Short Communication

Effect of acetic acid on rice seeds coated with rice husk ash

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ABSTRACT

Flooded rice cultivation promotes anaerobic conditions, favoring the formation of short chain organic acids such as acetic acid, which may be toxic to the crop. The objective of this study was to evaluate the effect of acetic acid on rice seeds coated with rice husk ash. The experiment was arranged in a 2 x 5 x 5 factorial randomized design, with two cultivars (IRGA 424 and BRS Querência), five doses of coating material (0, 2, 3,4 e 5 g kg^{-1} seed) and five concentrations of acetic acid (0, 3, 6, 9 and 12 mM), with 4 replications, totaling 50 treatments. The variables first count of germination, germination, shoot and root length, dry weight of shoots and roots were recorded. The results showed that coating rice seeds with rice husk ash up to 5 g kg^{-1} seed does not influence the performance of rice seeds of cultivars IRGA 424 and BRS Querência when exposed to concentrations of 12 mM acetic acid. The presence of acetic acid in the substrates used for seed germination reduced the vigor and viability of seeds of cultivars IRGA 424 and BRS Querência, as well as seedling development, affecting mainly the roots of BRS Querência.

Key words: *Oryza sativa* L., anaerobic digestion, toxicity, germination.

RESUMO

Efeito do ácido acético em sementes de arroz recobertas com cinzas de casca de arroz

O alagamento do solo para o cultivo do arroz irrigado promove condições anaeróbias que favorecem a produção de ácidos orgânicos de cadeia curta, como o ácido acético, os quais podem ser tóxicos para a cultura. O objetivo foi avaliar o efeito do ácido acético em sementes de arroz recobertas com cinzas de casca de arroz. Foi utilizado o delineamento inteiramente casualizado, usando-se o esquema fatorial 2 x 5 x 5, sendo dois cultivares (IRGA 424 e BRS Querência), cinco doses de recobrimento com cinzas de casca de arroz (0, 2, 3, 4 e 5 g.kg^{-1} de semente) e cinco concentrações de ácido acético (0, 3, 6, 9 e 12 mM), totalizando 50 tratamentos com quatro repetições. Os testes realizados foram: primeira contagem da germinação, germinação, comprimento da parte aérea, comprimento da raiz, fitomassas secas da parte aérea e da raiz. Conclui-se que o recobrimento de sementes de arroz com cinzas de casca de arroz até 5 g.kg^{-1} de semente não influencia o desempenho de sementes de arroz dos cultivares IRGA 424 e BRS Querência, quando submetidas a concentrações de ácido acético até 12 mM. A presença do ácido acético, em substratos para germinação de sementes, reduz o vigor e a viabilidade de sementes de arroz dos cultivares IRGA 424 e BRS Querência, além de reduzir o desenvolvimento de plântulas, afetando, principalmente, as raízes da BRS Querência.

Palavras-chave: *Oryza sativa* L., decomposição anaeróbica, toxicidade, germinação.

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INTRODUCTION

In low land soils with high organic matter content or those in which organic waste is added, the activity of anaerobic microorganisms is high and soil reduction is intensified, occurring, therefore, greater release of nutrients to the soil solution and increased production of toxic substances. Among the toxic substances produced, the organic acids of short-chain such as acetic, propionic and butyric acids stand out, and depending on the amount produced they can exert negative effect on rice plants (Sousa, 2001). Acetic acid has been found in higher concentrations in the soil, followed by propionic and butyric acids (Bohnen *et al*., 2005).Organic acid toxicity appears in the early stages of rice development, causing reduction in germination (Neves *et al*., 2006), root growth, weight and height of seedlings (Sousa & Bortolon, 2002).

The harmful effect of organic acids can be mitigated, if the plant is correctly nourished, by including beneficial elements such as Si. Rice husk ash is a non-expensive source of silicon that can be used (Foletto *et al*., 2005). Si application has provided a higher degree of plant resistance to attack by various insects, especially in Poaceaes, stimulating growth, increasing production and protecting against biotic and abiotic stresses because of the mechanical barrier provided by the silica deposition on tissues of the leaves and trichomes, besides the production of phenolic defense (Gomes *et al*., 2005).

In this context, the objective of this study is to evaluate the effect of acetic acid on rice seeds coated with rice husk ash.

MATERIAL AND METHODS

The study was conducted at the seed laboratory of Agronomy School "Eliseu Maciel" of Universidade Federal de Pelotas, Capão do Leão – RS, Brazil. The seeds were treated with rice husks ash with approximately 95% SiO_2 and coated with PolySeed CF® polymer in a dose of 8 mL kg^{-1} seed. An aqueous solution was prepared, providing a spray volume of 10 mL kg^{-1} seed.

The experiment was arranged in a 2 x 5 x 5 factorial randomized design, with two cultivars (IRGA 424 and BRS Querência), five doses of coating material (0, 2, 3,4 e 5 g kg^{-1} seed) and five concentrations of acetic acid (0, 3, 6, 9 and 12 mM), with 4 replications, totaling 50 treatments. Doses of acetic acid were added together with the tests below.

The quality of the seeds after the coating was evaluated by the following laboratory tests: standard germination (G) - using with 200 seeds and paper towels previously moistened with acetic acid at a ratio of 2.5 times the weight of dry paper as substrate and left to germinate at 25 °C. The evaluations were performed 14 days after sowing (Brasil, 2009) and the results expressed in percentage of normal seedlings. The first count (FCG) was evaluated seven days after sowing at the end of standard germination.

The length of shoot and primary root (SL and RL) was evaluated using replicates of 20 seeds per treatment. The paper towels were moistened as in the standard germination test (G). The seeds were distributed in two straight longitudinal lines in the upper third of the paper and placed in a germination chamber at 25 °C. Seven days after sowing, SL and RL of normal seedlings were recorded, and then the average length of shoot and primary root were recorded. For the dry weight of shoot and root of seedlings (SDW and RDW), the plant parts were separated with a scalpel, placed in paper bags and dried in an forced air circulation oven at 60 ± 2 °C for 48 hours. The results were expressed as mg $seedling^{-1}$ (Nakagawa, 1999).

The experiment was arranged in a completely randomized design. The data were subjected to ANOVA and the qualitative analysis by the Tukey test at 5% of probability for both factors and the interaction between them. The quantitative data were submitted to polynomial regression.

RESULTS AND DISCUSSION

Table 1 shows data refering to FCG and G tests of rice seeds cultivars BRS Querência and IRGA 424 coated with doses of Si and subjected to concentrations of acetic acid. There was no significant interaction between the factors. Significance was obtained only for the factors cultivar and acetic acid concentration (Figure 1A). Cultivar IRGA 424 showed higher performance than BRS Querência, with both FCG as in germination. These results agree with Neves & Moraes (2005) that subjected seeds to acetic acid at concentrations of zero, 0.017, 0.034, 0.068, 0.136 and 0.272 Mol L^{-1} and also found reduced FCG and G.

The results of SDW, RDW, SL and RL of rice seedlings of cultivars IRGA 424 and BRS Querência subjected to acetic acid concentrations are shown in Table 2. It was found that BRS Querência had higher performance than IRGA 424 only for variable SDW, but RDW, SL and RL were significantly lower than IRGA 424 when both cultivars were exposed to doses and concentrations of Si and acetic acid.

Figure 1 shows the significant effect of acetic acid concentrations on the variables FCG, G, SDW, RDW, SL and RL of seeds and seedlings of cultivars IRGA 424 and BRS Querência, but there is no significant effect of Si coating levels between them. When the rice seeds were

Table 1. First count germination (FCG) and standard germination (G) of rice seeds of cultivars IRGA 424 and BRS Querência coated with Si and treated with concentrations of 0, 3, 6, 9, 12 mM of acetic acid

Dose (g kg^{-1} seed)	Concentration (mM)	Cultivar			
		IRGA 424	Querência	IRGA 424	Querência
		FCG (%)		G (%)	
0	0	75	64	83	81
0	3	65	54	86	80
0	6	56	47	83	76
0	9	50	51	70	67
0	12	34	32	55	51
1	0	71	64	84	81
1	3	61	54	86	82
1	6	70	48	83	77
1	9	48	52	68	66
1	12	32	33	56	51
2	0	74	63	83	83
2	3	63	55	84	80
2	6	55	47	82	76
2	9	51	51	67	68
2	12	35	33	55	52
3	0	71	63	82	87
3	3	64	55	85	79
3	6	56	47	82	76
3	9	52	53	69	68
3	12	35	32	52	52
4	0	71	62	81	93
4	3	63	53	83	80
4	6	57	48	82	77
4	9	54	51	70	68
4	12	36	32	52	53
Average		56 A*	50 B	74 A	72 B
C.V. (%)		7.3		6.5	

* Means followed by same capital letter in the rows of the response variable does not differ by the Tukey test at 5% probability.

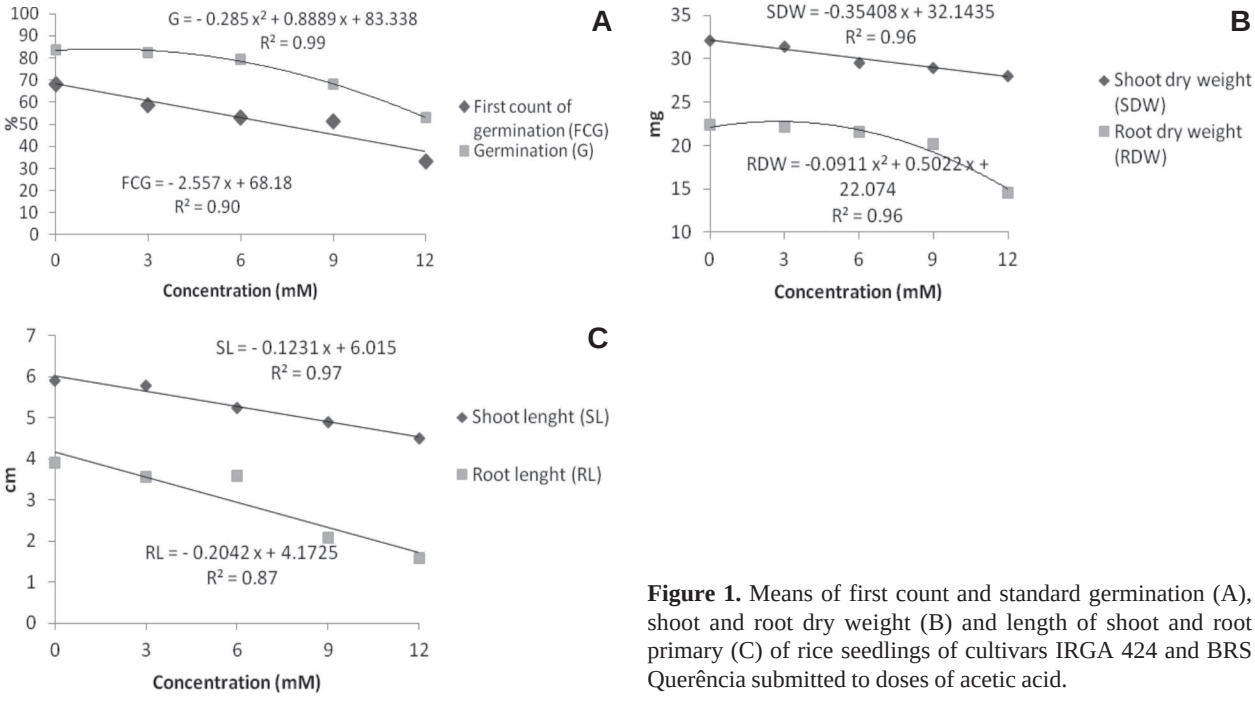

Figure 1. Means of first count and standard germination (A), shoot and root dry weight (B) and length of shoot and root primary (C) of rice seedlings of cultivars IRGA 424 and BRS Querência submitted to doses of acetic acid.

Table 2. Shoot dry weight (SDW), root dry weight (RDW), shoot length (SL) and root primary length (RL) of rice seeds, cultivars IRGA 424 and BRS Querência, coated with Si and submitted to concentrations of 0, 3, 6, 9, 12 mM acetic acid

Dose (g kg^{-1} seed)	Concentration (mM)	Cultivar							
		IRGA 424	BRS Que	IRGA 424	BRS Que	IRGA 424	BRS Que	IRGA 424	BRS Que
		SDW (mg)		RDW (mg)		SL (cm)		RL (cm)	
0	0	22.4	32.6	11.1	22.6	6.2	5.5	6.2	2.8
0	3	21.2	32.2	10.2	21.3	6.1	5.7	6.1	3.5
0	6	22.2	30.6	9.9	20.1	5.3	5.1	5.3	2.4
0	9	22.1	30.5	7.4	19.5	5.0	5.1	5.0	2.0
0	12	15.1	29.6	6.1	13.5	4.5	4.9	4.5	1.6
1	0	22.2	32.6	11.1	22.3	6.3	5.7	6.3	3.3
1	3	22.4	32.1	10.3	21.2	6.3	5.6	6.3	3.9
1	6	22.7	29.9	10.2	19.4	5.6	5.0	5.6	3.1
1	9	22.9	28.9	7.3	18.6	5.3	4.5	5.3	1.8
1	12	16.5	28.3	6.2	13.4	4.4	3.9	4.4	1.5
2	0	22.3	31.5	10.7	22.4	6.1	5.7	6.1	3.8
2	3	22.7	31.2	9.4	21.3	6.1	5.6	6.1	2.8
2	6	22.8	30.3	9.4	20.4	5.4	5.1	5.4	2.8
2	9	22.3	30.1	7.4	19.9	5.3	5.0	5.3	1.7
2	12	16.1	29.5	6.5	13.4	4.8	4.4	4.8	1.4
3	0	22.3	31.6	9.7	22.5	5.8	5.6	5.8	3.2
3	3	24.0	31.4	9.7	21.2	5.8	5.2	5.8	3.1
3	6	26.1	29.5	9.7	20.6	5.7	4.7	5.7	3.6
3	9	21.8	30.0	7.4	19.3	5.5	4.6	5.5	1.9
3	12	15.6	29.7	6.2	13.5	4.6	4.3	4.6	1.5
4	0	22.4	32.4	10.4	22.8	6.3	5.9	6.3	3.8
4	3	25.6	31.3	9.6	21.2	6.1	5.4	6.1	3.5
4	6	21.2	29.7	9.5	19.9	5.7	5.1	5.7	2.9
4	9	16.6	29.3	7.0	18.7	4.3	4.3	4.3	2.4
4	12	14.9	29.0	6.6	13.5	4.9	4.2	4.9	1.6
Average		29.5 B*	30.5 A	21.0 A	19.3 B	5.5 A	5.0 B	3.2 A	2.6 B
C.V. (%)		9.3		9.2		11.2		16.1	

* Means followed by same capital letter in the rows of the response variable does not differ by Tukey test at 5% probability.

coated with Si and subjected to concentrations of acetic acid, G showed a quadratic trend with the increase in acetic acid, while FCG showed a linear trend, with a decrease in the percentage of normal seedlings with increasing doses of acetic acid. The dose of 12 mM was the most harmful for both variables (Figure 1A). There was reduction of 45 to 37% in vigor and viability of seeds, in average, for cultivars IRGA 424 and BRS Querência, when they were subjected to the dose of 12 mM acetic acid compared with the control.

There was a significant reduction in shoot dry weight (SDW) and root dry weight (RDW) with increasing concentration of acetic acid (Figure 1B). SDW showed a linear response with increasing concentrations of acetic acid, RDW showed a quadratic behavior. SDW and RDW showed a reduction of approximately 13 to 35%, respectively, at the concentration of 12 mM compared with the control (0 mM).

There was a significant effect of concentrations of acetic acid on shoot length (SL) and root length (RL) (Figure 1C). Both SL, as RL, showed linear negative behavior with increasing acetic acid concentration. SL showed a 19% reduction at the concentration of 12 mM acetic acid compared with the control, while RL was reduced by 60%. Sousa & Bortolon (2002) reported 50% inhibition of growth of rice roots with 4.7 mM of acetic acid, whereas the aerial parts required the concentration of 8 mM to achieve the same percentage of inhibition.

CONCLUSIONS

Coating rice seeds with rice husk ash up to 5 g kg^{-1} seed does not influence the performance of rice seeds of cultivars IRGA 424 and BRS Querência when exposed to concentrations of acetic acid to 12 mM.

The presence of acetic acid in substrates for seed germination reduces vigor and viability of rice seeds, cultivars IRGA 424 and BRS Querência, as well as the seedling development, affecting mainly roots of cultivar BRS Querência.

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