Performance of lowland rice seeds coated with dolomitic limestone and aluminum silicate[1]

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ABSTRACT - The objective of this study was to evaluate the performance of seeds of two cultivars of lowland rice (*Oryza sativa* L.), coated with dolomitic limestone and aluminum silicate. It was used a completely randomized experimental design, with the treatments arranged in a 4 X 2 factorial scheme [4 treatments: dolomitic limestone; dolomitic limestone + aluminum silicate; aluminum silicate, at the dosages of 50 g/100 kg of seeds; and control (without the products) X 2 cultivars: IRGA424 and IRGA 422 CL], totaling eight treatments with four replications each. The variables analyzed were: fresh and dry weights of aerial biomass; plant height; leaf area at 10, 20, and 30 days after emergence (DAE). The physiological quality of seeds was also assessed using tests of: seed emergence; first count of germination; emergence speed index; and field emergence. It was concluded that the coating of rice seeds with dolomitic limestone and aluminum silicate does not affect seed germination and field seedling emergence. Aluminum silicate used via seed coating on cultivar IRGA 424 promoted greater leaf area, after 20 DAE. The dolomitic limestone and the aluminum silicate used via seed coating generated plants with larger dry biomass, after 20 DAE, for the cultivar IRGA 422 CL.

Index terms: *Oryza sativa*, seed coating, physiological quality.

Desempenho de sementes de arroz irrigado recobertas com calcário dolomítico e silicato de alumínio

RESUMO – O objetivo do presente trabalho foi avaliar o desempenho de sementes de duas cultivares de arroz irrigado (*Oryza sativa* L.), recobertas com calcário dolomítico e silicato de alumínio. O delineamento experimental utilizado foi inteiramente casualizado com os tratamentos arranjados em esquema fatorial 4 X 2 [4 tratamentos: calcário dolomítico; calcário dolomítico + silicato de alumínio; silicato de alumínio, na dosagem de 50 g/100 kg de sementes; e testemunha (sem os produtos) X 2 cultivares IRGA424 e IRGA 422 CL], totalizando oito tratamentos, com quatro repetições cada. As variáveis analisadas foram: biomassa fresca e seca da parte aérea; altura de planta; e área foliar aos 10, 20 e 30 dias após a emergência (DAE) A qualidade fisiológica das sementes também foi avaliada pelos testes de: germinação; primeira contagem de germinação; índice de velocidade de emergência; e emergência em campo. Concluiu-se que o recobrimento de sementes de arroz com calcário dolomítico e silicato de alumínio não afetam a germinação e a emergência das plântulas em campo. O silicato de alumínio, utilizado via recobrimento de sementes na cultivar IRGA 424, promoveu maior área foliar após os 20 DAE. O calcário dolomítico e o silicato de alumínio, usados via recobrimento de sementes, geram plantas com maior fitomassa seca após os 20 DAE, na cultivar IRGA 422 CL.

Termos para indexação: *Oryza sativa*, recobrimento, qualidade fisiológica.

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Introduction

In the State of Rio Grande do Sul, the southernmost state of Brazil, the rice crop occupies an area of approximately one million hectares, which composes one of the most technological crop lands in the country, with a mean productivity higher than 7.0 metric tons per hectare (CONAB, 2009).

Among the several different techniques that contribute for productivity increases in the rice crop, soil fertilization with nutrients is essential and among the most important nutrients for that crop is the silicon (Si), which favors growth and development of rice plants with significant increases on productivity; besides, this element provides increases on plant resistance to several different diseases affecting the crop (Savant et al., 1997a). On experiments for assessing the effect of calcium silicate on the rice crop, it has been observed a positive correlation of different dosages of this component on the Si concentration in the straw and in the shells of rice grains, with increases of more than 100% as compared to treatments without calcium silicate (Barbosa Filho and Prabhu, 2002). According to Santos et al. (2003), Si fertilization increased 47% the productivity of rice grains. For Deren et al. (1994), the use of Si has promoted improvements on plant architecture and photosynthesis, as a result of a smaller opening of the angle in the leaf insertion, what makes the leaves more erected, thus diminishing the plant self-shading and consequently promoting a better use of solar energy.

In addition, calcium and magnesium, the so called cationic macro-elements or elements that are conveyed through mass flux, also stand out (Barber, 1974). In irrigated crops, cultivated in acid soils, where a natural pH elevation occurs through inundation with a consequent inhibition of aluminum action, rice responses to liming may also occur; mainly on soils with extreme acidity and low contents of calcium and magnesium (Barbosa Filho, 1987). In this context, not only the importance of calcium in plant and in soil cultivated with lowland rice should be taken into account (Patella, 1976); but also the role of magnesium on phosphorus uptake by the rice plant should be considered (Fageria, 1984).

According to Mauad et al. (2003), reductions in rice productivity in several different regions throughout the world are correlated to several factors, among which the low availability of nutrients or beneficial elements such as silicon. In the Si case, some factors may be associated to its low availability for plants grown in soils such as: (a) many soils of tropical and subtropical rice producing areas display variable degrees of desilification; (b) the kinetics of Si dissolution is too much low; and (c) the Si of the soil solution is absorbed by sesquioxides that are present in many tropical soils (Savant et al., 1997b).

Calcium has many effects on plant growth and development since it improves photosynthesis and other processes as cellular division, cytoplasmic movements and augmentation of cellular volume (Malavolta et al., 1997). The use of limestone as source of calcium and magnesium was chosen because it is a less costly and because extensive reservoirs of calcium exist distributed throughout Brazilian territory (Fageria, 2001).

Thus, the use of production methods and technologies, as the seed coating, have become each time more a requirement of the competitive market. But, for reaching such new findings, further research on evaluating seeds with a safer field seedling emergence and with higher production potential are still needed.

Within this context, the objective of this research work was to evaluate the performance of two lowland rice cultivars starting form seeds coated with dolomitic limestone and aluminum silicate, as well as with a combination of these two products.

Material and Methods

The research work was carried out during the 2009/2010 crop season in the Didactic Laboratory of Seed Analysis and under greenhouse conditions in the College of Agronomy Eliseu Maciel of the Federal University of Pelotas, Capão do Leão Campus, State of Rio Grande do Sul, Brazil. Seeds of two lowland rice cultivars IRGA 424 and IRGA 422 CL, produced during the 2008/2009 crop season by the Hadler Hasse Seed Company were used in the experiments.

Before the sowing procedure, seeds were coated with the following products: fludioxinil + metalaxyl-M (25 g/L + 10 g/L), trade mark Maxim-XL®, in the dosages of 100 mL/100 kg seeds; dolomitic limestone and aluminum silicate; and finally covered with the polymer Sepiret® in the dosage of 300 mL/100 kg seeds. It is worth to stress that H_2O was added at the same proportion, thus providing a volume of the mixture (fungicide + nutrients + polymer + H_2O) of 700 mL/kg seeds. The source of the silicon used was aluminum silicate, which is a whitish non-toxic dust of ground rock, containing 77.9% SiO2; 23.73% Al_2O_3; 0.23% CaO; 0.36% K_2O; and pH 5.5. The source of Ca and Mg was the dolomitic limestone, which contains calcium oxide (CaO) and magnesium oxide (MgO) with a Relative Power of Total Neutralization (RPTN) of 75% and reactivity of 77%.

A completely randomized experimental design was used, with the treatments arranged into a 4 X 2 factorial scheme [4 treatments: dolomitic limestone + aluminum silicate; dolomitic limestone; aluminum silicate (all products used in the dosage of 50 g/100 kg seeds); and control (without the products) X 2 cultivars IRGA 424 and IRGA 422 CL]. Seeds of the two cultivars were treated into a plastic bag with the following order of products application: fungicide + dolomitic limestone + aluminum silicate + polymer. All these products were directly placed, one after other, at the bottom of a plastic bag, until approximately 15 cm high. In sequence, a seed sample of 200 g was placed into the bag, which was then agitated during three minutes. Immediately after treatment the seeds were placed to dry, under room temperature, for 24 h (Nunes, 2005).

After the sowing, carried out into 1.0 m x 6.0 m plots (experimental units), these plots were then daily irrigated in a manner to maintain the soil from close to field capacity until flooding.

After coating, the seed quality was evaluated in the laboratory by means of the following tests: *Germination (G)* – performed with four replications of 50 seeds each, for each treatment. Seeds were arranged on top of three sheets of paper towel, previously moistened with sterile distilled H_2O in the proportion of 2.5 times the weight of dry substrate and were then maintained into a seed germinator at a temperature of 25 ºC for fourteen days. Evaluations were performed according to Rules for Seed Testing (Brasil, 2009) and results were expressed on percent normal seedlings; *First Count of Germination (FCG):* carried out seven days after sowing and using the seeds of the germination test; *Accelerated Aging (AC):* performed into individual plastic germination boxes (Gerbox) topped with a metallic screen, into which 40 ml of sterile distilled H2O was added at the bottom. On top of the screen, 50 seeds of each treatment and each replication were uniformly distributed on a single layer. Immediately after the gerbox containing seeds were lidded and placed into a BOD type incubator, at 42 ºC for 96 h. After that time span, seeds were subjected to the germination test (Delouche and Baskin, 1973).

The sowing of coated seeds was carried out in experimental units containing natural soil into which nutrients nitrogen, phosphorus and potassium were incorporated at sowing moment. Prior to sowing and after the coating, the seed quality was evaluated by the following tests: *Emergence Speed Index (ESI)* – obtained from field seedling emergence test. For that, a daily counting of normal seedlings was performed until the 21st day after emergence (DAE). The seedling emergence speed index was computed using the equation proposed by Maguire (1962*); Field emergence (FE):* four replications of 100 seeds each, per each treatment, were sown and the test was carried out jointly with the ESI test. The evaluations were performed at the 21st DAE, by determining the percentage of seedling emergence (Nakagawa, 1994). The experimental units were daily irrigated until flooding, thus maintaining soil close to field water capacity.

Seedling samples were collected for evaluating initial growth and afterwards the following determinations were performed: fresh weight of aerial part (FW); plant height (PH); leaf area (LA); and dry weight of aerial part (DW). For such determinations, five seedlings were randomly collected from each treatment and replication, which were cut at the soil level at 10, 20, and 30 DAE. Measurement of FW was performed by weighing the samples using a centesimal precision scale. Determination of LA was achieved with the aid of a photoelectric leaf-area meter (Area Meter, model LI-3100, Li-cor Ltd. brand), which provides a direct reading in cm^2. For PH determination, a millimeter ruler was used and results were expressed in cm. The DW was obtained by the oven method, at 60 ºC, into which seedling were maintained for a 72 h period and then weighed on a centesimal precision scale. With results obtained from evaluations of LA and DW the following parameters were determined: crop growth rate (CGR – $mg.day^{-1}$); relative growth rate (RGR – $mg.g.day^{-1}$); and net assimilation rate (NAR – $mg.cm^2.day^{-1}$). These determinations were based on methodology described by Gardner et al. (1985) in which $CGR = (DM_2 - DM_1)/(T_2 - T_1)$; $RGR = (\ln DM_2 - DM_1)/(T_2 - T_1)$; $NAR = (MS_2 – MS_1)/(T_2 - T_1) * (\ln LA_2 - \ln LA_1/(LA_2 - LA_1)$; where DM= dry matter, T= time, and LA= leaf area.

For statistical analysis, the Windows Statistical Analysis System – Winstat, Version 2.0 (Machado and Conceição, 2003) was used and the treatment means were compared by the Duncan test at 5% probability.

Results and Discussion

By observing data shown on Table 1, it can be verified that the seed coating with dolomitic limestone and aluminum silicate had better performance than the remaining treatments for the variable FCG, for both cultivars studied. Result means obtained for the rice cultivars IRGA 424 and IRGA 422 CL did not statistically differ between each other when seeds were subjected to coating with the nutrients studied. This behavior was also observed in the germination test. It can likewise be observed that the seed coating with both nutrients did not affect seed germination for the cultivars in study.

Table 1. Mean of values for: first count of germination (FCG); germination (G); accelerated aging (AA); emergence speed index (ESI); and field seedling emergence (FE), obtained from two cultivars of lowland rice seeds coated with dolomitic limestone and aluminum silicate, both either alone or in combination.

Variable	Treatment	Cultivar		Mean
		IRGA 424	IRGA 422 CL	
FCG (%)	Dolomitic limestone + aluminum silicate	77 A*	75 A*	76 a*
	Dolomitic limestone	71 A	72 A	72 ab
	Aluminum silicate	72 A	67 A	70 b
	Control	71 A	72 A	72 ab
	CV (%)	5.9		
G (%)	Dolomitic limestone + aluminum silicate	90 A	93 A	92 a
	Dolomitic limestone	91 A	86 A	89 a
	Aluminum silicate	92 A	87 A	90 a
	Control	88 A	87 A	88 a
	CV (%)	5.3		
AA (%)	Dolomitic limestone + aluminum silicate	92 A	94 A	93 a
	Dolomitic limestone	91 A	84 B	88 b
	Aluminum silicate	91 A	85 B	88 b
	Control	92 A	84 B	88 b
	CV (%)	4.4		
ESI	Dolomitic limestone + aluminum silicate	2.82 B	2.95 A	2.89 a
	Dolomitic limestone	2.75 B	3.52 A	3.40 a
	Aluminum silicate	3.02 B	3.27 A	3.15 a
	Control	2.80 B	3.32 A	3.06 a
	CV (%)	10.8		
FE (%)	Dolomitic limestone + aluminum silicate	79 A	79 A	79 a
	Dolomitic limestone	75 B	92 A	84 a
	Aluminum silicate	77 B	84 A	81 a
	Control	76 B	85 A	81 a
	CV (%)	10.2		

*Means followed by the same small letter in the column and capital letter in the line for each response variable are not statistically different between each other by the Duncan test at 5% probability.

Concerning the variable AA, it was verified that seed treatment with dolomitic limestone and aluminum silicate had a superior performance as compared to the other treatments. Cultivar IRGA 424 had a better performance than cultivar IRGA 422 CL. Related to tests ESI and FE, it can be noticed that the seed coating with nutrients did not alter neither speed of seedlings establishment nor the number of field emerging seedlings. The cultivar IRGA 422 CL has had faster initial establishment as well as higher percentage of emerging seedlings than the cultivar IRGA 424, as found in the results obtained in the tests ESI and FE, respectively.

Nevertheless, researches aiming at seed coating studies involving nutrients have raised divergences among researchers. Studies on seed coating with dolomitic limestone or aluminum silicate used together, aiming at evaluating initial growth and seed physiological quality, were not found in the literature. However, Funguetto et al. (2010) working with rice seeds coated with zinc, concluded that seed germination is not affected; and Vieira and Moreira (2005) obtained similar results.

Results presented on Table 2 allow verifying that seed coating with dolomitic limestone and aluminum silicate did not statistically differ for the variables FW, PH, and DW, for both cultivars studied. It can also be verified that cultivar IRGA 424 had a better performance than the cultivar IRGA 422 CL for the DW variable. Among the benefits provided by the fertilization with silicon, its positive influence on plant growth and development has to be highlighted. Such effect, however, was not detected on growth and development of potato (*Solanum tuberosum* L.) plants, perhaps because this crop is not considered silicon accumulator (Ma et al., 2001).

Table 2. Mean values of fresh weight (FW), plant height (PH), leaf area (LA) and dry weight (DW) of seedlings of two different cultivars of lowland rice originated from seeds coated with dolomitic limestone and aluminum silicate, both either alone or in combination, and evaluated 10 days after seedlings emergence.

Variable	Treatment	Cultivar		Mean
		IRGA 424	IRGA 422 CL	
FW (g)	Dolomitic limestone + aluminum silicate	8.4 A*	9.2 A*	8.8 a*
	Dolomitic limestone	8.3 A	7.5 A	7.9 a
	Aluminum silicate	9.3 A	8.2 A	8.7 a
	control	8.6 A	8.0 A	8.3 a
	CV (%)	13.1		
PH (cm)	Dolomitic limestone + aluminum silicate	13.6 A	16.1 A	14.9 a
	Dolomitic limestone	14.6 A	14.9 A	14.8 a
	Aluminum silicate	15.0 A	14.5 A	14.8 a
	control	13.4 A	15.3 A	14.3 a
	CV (%)	9,8		
LA (cm^2)	Dolomitic limestone + aluminum silicate	26.8 bB	37.5 aA	31.2
	Dolomitic limestone	33.0 abA	33.9 aA	33.4
	Aluminum silicate	36.6 aA	37.2 aA	36.9
	control	28.2 abA	33.6 aA	30.9
	CV (%)	11.1		
DW (g)	Dolomitic limestone + aluminum silicate	0.148 A	0.118 B	0.33 a
	Dolomitic limestone	0.145 A	0.136 B	0.41 a
	Aluminum silicate	0.149 A	0.126 B	0.14 a
	control	0.136 A	0.136 A	0.14 a
	CV (%)	13.7		

*Means followed by the same small letter in the column and capital letter in the line for each response variable are not statistically different between each other by the Duncan test at 5% probability.

In relation to the parameter LA, it was found that seed coating with dolomitic limestone and aluminum silicate did not affect the leaf area of cultivar IRGA 422 CL plants. However, the seed coating with aluminum silicate did cause leaf area increases on plants of cultivar IRGA 424. In studies carried out on the development of Stylosanthes [*Stylosanthes guyanensis* (Aubl.) Sw.] by providing four additional doses of calcium, Rodrigues et al. (1993) verified linear increases on leaf area of plants as a function of the increment of the calcium dosages applied. In this study, the cultivar IRGA 424 had a better performance than cultivar IRGA 422 CL independently of the treatment used for the DW variable. Mauad et al. (2003) found similar results, furthermore stating that the silicon application does not affect dry matter production.

Data presented on Table 3 show that statically significant differences did not occur among treatments in the FW variable, for cultivar IRGA 424. For the cultivar IRGA 422 CL, however, the treatments with dolomitic limestone + aluminum silicate and dolomitic limestone alone had statistically superior performance as compared to the other treatments. Notwithstanding, the cultivar IRGA 422 CL presented a better performance than cultivar IRGA 424 when the seed coating was performed with dolomitic limestone + aluminum silicate, but the cultivar IRGA 424 presented better performance than cultivar IRGA 422 CL in the treatment with aluminum silicate alone and at the control treatment. In relation to PH, the treatment with aluminum silicate presented superior performance as compared to the other treatments, for both cultivars. Cultivar IRGA 422 CL, however, did not differ statistically from cultivar IRGA

424 in all treatments used. Data obtained within this research work are in contrast with those of Gomes et al. (2009) that working with different manners of silicon application on potato plants, did not observe statistically significant difference among treatments for the plant height parameter.

Table 3. Mean values of fresh weight (FW), plant height (PH), leaf area (LA) and dry weight (DW) of seedlings of two different cultivars of lowland rice originated from seeds coated with dolomitic limestone and aluminum silicate, both either alone or in combination, and evaluated 20 days after seedlings emergence.

Variable	Treatment	Cultivar		Mean
		IRGA 424	IRGA 422 CL	
FW (g)	Dolomitic limestone + aluminum silicate	17.0 aB*	20.3 aA*	18.6*
	Dolomitic limestone	17.4 aA	17.9 aA	17.7
	Aluminum silicate	19.1 aA	13.4 bB	16.2
	control	17.5 aA	11.6 bB	14.5
	CV (%)	9.6		
PH (cm)	Dolomitic limestone + aluminum silicate	35.2 A	40.7 A	38.0 ab
	Dolomitic limestone	37.6 A	35.5 A	36.5 b
	Aluminum silicate	44.2 A	40.8 A	42.5 a
	control	41.9 A	33.5 A	37.7 ab
	CV (%)	12.2		
LA (cm^2)	Dolomitic limestone + aluminum silicate	415.4 B	487.6 A	451.5 b
	Dolomitic limestone	411.9 B	484.9 A	448.4 b
	Aluminum silicate	492.8 B	513.1 A	502.9 a
	control	398.0 B	412.0 A	405.0 b
	CV (%)	9.4		
DW (g)	Dolomitic limestone + aluminum silicate	2.3 aA	2.3 aA	2.3
	Dolomitic limestone	2.2 aA	2.3 aA	2.3
	Aluminum silicate	2.2 aA	2.6 aA	2.4
	control	2.2 aA	1.7 bB	1.9
	CV (%)	12.19		

*Means followed by the same small letter in the column and capital letter in the line for each response variable are not statistically different between each other by the Duncan test at 5% probability.

Concerning the LA variable (Table 3) it was found that the mean of the treatment with aluminum silicate was statistically higher than those of the remaining treatments for both cultivars. In addition, the cultivar IRGA 422 CL presented a better performance in relation to cultivar IRGA 424, independently of the treatment used. The DW variable did not present statistically significant difference among treatments for cultivar IRGA 424; although it have been also verified that the treatments with dolomitic limestone and aluminum silicate, both either alone or in combination, were statistically better than the control treatment for cultivar IRGA 422 CL. It is also stressed that cultivar IRGA 424 presented a better performance than cultivar IRGA 422 CL for that treatment. For Faria Júnior et al. (2009), who by observing dry matter production and content and accumulation of silicon on different rice cultivars subjected to variable dosages of silicon, verified that the Si doses did not influence the growth components, except for root dry matter and with differences only among cultivars.

Results presented on Table 4 indicate that the lowland rice seeds coated with dolomitic limestone + aluminum silicate did not statistically differ from the control treatment for the variables FW and PH, at 30 DAE, and that the cultivars studied did not differ statistically for the variable FW. Results observed for PH come into accord with those of Assis et al. (2000), who working with nutritional limitations for the rice crop grown in organic soils under inundation, did not find differences on the growth of rice plants when silicon was added to fertilization. Herein, it was also verified that the cultivar IRGA 424 presented higher PH than cultivar IRGA 422 CL.

Table 4. Mean values of fresh weight (FW), plant height (PH), leaf area (LA) and dry weight (DW) of seedlings of two different cultivars of lowland rice originated from seeds coated with dolomitic limestone and aluminum silicate, both either alone or in combination, and evaluated 30 days after seedlings emergence.

Variable	Treatment	Cultivar		Mean
		IRGA 424	IRGA 422 CL	
FW (g)	Dolomitic limestone + aluminum silicate	104.6 A*	105.6 A*	105.1 a*
	Dolomitic limestone	104.4 A	100.4 A	102.4 a
	Aluminum silicate	114.2 A	104.0 A	109.1 a
	control	105.5 A	98.2 A	101.9 a
	CV (%)	8.3		
PH (cm)	Dolomitic limestone + aluminum silicate	39.0 A	37.5 B	38.2 a
	Dolomitic limestone	40.1 A	37.5 B	38.8 a
	Aluminum silicate	43.2 A	38.3 B	40.7 a
	control	42.6 A	35.3 B	38.9 a
	CV (%)	8.3		
LA (cm^2)	Dolomitic limestone + aluminum silicate	2,149.1 bA	2,235.8 aA	2,192.5
	Dolomitic limestone	2,163.3 bA	2,250.0 aA	2,206.7
	Aluminum silicate	2,671.9 aA	2,232.8 aB	2,452.4
	control	2,109.5 bA	1,818.8 bA	1,964.2
	CV (%)	9.4		
DW(g)	Dolomitic limestone + aluminum silicate	14.1 A	13.9 A	14.0 a
	Dolomitic limestone	14.2 A	13.8 A	14.0 a
	Aluminum silicate	14.7 A	13.8 A	14.3 a
	control	11.0 A	10.3 A	10.6 b
	CV (%)	10.9		

*Means followed by the same small letter in the column and capital letter in the line for each response variable are not statistically different between each other by the Duncan test at 5% probability.

For the LA variable (Table 4) it is noticeable that the addition of aluminum silicate, via seed coating, has promoted larger leaf area than the remaining treatments for cultivar IRGA 424 and that the seed coating with dolomitic limestone and aluminum silicate, both either alone or in combination, presented better performance than the control treatment for cultivar IRGA 424. Working with silicon application on common wheat (*Triticum aestivum* L.) crop, grown into pots, Gong et al. (2003) obtained increases on the leaf area of plants. Herein it can be verified that the cultivar IRGA 424 presented a better performance than cultivar IRGA 422 CL in the treatment with aluminum silicate.

In reference to the parameter DW (Table 4) it is possible to verify that the seed coating with dolomitic limestone and aluminum silicate, both either alone or in combination, presented a better performance for the control treatment for both cultivars. Similar results were found by Guo et al. (2005), who studying the addition of silicon through a nutritive solution found that such solution increased the dry matter of aerial parts of rice seedlings. Under saline stress conditions, the application of silicon increased the percentage of seed germination as well as the biomass of wheat plants (Matichenkov et al., 2005). It has to be emphasized, however, that the rice cultivars IRGA 424 and IRGA 422 CL did not statistically differ when subjected to seed coating with those two nutrients.

The *CGR* (Table 5) demonstrate the growth speed of plants; and the assessment of this parameter was performed by means of consecutive measurements of plants at different assessment periods. As it can be verified, the plants from seeds coated with both nutrients did not statistically differ in the evaluation periods varying either from 1 to 10 DAE, or between 21 to 30 DAE; as well as between the evaluation period varying from 11 to 20 DAE for the cultivar IRGA 424.

The plants from seeds coated with dolomitic limestone + aluminum silicate, however, presented a CGR higher than those plants of the control treatment within the period of 11 to 20 DAE for the cultivar IRGA 422 CL.

Table 5. Mean data on crop growth rate (CGR), relative growth rate (RGR), and net assimilatory rate (NAR) of plants of two different cultivars of lowland rice, originated from seeds coated with dolomitic limestone and aluminum silicate, both either alone or in combination, and evaluated in different days after emergence (DAE)

DAE	Treatment	Cultivar		Mean
		IRGA 424	IRGA 422 CL	
		CGR (mg.dia^{-1})		
1 to 10	Dolomitic limestone + aluminum silicate	148 A*	118 B*	133 a*
	Dolomitic limestone	145 A	136 B	141 a
	Aluminum silicate	149 A	126 B	138 a
	control	136 A	136 B	136 a
	CV (%)	13.7		
11 to 20	Dolomitic limestone + aluminum silicate	216 aA	226 aA	221 a
	Dolomitic limestone	210 aA	224 aA	217 a
	Aluminum silicate	213 aA	251 aA	232 a
	control	207 aA	159 bB	183 a
	CV (%)	12.7		
21 to 30	Dolomitic limestone + aluminum silicate	1,179.0 A	1,156.0 A	1,168.0 a
	Dolomitic limestone	1,203.0 A	1,144.0 A	1,174.0 a
	Aluminum silicate	1,250.0 A	1,119.0 A	1,185.0 a
	control	884.0 A	860.0 A	872.0 a
	CV (%)	13.3		
		RGR (mg.g^{-1}.dia^{-1})		
11 to 20	Dolomitic limestone + aluminum silicate	0.27 aB	0.30 aA	0.28 a
	Dolomitic limestone	0.27 aA	0.28 aA	0.28 a
	Aluminum silicate	0.27 aB	0.30 aA	0.28 a
	control	0.27 aA	0.25 bB	0.26 a
	CV (%)	5.3		
21 to 30	Dolomitic limestone + aluminum silicate	0.18 A	0.17 A	0.17 a
	Dolomitic limestone	0.18 A	0.17 A	0.18 a
	Aluminum silicate	0.18 A	0.16 A	0.17 a
	control	0.16 A	0.17 A	0.17 a
	CV (%)	8.9		
		NAR (mg.cm^{-2}.dia^{-1})		
11 to 20	Dolomitic limestone + aluminum silicate	1.52 aA	1.27 abA	1.41 a
	Dolomitic limestone	1.40 abA	1.32 abA	1.36 a
	Aluminum silicate	1.21 bA	1.39 aA	1.30 a
	control	1.49 abA	1.07 bB	1.28 a
	CV (%)	13.3		
21 to 30	Dolomitic limestone + aluminum silicate	1.11 A	1.00 A	1.06 a
	Dolomitic limestone	1.14 A	0.99 A	1.07 a
	Aluminum silicate	0.97 A	0.95 A	0.96 ab
	control	0.85 A	0.91 A	0.88 b
	CV (%)	11.5		

*Means followed by the same small letter in the column and capital letter in the line for each response variable are not statistically different between each other by the Duncan test at 5% probability.

The *RGR* (Table 5) is the variation of the dry mass as a function of the initial dry mass on a given time interval. As it can be noticed, plants from the treatments studied did not differ statistically for the cultivar IRGA 424. Nevertheless, for the cultivar IRGA 422 CL the plants from seeds treated with dolomitic limestone and aluminum silicate, either alone or in combination, presented a performance higher than the plants from the control treatment during the evaluation period varying from 11 to 20 DAE. Within the period varying from 21 to 30 DAE, however, the RGR of plants from the treatments studied did not differ statistically for both IRGA 424 and IRGA 422 CL cultivars, which presented similar performance.

The *NAR* (Table 5) expresses the dry mass produced per unit of leaf area per unit of time. The plants from seeds coated with dolomitic limestone and aluminum silicate, either alone or in combination, in a general way presented a performance higher than the control treatment for cultivar IRGA 422 CL, but for cultivar IRGA 424 the performance of plants from seeds coated with aluminum silicate was lower than the remaining treatments during the period from 11 to 20 DAE. Plants of cultivar IRGA 424 had a better performance than cultivar IRGA 422 CL when the seed coating procedure was not performed (control). During the period of 21 to 30 DAE, it was found that the seed coating with dolomitic limestone and with dolomitic limestone + aluminum silicate significantly differed from the remaining treatments for cultivar IRGA 424. However, no statistically significant differences in those parameters were found for the cultivar IRGA 422 CL.

The coating of lowland rice seeds with dolomitic limestone and aluminum silicate did not negatively affect the seed physiological quality, however, on the contrary, promoted increments on the initial growth of seedlings as compared to the control treatment. Once significant interactions among the majority of variables did not occur, it can be inferred that the effect of the treatments is identical for different cultivars, thus indicating that the coating of seeds with dolomitic limestone and aluminum silicate can be used as a promising tool for the treatment of rice seeds.

In addition, the coating of rice seeds with polymers is also promising, once it maintains the products used adhered to the seed, thus avoiding losses of these products to the environment and also allowing for a better use of lower dosages. In consequence, the environmental impact is reduced, besides the occurrence of significant increases on crop initial growth.

Conclusions

The coating of lowland rice seeds with dolomitic limestone and aluminum silicate does not affect either seed germination or field seedling emergence;

The aluminum silicate when used via seed coating on the lowland rice cv. IRGA 424 promotes larger leaf area on the plants, at 20 days after emergence;

The dolomitic limestone and the aluminum silicate when applied either alone or in combination, via seed coating, generate plants with larger dry biomass already at 20 days after emergence for the lowland rice cv. IRGA 422 CL.

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