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Performance of Rice Crop as Function of Seed Treatment and Irrigation Method

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***Abstract*— *we aimed with this study to evaluate the performance of irrigated rice plants, as a function of seed treatment composition and crop irrigation management. Two factors were studied in the trial: (A) irrigation management (continuous or intermittent); and (B) seed treatment composition (complete, fungicide only, insecticide only, no treatment + clomazone, and no treatment without herbicide). Standak and Vitavax-Thiram were used as insecticide and fungicide standards, respectively. The Guri Inta CL rice variety, treated three days before planting, was adopted. Irrigation was established twenty days after emergence. In continuous irrigation, a 7 cm mean water layer was maintained during the experimental period; in intermittent irrigation, a 10 cm initial water layer was established and then water supply was interrupted until 10-15% of the plot was aerated, when the 10 cm layer was reestablished. Twelve days after sowing, rice emergence was evaluated. Twenty days after crop emergence, the rice plant height was evaluated. Thirty days after emergence, plant density was again measured. At the end of the crop cycle, grain yield was evaluated. Data were analyzed based on confidence intervals at 95% level. There is no evidence of interference from the differential seed treatment on the agronomic performance of rice, nor differences resulting from their interaction with the irrigation management.*
Keywords*— Oryza sativa*, establishment, development, productivity.

I. INTRODUCTION

Rice (*Oryza sativa*) is a staple food for approximately half the world's population. In Brazil, approximately 3 million hectares are cultivated annually, with the Southern region (Rio Grande do Sul and Santa Catarina) accounting for more than 70% of production (Conab, 2017).

In Rio Grande do Sul, the recommended time for planting rice is between September and November, depending on the locality, cultivar cycle and cultivation system, among others (Recommendations..., 2016). In early season planting, the seeds can remain for many days in the soil seed bank until the temperature and humidity conditions that trigger germination are reached. Thus, most producers end up by treating seeds in order to avoid problems of establishment of rice seedlings due to unfavorable climatic conditions (Lobo, 2008), even with no recommendation of this procedure for the South Brazilian rice fields (Recommendations…, 2016). Early season planting promotes the matching of the reproductive period with the greatest solar radiation abundance (December / January), which may contribute to increase the rice grain yields (Mertz et al., 2009).

The action of pre-emergent herbicides, both those affecting the germination process and emergence, as well as those affecting rice seedlings, should also be considered in the initial crop establishment. Among these herbicides, one of the most used in rice cultivation is clomazone. Therefore, damage to the initial plant population, often attributed to pests and diseases, may result from herbicide phytotoxicity. Thus, there are some "protectors", also known as "safeners", which when used in conjunction with seed treatment confer to the plant greater herbicide tolerance (Oliveira Jr and Inoue, 2011).

The mixture of different products in seed treatment, however, has generated complaints by rice farmers, who claim to observe reduction in the stand of rice plants when seed treatment includes two or three chemicals with different purposes. These same farmers raised the hypothesis that this possible negative interaction between products used in seed treatment may be linked to water management in the rice field. The products used for seed treatment in some regions of Brazil include the insecticides thiamethoxam, imidacloprid and fipronil, and the fungicides carboxin and thiram, among others (Lobo, 2008).

II. OBJECTIVES

Thus, the objective of this work was to evaluate the performance of irrigated rice plants, as a function of seed treatment composition and crop irrigation management.

III. MATERIAL AND METHODS

The experiment was installed in a systematized area of the Embrapa Temperate Climate, Terras Baixas Experimental Station, Capão do Leão-RS, geographic coordinates -31.8153, -52.4698, in strip-plot design (Tantiphanwadi and Ayudthya, 2017), with plots measuring 25 m^2. Two factors were studied: (A) irrigation management, being continuous irrigation (C_), and intermittent irrigation (I_); and (B) seed treatment composition, being complete treatment with fungicide and insecticide (FI); treatment with fungicide only (Fung); treatment with insecticide only (Inset); without seed treatment, with application of clomazone in pre-emergence (Herb); and control without seed treatment and without pre-emergent herbicide (Test). Standak was used as insecticide for seed treatment (120 mL 100 kg^{-1} of seeds); as fungicide, Vitavax Thiram (300 mL 100 kg^{-1} seeds) was adopted.

For the experiment, the rice cv. Guri Inta CL was adopted. All seed treatments (factor B) were carried out three days before planting, effected on November 9, 2016, using a drill with 11 rows spaced in 0.17 m, with each plot of the experiment consisting of three drill passes, 5 m long each. The basic fertilization consisted on the application of 300 kg ha^{-1} of the formula 5-25-25, in the planting row. Topdressing fertilization consisted of two applications of 100 kg ha^{-1} of urea (45% N): beginning of tillering (December 9, 2016) and a few days before panicle initiation (January 13, 2017).

Irrigation was established on December 8, 2016, twenty days after plant emergence (DAE). In continuous irrigation, an average 7 cm of water was maintained during the experiment period, allowing variation from 10 to 5 cm; in the intermittent irrigation an initial 10 cm water layer was established, and then the water supply closed until the plot area was between 10 - 15% aerated (without water layer), when the 10 cm layer was again established.

Weed management was carried out with the application of clomazone in treatments C_Herb and I_Herb, and in the other treatments, only one application of the grass killer (inhibitor of the enzyme ACCase), registered and recommended for the crop, was used (Recommendations..., 2016).

Twelve days after planting, rice emergence was evaluated in four distinct rows of each plot, by counting all plants in 1 m. Live seedlings measuring more than 1 cm high were considered to be effectively emerged. Twenty DAE (beginning of irrigation and tillering), the average rice plant height was assessed, by measuring 10 plants per plot with a ruler. Thirty DAE (10 days after irrigation starts), the plant density was again measured, and four distinct row sections 1 m long were evaluated per plot, similarly to the first assessment. At the end of the crop cycle, rice grain yield was evaluated by harvesting 4 m^2 (4 x 1 m^2) per plot; the impurities were removed and then the yield was weighed and corrected to 13% moisture.

Data presentation was based on the confidence intervals at the 95% level, according to Cumming et al. (2004). By this method, the comparison between treatments is done based on an expected response interval for similar cropping situations, and not based only on the responses of the treatments in the experiment. All analyzes were performed into the statistical environment "R".

IV. RESULTS AND DISCUSSION

The initial number of seedlings emerged twelve days after sowing (Figure 1) was approximately 160 per square meter, as the average of treatments. Although the confidence interval (95% confidence) showed no difference among treatments in soil-climatic conditions similar to those of the experiment, treatment with pre-emergence herbicide presented a smaller number of live plants twelve days after planting .

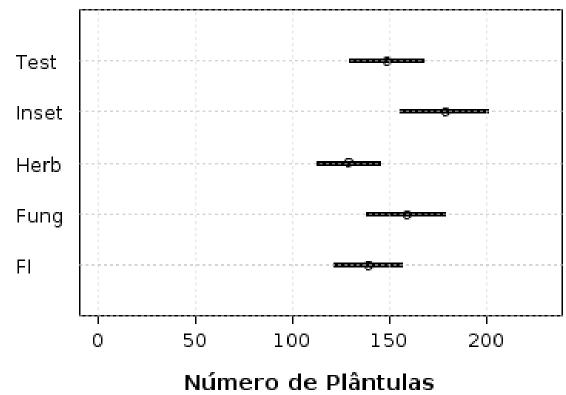

Fig.1: Number of plants emerged 12 days after planting, as function of seed treatment as follows: Fung = fungicide; Herb = no treat. + pre-emergence herbicide; Inset = insecticide; FI = fungicide + insecticide; and Test = control treatment without seed treatment and withouth pre-emergence herbicide. Confidence interval is presented (n = 8). Irrigation management was not considered as it was yet to be applied to the fields at the time of the evaluation.

On the other side, seed treatment with insecticide alone had a higher number of live plants (faster emergence) compared to other treatments, but the confidence interval again reports that this difference may not be supported in field conditions similar to those of the experiment, because there was overlap in the confidence interval bars. Based on the 95% confidence intervals, the only difference was that seed treated with insecticides only performed better than those not treated and submitted to clomazone (Herb treatment) (Figure 1). A similar result occurred for the treatment with fungicide, in which a number of live plants were obtained close to that of the insecticide treatment (Figure 1).

For the average height of rice plants, no differences were observed between treatments (Figure 2), most likely because once emerged, the plants (or clomazone survivors) develop normally. If crop damage occurs as function of seed treatment, it may be due to lower plant establishment, with less impact on the growth of surviving seedlings. However, for cotton, it was observed that the higher doses of clomazone reduced plant stand and height (Silva and Santos, 2011). For rice, Concenço et al. (2006) also verified that the application of clomazone in doses higher than those indicated, combined with crop irrigation, caused a greater phytotoxicity to rice plants 19 DAE.

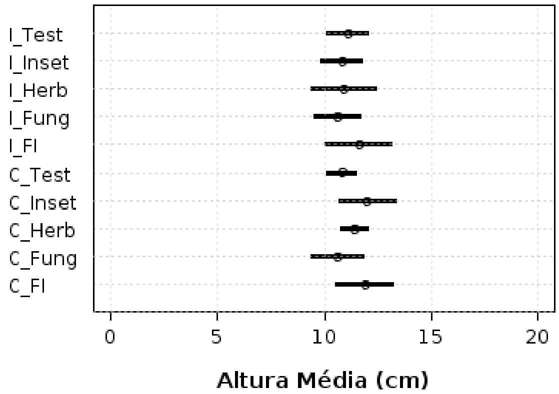

Fig.2: Rice plant height 20 days after emergence, as function of irrigation management (C_ = continuous; I_ = intermittent), and seed treatment as follows: Fung = fungicide; Herb = no treat. + pre-emergence herbicide; Inset = insecticide; FI = fungicide + insecticide; and Test = control treatment without seed treatment and without pre-emergence herbicide. Confidence interval is presented (n = 10).

The number of plants at tillering start (Figure 3) varied between 320 and 430 plants m^{-2}, and the variation of the confidence intervals - due to the small number of samples per treatment (n = 4) for this variable, indicates that the values obtained in the experiment are not conclusive in relation to what could be observed in areas under similar soil and climatic conditions to those of the experiment, thus not allowing a clear differentiation between treatments.

The rice grains yield averaged 8000 kg ha^{-1} (Figure 4), but in field conditions it is possible to obtain productivity of up to 12000 kg ha^{-1} in some situations (95% confidence interval). It should be noted, however, that the number of samples contributed to the wide confidence intervals obtained and should not be considered as conclusive. Rice has compensatory capacity in its production components, counterbalancing some effects generated by the height of the water layer (ROSSO, 2014).

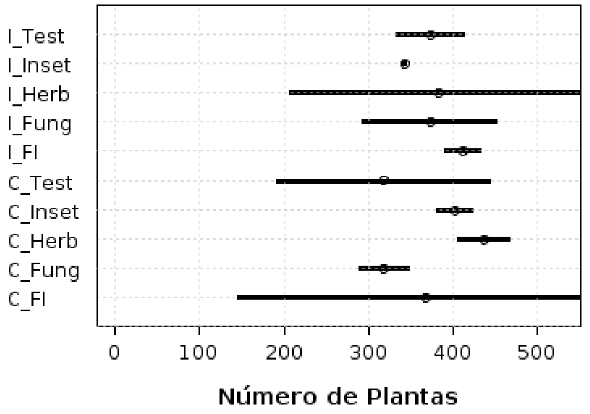

Fig.3: Number of rice plants 30 days after emergence, as function of irrigation management (C_ = continuous; I_ = intermittent), and seed treatment as follows: Fung = fungicide; Herb = no treat. + pre-emergence herbicide; Inset = insecticide; FI = fungicide + insecticide; and Test = control treatment without seed treatment and without pre-emergence herbicide. Confidence interval is presented (n = 4).

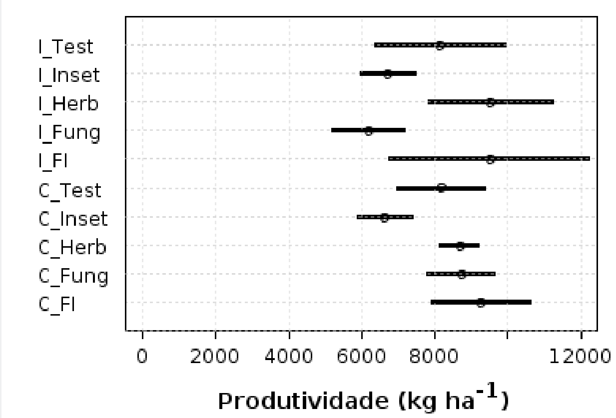

Fig.4: Rice grain yield cv. Guri Inta CL, corrected to 13% humidity, as function of irrigation management (C_ = continuous; I_ = intermittent), and seed treatment as follows: Fung = fungicide; Herb = no treat. + pre-emergence herbicide; Inset = insecticide; FI = fungicide + insecticide; and Test = control treatment without seed treatment and without pre-emergence herbicide. Confidence interval is presented (n = 4).

Barrigossi and Ferreira (2002), also treated seeds with insecticide, and between 20 and 25 days after planting they reported greater number of plants, mainly when used fipronil and furathiocarb, thiamethoxan, thiodicarb and carbosulfan were used, without productivity difference among treatments with insecticides. Almeida et al. (2014b), when treating seeds with thiamethoxam and lambdacyhalotrin, reported an increase in germination, especially when seeds were submitted to temperatures between 10 and 13 ºC. Thiamethoxan also optimized seed performance (Almeida et al., 2014a).

In the treatment with the fungicide carboxim + thiram, Lobo (2008) verified that even though there was no blast (*Pyricularia grisea*) control under high pressure in the field, the fungicide helped optimizing seed emergence and performance.

Therefore, treatments that include the association of fungicides and insecticides seem to favor crop establishment (Brzezinski et al., 2015). In corn and wheat, the associated treatments did not affect the initial establishment of seedlings (Dartora et al., 2013), and there was increase in maize grains yield only with application of insecticide (Schlosser et al., 2012). In soybean, seed treatment with insecticides and fungicides helped to maintain the physiological and sanitary seed quality, providing benefits at different stages of growth and development, not reflecting, however, higher crop productivity (Cunha et al. 2015).

It should be emphasized that in none of the variables evaluated in the present study, were there evidences that the differential water management could have affected the performance of the rice crop, since means and their respective confidence intervals were not different between treatments submitted to the continuous or to intermittent irrigation (Figures 1, 2, 3, 4).

The only comment that can be raised in this respect is that crop productivity showed higher confidence intervals - and therefore greater variability in cropping situations similar to those of the experiment, under intermittent irrigation, which may require more attention from farmers to the correct water management, avoiding possible damages to the productivity - damages that were not observed in the present study. This corroborates with Santos et al. (2015), who reported that regardless of the irrigation method, rice yield remained unchanged.

V. CONCLUSIONS

There is no evidence of differential seed treatment interference on the agronomic performance of this crop, nor differences due to its interaction with irrigation management.

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