole grains, vitreous grains, and chalky kernels in a flood-irrigated rice cultivar sensitive to the disease. Two experiments were conducted in a randomized complete block design, in a 4×4×2 factorial arrangement, with four replicates: in experiment 1, four doses of nitrogen × four doses of calcium and magnesium silicate on soil × with and without fungicides; and, in experiment 2, four doses of nitrogen × four doses of potassium silicate applied on leaves × with and without fungicides. At the doses above 60 kg ha⁻¹ nitrogen without fungicides, there was an increase of rice blast severity on panicles, a decrease in the percentage of whole and vitreous grains, and an increase in chalky kernels and chalky area. The greatest effects of silicates occurred without fungicides. Fungicide use reduced the severity of rice blast on panicles. Milling yield ranged from 60 to 70% in both experiments. The control of rice blast with fungicides maintains high rice grain quality, milling yield, and percentages of whole and vitreous grains.

Index terms: Oryza sativa, Pyricularia oryzae, grain yield, whole grains.

Ocorrência de brusone e qualidade de grãos em arroz irrigado adubado com nitrogênio e silicatos

Resumo – O objetivo deste trabalho foi avaliar os efeitos da adubação com nitrogênio em cobertura e silicatos, bem como da utilização de fungicidas, sobre a ocorrência de brusone nas panículas, a renda do benefício e os grãos inteiros, vítreos e gessados, em cultivar de arroz irrigado por inundação sensível à doença. Foram conduzidos dois experimentos em delineamento de blocos ao acaso, em arranjo fatorial 4×4×2, com quatro repetições: no experimento 1, quatro doses de nitrogênio × quatro doses de silicato de cálcio e magnésio via solo × com e sem uso de fungicidas; e, no experimento 2, quatro doses de nitrogênio × quatro doses de silicato de potássio via foliar × com e sem fungicidas. Nas doses acima de 60 kg ha⁻¹ de nitrogênio sem fungicidas, houve aumento da severidade de brusone nas panículas, redução do percentual de grãos inteiros e vítreos, e aumento de grãos gessados e área gessada. Os maiores efeitos dos silicatos ocorreram sem aplicações de fungicidas. O uso de fungicidas reduziu a severidade de brusone nas panículas. A renda do benefício oscilou entre 60 e 70%, em ambos os experimentos. O controle da brusone com fungicidas mantém elevadas a qualidade de grãos do arroz, a renda do benefício e as percentagens de grãos inteiros e vítreos.

Termos para indexação: Oryza sativa, Pyricularia oryzae, rendimento do grão, grãos inteiros.
Introduction

Rice (Oryza sativa L.) is one of the most important cereals for the world population and much of its consumption is in the form of whole milled kernels. Therefore, grain quality is a characteristic that determines the value paid to the producer and is a decisive factor for the consumer at the time of purchase (Fang et al., 2015).

The physical quality of the grain, expressed by milling yield, whole grains, and grain dimensions and characteristics, steers the commercialization process (Mingotte et al., 2012). According to the Brazilian legislation, milling yield is considered as the percentage of milled rice or of milled and polished rice, resulting from the rice milling process (Brasil, 2009). In the Brazilian market, the preference is for grains with a high milling yield of over 70%, without defects and with a high whole grain yield above 60% (Reunião Técnica…, 2018). The characteristics of whole grains, vitreous grains, and chalky kernels, as well as staining defects, are affected by physiological disturbances caused by biotic or abiotic factors and result in the depreciation of the final product (Streck et al., 2018). Therefore, the improvement of grain quality is one of the main selection criteria in breeding programs.

The increase in productivity and grain quality, however, requires a greater use of agricultural inputs and an adequate management of the crop, which increases the cost of production. One of the items with the largest participation in this cost is the management of basic fertilization and topdressing (Irga, 2018) due to the greater requirement of nitrogen, one of the most limiting nutrients to the crop (Ahmed et al., 2016). However, the supply of N at high doses may increase the susceptibility of plants to rice blast (Huang et al., 2017).-2

Materials and Methods

Two experiments were installed in the paddy field, during the 2014/2015 crop season, in the experimental area of the Department of Plant Science of Universidade Federal de Santa Maria, located in the state of Rio Grande do Sul, Brazil (29º43’S, 53º43’W, at 90 m of altitude). The local climate is Cfa, subtropical humid, according to Köppen-Geiger’s classification, adapted from Alvares et al. (2013), without a dry season and with the average temperature of the hottest month exceeding 22ºC. The air temperature and precipitation during the experimental period are shown in Figure 1. The soil is classified as a Planossolo Háplico eutrófico arênico (Santos et al., 2013), i.e., a sandy Eutrophic Haplic Alfisol, with the following chemical characteristics: pH_{H_2O} (1:2.5) 6.0, 1.7 dag kg^{-1} organic matter, 23 mg dm^{-3} P-Mehlich-1, 49 mg dm^{-3} K, 5.0 cmol c dm^{-3} Ca, 0.2 cmol c dm^{-3} Mg, 9.0 cmol c dm^{-3} S, 0.0 cmol c dm^{-3} Al, 6.0 mg dm^{-3} Si_{CaCl_2}, Al saturation of 0.0%, and base saturation of 65.5%.

The experimental design was a randomized complete block, in a 4x4x2 factorial arrangement with four replicates. In experiment 1, the treatments were composed of four N doses (0, 60, 120, and 180 kg ha^{-1})
applied as topdressing, of four Ca and Mg silicate doses (85% effective Ca carbonate equivalent, 25% Ca, 6% Mg, 10.5% Si, and 22.4% SiO₂, the product is a steel residue, derived from stainless steel slag) applied to the soil surface without incorporation at the time of sowing 0, 3,000, 6,000, and 9,000 kg ha⁻¹ seeds, and the use or not of the mixture of fungicides with tricyclazole, azoxystrobin, and difenoconazole as active ingredients. In experiment 2, the treatments were composed of four N doses applied as topdressing (0, 60, 120, and 180 kg ha⁻¹) and four K silicate doses [K₂SiO₃ (10% Si, 24% K₂O, and a density of 1.41 g cm⁻³)] applied on leaves (0.0, 2.9, 5.8, and 8.7 L ha⁻¹), with a stem volume of 135 L ha⁻¹ and the use or not of the same fungicide mixture of experiment 1.

For both experiments, all management practices followed the technical recommendations for flood-irrigated rice cultivation (Reunião Técnica..., 2014), except the applied treatments. The cultivar used was Guri INTA CL, with a medium cycle of 125 to 130 days, susceptibility to rice blast, and high grain quality. Seeding was performed on December 8, 2014, at a density of 80 kg ha⁻¹ seeds, in the minimum tillage system. Each plot was formed by nine rows spaced at 0.17 m, totaling 3,825 m². Basic fertilization was carried out in the sowing line with 16 kg ha⁻¹ N, 68 kg ha⁻¹ P₂O₅, and 108 kg ha⁻¹ K₂O. For topdressing, urea was used as the source of N – two thirds of the doses were applied in the V₃/V₄ stage and the remainder in R₆, according to the scale proposed by Counce et al. (2000). The fungicides were applied four times, when the first blast spots appeared, between the V₆ and V₇ growth stages, by spraying 225, 100, and 50 g a.i. ha⁻¹, respectively, of the mixture of tricyclazole, azoxystrobin, and difenoconazole. For this, a backpack sprayer propelled by CO₂, with a pressure of 40 lbs pol⁻² and 135 L ha⁻¹ stem volume, with the addition of 0.5% v/v emulsifiable mineral oil, was used.

Panicle blast severity was measured at the R₈ growth stage, using a scale of 0 to 100% on 1 m of the second seeding line (Silva-Lobo et al., 2012). Milling yield was considered the percentage of milled and polished rice obtained by weighing the grains after processing 100 g rice with husk (Brasil, 2009); using a rice-testing machine to test rice samples. The percentage of whole grains was calculated according to the method described in Teló et al. (2011).

The variables related to grain quality (vitreous grains, white-belly grains, chalky kernels, and chalky area) were evaluated using the S21 statistical rice analyzer (iSuzuki Software, Santa Cruz do Rio Pardo, SP, Brazil). Coupled to a computer, this equipment captures and processes images that analyze the individual grains using a digital image analysis software to calculate grain quality parameters; after sample processing, it provides reports to the equipment.

Figure 1. Maximum and minimum air temperature, and rainfall in the experimental period during the 2014/2015 rice (Oryza sativa) crop season in the municipality of Santa Maria, in the state of Rio Grande do Sul, Brazil.
operator. The software considers vitreous grains as those with less than 25% chalky area, chalky grains as those with 70% or more chalky area, and white-belly grains as those with a chalky area that represents between 40 and 70% of the grain surface.

The results of the experiments were subjected to the tests of assumptions of the mathematical model for normality and homogeneity of variances. The analysis of variance was performed using the F-test. The means were subjected to the polynomial regression analysis, and the confidence interval of $p \leq 0.05$ was determined. The data of the variables panicle blast severity and chalky kernels, for both experiments, and of white-belly grains, for experiment 1, were transformed according to the equation: $y_t = \sqrt{(y + 0.5)}/100$.

**Results and Discussion**

The climatic conditions in the 2014/2015 crop season (Figure 1), such as temperature and frequent rains, were one of the factors that favored the occurrence of rice blast. When fungicides were applied, the percentages of disease severity were lower than 2%, regardless of the N dose used (Figure 2). However, when the rice plants were not treated with fungicides, the effect of N doses on panicle blast severity differed. There was an increase in severity with the highest doses, with a mean of 3, 3, 56, and 67% panicle blast severity for 0, 60, 120, and 180 kg ha$^{-1}$ N, respectively. The lower incidence of the disease with the lower N doses could be explained by the lower development of the aerial part of the plants, which may have decreased humidity between lines and created unfavorable conditions for the fungus. Huang et al. (2017) also found increased rice blast severity with high levels of N fertilization. With the higher availability of nutrients due to this fertilization, the fungus is able to detect the metabolic modifications of the host when in contact with the leaf surface, accelerating its growth. In this case, the susceptibility to fungicides with systemic activity allows protecting the plants from infection by reducing mycelial growth and the germination of conidia (Chen et al., 2015; Pak et al., 2017). In studies conducted in China, the fungicide azoxystrobin presented more than 73% efficacy in rice blast control (Chen et al., 2015).

There was an interaction between N, Ca, and Mg silicate doses and fungicides in the percentage of milling yield, whole grains, and vitreous grains...
Figure 3. Milling yield (A and B), whole grains (C and D), and vitreous grains (E and F) for the Guri INTA CL flood-irrigated rice (*Oryza sativa*) cultivar, according to doses of nitrogen, calcium, and magnesium silicate, without (A, C, and E) and with (B, D, and F) fungicide applications in the 2014/2015 crop season.
The values for milling yield, regardless of the application or not of fungicides, remained between 68 and 71%. However, the high rice blast severity index presented in the crop’s vegetative development stage directly affected grain filling, resulting in a lower rice grain quality. This justifies the decrease in the percentage of whole grains with the increase of N doses, which, without fungicide application, increased the amount of broken grains. Groth (2006) concluded that rice plants with panicle blast severity from 32 to 69% showed whole grain parameters and milling yield with values considered inferior to the commercial standards of 55 and 70%, respectively; however, it should be noted that under conditions of low disease pressure, the values obtained in the present study are acceptable. The same author, when evaluating the M202 cultivar, which is very susceptible to rice blast, observed a reduction of 23% in whole grain yield when fungicides were not used for disease control. This happens because rice blast, especially of the neck, compromises the ability of the plant to transport nutrients to the panicles, which affects grain filling.

The percentage of whole grains remained from 55 to 60% with the use of fungicides, but decreased to 45 to 54% when no fungicides were applied (Figure 3). A similar pattern was observed for vitreous grains, whose percentage varied from 49 to 57% with the use of fungicides and from 30 to 49% without their application. There was a difference between the doses of silicates in the absence of fungicides, and the values of both vitreous and whole grains were lower than those obtained with fungicide use, which resulted in the highest percentages. The lowest percentages of 38.42 and 39.67% vitreous grains were found in plants without fungicides, in the combinations of 120 kg ha\(^{-1}\) N with 6,000 kg ha\(^{-1}\) Ca and Mg silicate and of 180 kg ha\(^{-1}\) N with 3,000 kg ha\(^{-1}\) silicates, respectively. Similar results were reported by Artigiani et al. (2012) and Reis et al. (2008), who did not find that the application of these silicates affected milling yield and whole grains. A possible explanation is that the Si available in the soil may have supplied the needs of the rice plants (Artigiani et al., 2012).

The use of fungicides was efficient in panicle blast control and maintained the amounts of whole and vitreous grains. This happened because in the R\(_5\) to R\(_9\) stages, when grain filling occurs, the leaves and panicles were healthy. When blast attacks the knot below the panicle, it can interrupt the flow of photoassimilates to the grains, which interferes with their filling and mass, causing greater losses in productivity (Hao et al., 2014).

The white belly and chalky kernel parameters were influenced by the doses of N, Ca, and Mg silicate, as well as by the fungicides (Figure 4). Regarding these characteristics, a better grain quality was found in the treatments that received fungicide application. The defect white-belly grains was observed at an average of 3 to 9% and of 0.8 to 4%, without and with the application of fungicides, respectively. The lowest percentage of 0.8% was a result of the combination of 120 and 180 kg ha\(^{-1}\) N, with the application of fungicides and without the application of silicates.

Silicate application did not reduce the percentage of grains (Figure 4), since, at the dose of 9,000 kg ha\(^{-1}\) Ca and Mg silicate with the application of 120 and 180 kg ha\(^{-1}\) N, there was an increase in grains. Kornndörfer & Datnoff (1995), however, found that the use of Si in crops efficiently controls or minimizes the incidence of diseases. Chalky area was also affected by increased N doses and fungicide application, which resulted in a lower chalky area. Similar results were obtained by Grigg et al. (2016). The data of the variables milling yield, whole grains, vitreous grains, chalky kernels, and white-belly grains had linear and quadratic adjustments (Table 1).

There was a triple interaction between all treatments only for milling yield, with values ranging from 60 to 71% (Figure 5 and Table 2). In the absence of fungicides, there were different responses to K silicate applications, without increases in milling yield when the doses of N and K silicate were increased. In fact, the lowest percentages of milling yield were observed for 8.7 L ha\(^{-1}\) K\(_2\)SiO\(_3\). This can be explained by the difference in the absorption of the applied product by the leaves and the architecture of the plants at the moment of application, among other factors that compromise foliar absorption (Fernández & Brown, 2013).

The percentage of whole grains was influenced by N fertilization, by the doses of K silicate, and by the interaction between N doses and fungicide applications (Figure 5). Regardless of the N doses, the percentage of whole grains remained at 56% for plants that received fungicides. However, the percentage of vitreous grains was only affected by N doses and
Figure 4. White-belly grains (A and B), chalky kernels (C and D), and chalky area (E) for the Guri INTA CL flood-irrigated rice (*Oryza sativa*) cultivar, according to doses of nitrogen, calcium, and magnesium silicate, without (A and C) and with (B and D) fungicide applications in the 2014/2015 crop season.
fungicide applications. The absence of fungicides caused a decrease in vitreous grains with increasing N doses, with the lowest value of 37% at the doses of 120 and 180 kg ha\(^{-1}\) N. When fungicides were applied to the rice plants, higher percentages of milling yield and of whole and vitreous grains were obtained with constant values, regardless of the use of K silicate. Bordin et al. (2016), while evaluating the application of fungicides at different phenological stages of irrigated rice cultivars, reported that, when the disease was less severe, there was a higher percentage of milling yield and whole grains.

The combined action of N, K silicate, and fungicides was only observed in white-belly grains, with a chalky area between 40 and 70% of the surface (Figure 6). The lowest percentages of white-belly grains ranged from 1.0 to 3.6 and the highest ones from 1.7 to 7.0, with and without the use of fungicides, respectively. There was no difference between doses of K silicate regarding the occurrence or reduction of white-belly

### Table 1. Equations and coefficients of determination (R\(^2\)) of the used regressions, according to nitrogen, calcium, and magnesium silicate doses and to fungicides applied to the Guri INTA CL flood-irrigated rice (Oryza sativa) cultivar.

| Treatment | Without fungicide application | With fungicide application |
|-----------|-------------------------------|---------------------------|
|           | Equation | R\(^2\) | Equation | R\(^2\) |
| Panicle blast severity (%) | | | | |
| 0 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0394x + 1.8037* | 0.817 | ns | - |
| 3,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0431x + 0.9967* | 0.844 | ns | - |
| 6,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0001x\(^2\) + 0.0190x + 1.2631* | 0.846 | ns | - |
| 9,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0007x\(^2\) + 0.0299x + 0.7719* | 0.860 | ns | - |

| Milling yield (%) | | | | |
| 0 kg ha\(^{-1}\) Ca and Mg silicate | ns | - | y = 0.0095x + 69.0683* | 0.765 |
| 3,000 kg ha\(^{-1}\) Ca and Mg silicate | ns | - | y = 0.0062x + 68.9900* | 0.534 |
| 6,000 kg ha\(^{-1}\) Ca and Mg silicate | ns | - | ns | - |
| 9,000 kg ha\(^{-1}\) Ca and Mg silicate | ns | - | ns | - |

| Whole grains (%) | | | | |
| 0 kg ha\(^{-1}\) Ca and Mg silicate | y = -0.0234x + 49.4541* | 0.370 | y = 0.0135x + 54.7975* | 0.561 |
| 3,000 kg ha\(^{-1}\) Ca and Mg silicate | y = -0.0003x\(^2\) + 0.0182x + 53.0387* | 0.829 | ns | - |
| 6,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0013x\(^2\) - 0.2716x + 55.3012* | 0.717 | y = 0.0003x\(^2\) - 0.0615x + 58.7337* | 0.836 |
| 9,000 kg ha\(^{-1}\) Ca and Mg silicate | y = -0.0402x + 53.5100* | 0.979 | y = -0.0003x\(^2\) + 0.0683x + 54.5775* | 0.757 |

| Vitreous grains (%) | | | | |
| 0 kg ha\(^{-1}\) Ca and Mg silicate | y = -0.0300x + 45.8830* | 0.808 | ns | - |
| 3,000 kg ha\(^{-1}\) Ca and Mg silicate | y = -0.0494x + 49.7326* | 0.891 | ns | - |
| 6,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0009x\(^2\) - 0.1879x + 50.0506* | 0.841 | ns | - |
| 9,000 kg ha\(^{-1}\) Ca and Mg silicate | y = -0.0508x + 49.9587* | 0.872 | ns | - |

| White-belly grains (%) | | | | |
| 0 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.00005x\(^2\) - 0.0132x + 2.9649* | 0.955 | y = 0.00004x\(^2\) - 0.0101x + 1.8894* | 0.987 |
| 3,000 kg ha\(^{-1}\) Ca and Mg silicate | ns | - | y = -0.0046x + 2.0113* | 0.960 |
| 6,000 kg ha\(^{-1}\) Ca and Mg silicate | ns | - | y = 0.00004x\(^2\) - 0.0118x + 2.0978* | 0.998 |
| 9,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.00003x\(^2\) - 0.0061x + 2.3108* | 0.739 | y = -0.0045x + 2.0115* | 0.942 |

| Chalky kernels (%) | | | | |
| 0 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0061x + 0.9743* | 0.967 | ns | - |
| 3,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0044x + 0.9135* | 0.960 | ns | - |
| 6,000 kg ha\(^{-1}\) Ca and Mg silicate | y = -0.00002x\(^2\) + 0.0092x + 0.8887* | 0.940 | ns | - |
| 9,000 kg ha\(^{-1}\) Ca and Mg silicate | y = 0.0084x + 0.7151* | 0.950 | ns | - |

*Significant by the F-test, at 5% probability. **Nonsignificant. - Not applicable.
Figure 5. Milling yield (A and B), whole grains (C and D), and vitreous grains (E) for the Guri INTA CL flood-irrigated rice (*Oryza sativa*) cultivar, according to doses of nitrogen and potassium silicate, without (A) and with (B) fungicide applications in the 2014/2015 crop season.
grains. The responses of rice plants treated with Si varied according to the levels of resistance and the different modes of action of each product applied (Nascimento et al., 2018). Furthermore, the x-ray microanalysis showed that the deposition of Si in rice plants applied via soil occurs on both sides of the leaf, while that of K silicate occurs only on the adaxial side. This may be one of the possible explanations for the greater disease control when Si is applied via soil (Rezende et al., 2009).

The occurrence of chalky kernels was influenced by the combination of N doses and fungicides and of K silicate doses and fungicides. The percentage of chalky kernels was below 1% with N doses associated with fungicides, but above 1% without fungicides (Figure 6). The chalky area was affected by the doses of N and of K silicate, as well as by fungicide applications (Table 3).

Therefore, when there was control of rice blast with fungicides, the percentages of chalky kernels and chalky area were lower. Zhou et al. (2015) evaluated fertilization with N doses in 351 cultivars of the Indica group, and observed that the percentage of chalky kernels decreased with increasing doses of N due to the higher accumulation of protein and starch in the grains.

In general, the occurrence of panicle blast in field experiments causes reductions in the industrial quality of rice grains.

The characteristics related to grain quality add a higher value of commercialization to the cereal; in the present study, their values remained constant with the use of fungicides, regardless of the application of silicates. The greater the presence of certain parameters, such as white-belly grains, chalky kernels, and chalky area, the lower the consumer’s

### Table 2. Equations and coefficients of determination (R²) of the used regressions, according to nitrogen and potassium silicate doses and to fungicides applied or not to the Guri INTA CL flood-irrigated rice (*Oryza sativa*) cultivar.

| Treatment                      | Without fungicide application | Equation                                                                 | R²    | With fungicide application | Equation                                                                 | R²    |
|--------------------------------|-------------------------------|-------------------------------------------------------------------------|-------|----------------------------|-------------------------------------------------------------------------|-------|
|                                |                               | Milling yield (%)                                                       |       |                            |                                                                         |       |
| 0 L ha⁻¹ K silicate            |                               | y = 0.0006x² - 0.1308x + 70.7908*                                      | 0.669 | ns                         |                                                                         |       |
| 2.9 L ha⁻¹ K silicate          |                               | y = 0.0005x² - 0.1457x + 61.2837*                                      | 0.942 | ns                         |                                                                         |       |
| 5.8 L ha⁻¹ K silicate          |                               | ns                                                                      |       | ns                         |                                                                         |       |
| 8.7 L ha⁻¹ K silicate          |                               | y = -0.0004x² + 0.0812x + 62.8908*                                    | 0.428 | ns                         |                                                                         |       |
|                                |                               | White-belly grains (%)                                                 |       |                            |                                                                         |       |
| 0 L ha⁻¹ K silicate            |                               | y = -0.0001x² + 0.0259x + 2.2106*                                     | 0.563 | ns                         |                                                                         |       |
| 2.9 L ha⁻¹ K silicate          |                               | y = -0.0001x² + 0.0404x + 1.4812*                                     | 0.886 | ns                         |                                                                         |       |
| 5.8 L ha⁻¹ K silicate          |                               | y = -0.0002x² + 0.0555x + 3.6481*                                     | 0.678 | ns                         | y = -0.0120x + 3.1137*                                                 | 0.744 |
| 8.7 L ha⁻¹ K silicate          |                               | y = 0.0002x² - 0.0333x + 3.0273*                                      | 0.980 | ns                         |                                                                         |       |

*Significant by the F-test, at 5% probability. nsNonsignificant. - Not applicable.

### Table 3. Equations and coefficients of determination (R²) of the used regressions, according to nitrogen and potassium silicate doses applied to the Guri INTA CL flood-irrigated rice (*Oryza sativa*) cultivar.

| Treatment                      | Equation                                                                 | R²    |
|--------------------------------|-------------------------------------------------------------------------|-------|
|                                | Whole grains (%)                                                        |       |
| 0 L ha⁻¹ K silicate            | y = 0.0006x² - 0.1435x + 54.9657*                                       | 0.965 |
| 2.9 L ha⁻¹ K silicate          | ns                                                                      | -     |
| 5.8 L ha⁻¹ K silicate          | ns                                                                      | -     |
| 8.7 L ha⁻¹ K silicate          | y = -0.0328x + 52.7128*                                                | 0.658 |
|                                | Chalky area (%)                                                         |       |
| 0 L ha⁻¹ K silicate            | ns                                                                      | -     |
| 2.9 L ha⁻¹ K silicate          | ns                                                                      | -     |
| 5.8 L ha⁻¹ K silicate          | y = -0.0004x² + 0.0263x + 16.7026*                                     | 0.995 |
| 8.7 L ha⁻¹ K silicate          | ns                                                                      | -     |

*Significant by the F-test, at 5% probability. nsNonsignificant. - Not applicable.
Figure 6. White-belly grains (A and B), chalky kernels (C and D), and chalky area (E and F) for the Guri INTA CL flood-irrigated rice (*Oryza sativa*) cultivar, according to doses of nitrogen and potassium silicate, without (A) and with (B) fungicide applications in the 2014/2015 crop season.
acceptance of the product, reducing the amount paid to the producer. The obtained results show that the use of fungicides continues to be the most efficient method to control the disease, especially at high levels of severity. However, the use of silicates mainly via soil has shown to be promising, requiring more studies to prove its efficacy.

Conclusions

1. The control of rice blast with fungicides keeps the quality of rice (Oryza sativa) grains, milling yield, and the percentages of whole and vitreous grains elevated.
2. Doses above 60 kg ha⁻¹ nitrogen, without the application of fungicides, decrease the percentage of whole and vitreous grains, but increase the rates of chalky kernels in cultivars sensitive to rice blast.
3. Fertilization with calcium, magnesium silicate, and potassium silicate, without the application of fungicides, has a greater effect on resistance to rice blast, on the occurrence of vitreous grains and chalky kernels, and on milling yield in flood-irrigated rice cultivars sensitive to the disease.

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