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Biofertilizer Microgeo® on Rice Crop: Yield and Seed Quality

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Abstract

Rice is the most important crop for the south and south-west region of the Rio Grande do Sul state (Brazil); as all commercial crops, irrigated rice is requiring the use of alternatives for increasing yield and quality of its product with less aggressive/toxic inputs in the environment. The aim of this study was to analyze the influence of the biofertilization in the rice crop yield and the parameter of its seed quality and grain quality. It was carried out a field experiment with two treatments (with and without biofertilization with 150 + 150 L CLC® ha^{-1}) with 12 repetitions in an irrigated rice. Biofertilization did not influenced the percentages of whole grain, polished grain and no broken grain. There were no difference between the treatments for final seed germination, seed hectoliter weight and pH. The rice yield with biofertilization using continuous liquid composting was not statistically higher, an expected result for a first year of biofertilization. However, it provided 398 kg ha^{-1} grain yield increase, which is a very positive and a promising result considering being the first year of application. Therefore, a significant yield increase for the following years of application is expected.

Keywords: grain quality, liquid composting, *Oryza sativa*, germinability

1. Introduction

The rice (*Oryza sativa* L.) crop has a crucial role in the Brazilian agriculture, specially in the south region (states of Rio Grande do Sul and Santa Catarina) that represents approximately 80% of the national production (SOSBAI, 2016). In recent years, the yield grain has been increased strongly, mainly due pesticide and chemical fertilizer popularization (Martini et al., 2012). However, the risk of damage by the overuse of pesticides can cause problems of human health and environmental contamination, mainly in the water table and water bodies. The contamination can be increased due the flood irrigation commonly used in the rice crop (Horrigan et al., 2002; Birch et al., 2015).

In order to bring crop changes, it is necessary to develop products that provides maximum yield with less chemicals, and biofertilization is a current agronomic practice that is helping to achieve such goal (Rêgo et al, 2017). Furthermore, biofertilization increases the organic matter in soil, which is very desirable in rice crops, where the soil tillage is in excess (Zandonadi et al., 2013). This is especially important to tropical and subtropical regions, where the majority of soils are high weathered and naturally poor in organic matter content (Lopes & Cox, 1977).

Biofertilizers have bioactive products of the organic biomass fermentation. These products of intense microbial activity are capable of protecting crops against pests and increase the degree of nutrients bioavailability for plants through biological processes (Alfa et al., 2014). Moreover, the biofertilizer application improves the soil physical properties (Galbiatti et al, 1996). The biofertilizer features described above sustain the fact that it can help increasing the yield of crops, although some researches are controversial (Mesquita et al., 2014; Aparecido et al., 2017; Kumar et al., 2014; Araujo et al., 2016). It should also be noted that biofertilizers are much more economically attractive than conventional chemical fertilizers (Freitas et al., 2015).

A balanced fertilization is one of the key factors for high quality seeds production and the studies of the how the plant nutrition affects the crops are necessary (Carvalho et al., 2001; Imolesi et al., 2001; Alves et al., 2005). Seed quality is determined by attributes that can be grouped into genetic, physical, pathological and physiological factors (Delouche, 1986). Physiological factors include seed germinability and vigor that are the core for the establishment of a uniform stand of vigorous plants (Delouche, 1986).

As the application of biofertilizer has been reported for its great capability of increasing soil properties, plant nutrition and crop yield, the seed quality harvested in a rice crop treated with a biofertilizer is expected to be improved. The aim of this study was to analyze the influence of the biofertilization in the rice crop yield and the parameter of its seed quality and grain quality.

2. Materials and Methods

2.1 Field Experiment Site Location Description

The experiment was carried out at field, in an experimental area of the Farroupilha Federal Institute (IFFar), Alegrete Campus, Alegrete, Rio Grande do Sul state, Brazil. The 20 ha experiment site is located at 29°42′57.0″ S, 55°31′55.8″ W, at an altitude of 87 m above sea level. According to Koeppen's classification, the regional climate is Cfa: humid-subtropical with warm summer and lack of a pronounced dry season. Average daily temperatures vary from 14.3 ºC in the winter to 26.3 ºC in the summer and annual precipitation average is approximately 1400 mm (Moreno, 1961). Monthly climate data during crop development are showed in Table 1.

Table 1. Monthly climate data during the field experiment in Alegrete, Brazil

		November 2016	December 2016	January 2017	February 2017
Average temperature (ºC)	Minimum	15.68[1]	19.55	20.51	20.36
	Maximum	29.06	32.21	31.56	31.21
Rainfall (mm)		78.4	79.4	76.9	173.9

Note. [1]Source data: National Institute of Meteorology (INMET). Retrieved from http://www.inmet.gov.br/portal/index.php?r=bdmep/bdmep

2.2 Field Experiment Soil Description

The region of the study is known for its lowland relief and its poorly drained soil. The most superficial soil layers are sandy, contrasting with the deeper layers that are more clayey. The soil fertility was determined by chemical analyses (Tables 2 and 3), in which the soil fertilization operation was based, following the regional recommendation for rice crop (Tedesco et al., 2004).

Table 2. Chemical soil analyses result for organic matter (OM), portion of clay soil, texture, phosphor (P) by Mehlich method, potassium (K) and cation exchange capacity (CEC)

% OM	% Clay	Texture	P Mehlich	K	CEC pH 7.0	K
---------- mass volume^{-1} ----------			----- mg dm^{-3} -----	------------ cmolc dm^{-3} -----------		--- mg dm^{-3} ---
1.4	18	4	16	0.15	12.08	60

Table 3. Chemical soil analyses result for pH, calcium (Ca), magnesium (Mg), aluminum (Al), aluminum and hydrogen (H + Al), effective CEC, SMP index, Al saturation and base saturation

pH in water	Ca	Mg	Al	H + Al	Effective CEC	SMP	Saturation (%)	
							Al	Bases
	-------------------------- cmolc dm^{-3} --------------------------							
4.6	0.8	0.2	1.1	10.93	2.25	5.2	48.81	9.55

2.3 Site Preparation, Crop Sowing and Management Operations

The rice crop was irrigated by flood. The area was systematized in order to prepare a leveled soil surface. A leveled soil surface is necessary for flood irrigation. The soil was ploughed and harrowed. It was built mud walls of approximately 40 cm high for water retention. The water used for irrigation was captured from a stream of the Ibicuí basin and conducted to the field by furrows.

The cultivar of rice used for crop implantation was the GURI INTA CL®. The sowing occurred in November 10th, 2016 in a density of 100 kg ha^{-1} and 0.17 m of row spacing. A KF® planter was the machinery used for sowing operation. The planter is equipped by a system of discs and a rod per row for furrowing, fertilization and seeding.

It was carried out all the operations necessary for crop maintenance as pesticide and nitrogen application, all based on specialized literature (SOSBAI, 2016).

2.4 Biofertilizer Preparation and Application

The biofertilizer was prepared by CLC® (Continuous Liquid Composting) factory using 5% of the commercial biological fertilizer Microgeo®, 15% of ruminal content and make up with water in a 2,000 L tank. Each 3 days and at sunlight, the CLC® was mixed using a paddle. After 15 days from preparation, the biofertilizer was ready to use. Every time after CLC® consumption, it was filled up with water and 2.5% of Microgeo® amount removed, as described in its manual (Microgeo, 2017).

A tractor mounted boom sprayer applied the biofertilizer on the rice field. A pre filter of the biofertilizer was placed in the CLC biofactory (Figure 1) in order to strain bigger particles and avoid them to enter in the sprayer tank during tank filling. The boom sprayer had a sprayer nozzle (Teejet XR 11002, conventional flat fan) in each 0.5 m of the bar. Two applications of 150 L ha^{-1} of the biofertilizer was performed at different moments: 20 days before the rice sowing and at the day of rice canopy full emergence.

Figure 1. CLC biofactory photos during operations of mixing with a paddle (a) and the pre filter placement used for sprayer tank filling (b)

2.5 Experimental Design, Treatments and Yield Evaluation of the Field Experiment

The experimental design used was random blocks with 2 treatments (with and without biofertilizer application) and 12 repetitions, making 24 plots. The rice yield was estimated by collecting every plant of a random 1 m^2 that represented one repetition. The maturity was identified through the grain moisture monitoring: the samples were collected when the canopy presented approximately 18% of moisture. The grains collected in each repetition were cleaned by an air fan, weighted using a digital scale (Sf-400), their moisture portion measured by the grain moisture meter AL 102 ECO (Agrologic) and corrected for 13% of moisture. Finally, the yield was determined in kg ha^{-1}.

2.6 Rice Seed Quality Evaluations

The physiological seed quality analyses were carried out in laboratory using the rice seeds harvested from each 24 field experiment plot, submitted with the treatments with or without biofertilizer application. It was carried out the following tests, according to the rules for testing seeds of Brasil (2009): standard germination (SG), first-count germination (FCG), thousand-seed weight (TSW), hectoliter weight (HW) and pH.

For standard germination (SG) and first-count germination (FCG) tests four 100-seed replications were germinated on moistened (at 2.5 times the paper weight) Germitest® paper rolls placed in a BOD (Biochemical Oxygen Demand) at 25 °C. First count was performed 5 days after planting and final counts after 14 days.

For thousand-seed weight (TSW), eight 100-seed replications where weighted in an analytical scale (Shimadzu AUW-220) of 0.0001 g precision. The seed moisture content was determined by drying at 105º oven for 24 h. With the results, it was possible to correct the moisture for 13% for TSW determination.

Hectolitre weight (HW) were determined using a Dalle Molle volumetric device (Balanças Dalle Molle Ltda) and an analytical scale (Shimadzu AUW-220).

2.7 Rice Grain Quality Evaluations

Manually and with the help of a blower, impurity and empty caryopsis was separated for percent whole grain determination. During 20 seconds, 100 g samples of whole rice grain was milled by a grain tester mill MT-95 (Suzuki Co.). Then the grain was glazed for 1 min. in the same equipment for percent polished rice grain determination. Polished grains was placed in a trieur and the grains were separated for 30 s. The grains that remained in the trieur were weighed for percent undamaged grains determination.

2.8 Statistical Analyses

The data were analyzed using ANOVA and Tukey's test at 5% probability, with SASM-Agri software (Canteri et al., 2001).

3. Results and Discussion

3.1 Rice Yield

The rice yield with biofertilization was 6310 kg ha^{-1}, whereas without biofertilization was 5912 kg ha^{-1}. However, besides the treated rice had a yield 7% higher, the results were not statistically significant (Table 4).

The application of continuous liquid composting manufactured using Microgeo® biofertilizer in soil did not increase the yield of organic mini tomato crop (Araujo et al., 2016). According to Araujo et al. (2016) the lack of significance of the biofertilizer may be related to the amount of organic matter present in the soil and addition of bovine manure and organic fertilizer, which mineralized, masking the effects of the biofertilizer. Mesquita et al. (2014) reported that the commercial biofertilizer Microgeo® did not cause qualitative or yield benefits for two melon cultivars. The biofertilization using Microgeo did not altered the plant initial growth, plant height, steam diameter and yield among other coffee crop parameters in the first yield year (Aparecido et al., 2017). Gama et al. (2014) studied de effect of Microgeo in the melon yield and soluble solids content. The doses they tested caused no significant difference compared to the crop control, even though the melon (*Cucumis melo* L.) treated with four different Microgeo doses presented greater yield value than the control without biofertilizer application. However, it is very important to emphasize that the studies cited above did not followed the manufacture's manual recommendation (Microgeo, 2017).

In other hand, research demonstrated benefits in lettuce using Microgeo®, with significant positive effect on several parameters (stem diameter, number of leaves and root system length) in addition to 77% fresh matter increase (Cardoso et al., 2017). In soybean crop, the presence of Microgeo® provided yield increase in a highly nematodes infested area (Marchioro Junior et al., 2015). Kumar et al. (2014) reported that organic matrix entrapped biofertilizers increase growth, productivity, and yield of wheat (*Triticum aestivum* L.) and transport of nutrients from soil to plant leaves, especially when doubling the recommendation doses. Specifically in rice crop, Gandhi and Sivakumar (2010) reported an 18.19 kg ha^{-1} yield using a vermicompost based inoculants biofertilization, 28% higher than its control. Melo et al. (2013) reported that a cheese whey, water and sugar-based biofertilizer provided significant benefits in the corn (*Zea mays* L.) yield but not significant for bean (*Vigna unguilata* L.) yield.

Foliar application (V1 growth stage) of 320 L of CLC® ha^{-1} is reported to provide a significant increase on soybean (*Glycine max* (L.) Merrill) yield at field condition (Prieto et al., 2017). As well as the present study, Prieto et al. (2017) used the CLC® besides conventional chemical fertilization, however our results had no significant difference on rice. A popular liquid biofertilizer named Supermagro was reported for increasing the raceme number of tomato (*Lycopersicon esculentum* Mill.) (Tanaka et al., 2003). Santos et al. (2013) studied a liquid bovine biofertilizer on the sorghum crop and found higher aboveground fresh mass compared to the control. Also several studies suggests that biofertilizer can cause benefits of increasing soil microbes on soil ecosystem by enhancing nutrient uptake, recycling organic nutrients, improving soil structure and controlling pathogens (Miransari et al., 2009; L. Böhme & F. Böhme, 2006; Principe et al., 2007).

Table 4. Rice (kg ha^{-1}) yield with and without biofertilizer application

	Yield (kg ha^{-1})	
	Biofertilized	No biofertilized
	6310 A	5912 A
CV (%)	16.54%	
F	4.84^{NS}	

Note. [1] Means in followed by the same letter are not significantly different (Tukey's test, P = 0.05); ^{NS} Not significant (Tukey's test, P = 0.05).

3.2 Seed Quality

The biofertilization did not statistically influenced the seed quality for the parameters SG, HW and pH (Table 5); however, the SG of the seeds from the biofertilized rice was 14% higher than no biofertilized. The biofertilization of the rice crop influenced the FCG and TSW of their seeds (Table 5). Seeds from not biofertilized plants showed greater FCG (44%) and TSW (7%). It is important to note that even though the treatments differed for FCG, eventually their germination was similar, as we can see in the SG results. Also, the coefficient of variance (CV) for FCG was considerable (18%) which could explain the difference in that parameter.

A biofertilization using vermicompost combined with *Trichoderma* seed treatment in a peanut (*Arachis hypogaea* L.) field increased the SG of their seeds (Kamdi et al., 2014). Arangajan et al. (1998) studied the effect of inoculants on rice TSW and reported that a combined crop biofertilization using *Azospirillum lipoferum* and *Bacillus megaterium* increase that parameter. Studying the CLC® on soybean field, neither its application of 160 or 320 L ha^{-1} cause increase in the TSW (Prieto et al., 2017). Mekki and Ahmed (2005) studied soybean in pots and reported TSW decrease by adding biofertilizer singly, but when it was associated with organic manure showed the highest seeds and pods weights.

Table 5. Seed quality (first-count germination, standard germination, thousand-seed weight, hectoliter weight and pH) with and without biofertilizer application

Treatment	FCG (%)	SG (%)	TSW (g)	HW (kg hl^{-1})	pH
Biofertilization	46.56 B[1]	88.44 A	24.62 B	51.69 A	6.99 A
No biofertilization	67.00 A	77.60 A	26.36 A	51.89 A	7.00 A
CV (%)	17.68	15.40	2.15	2.63	0.71
F	24.92**	4.34^{NS}	60.50**	0.12^{NS}	0.33^{NS}

Note. [1] Means in each column followed by the same letter are not significantly different (Tukey's test, P = 0.05); ** $P < 0.01$; ^{NS} Not significant.

3.3 Grain Quality

The biofertilization of the rice crop using CLC® did not influenced any evaluated parameter referred to its grain quality: whole grain, polished grain or undamaged grain (Table 6). Gandhi and Sivakumar (2010) by field and pot experiments reported the benefits of the biofertilization using vermicompost based inoculants was significant for the rice grain quality parameters: hulling percentage, grain milling percentage, water uptake, volume expansion, elongation ratio, protein and amylose of rice grain. However, for the present study using a different biofertilizer there were no significance for grain quality parameters.

Table 6. Grain quality (percent whole grain, polished grain and undamaged grain) with and without biofertilizer application

Treatment	Whole grain (%)		Polished grain (%)		Undamaged grain (%)	
Biofertilization	74.11	A	65.92	A	57.55	A
No biofertilization	76.89	A	67.52	A	58.00	A
CV (%)	4.14		4.52		13.75	
F	4.75^{NS}		1.68^{NS}		0.02^{NS}	

Note. [1] Means in each column followed by the same letter are not significantly different (Tukey's test, *P* = 0.05); [NS] Not significant.

Accordingly, many robust studies had reported the benefits of biofertilization for crop production, most of them for yield. However, the present study did not allow us to confirm that statement once they were not significant by the statistical analyses for yield and grain quality; for seed quality, the results were controversial.

4. Conclusion

The biofertilization using continuous liquid composting provided no significant extra benefits for the evaluated parameters of grain and seed quality. The rice yield with biofertilization using continuous liquid composting was not statistically higher, an expected result for a first year of biofertilization. However, it provided 398 kg ha^{-1} grain yield increase, which is very positive and a promising result considering being the first year of application. Therefore, a significant yield increase for the following years of application is expected.

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