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Original article

Application of the biofertilizer CBFert® in two rice production systems with low fertilizer input

Aplicación foliar del biofertilizante CBFert® en dos sistemas de producción de arroz con bajo insumo de fertilizante

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ABSTRACT: Rice is an essential food in the Cuban diet. Therefore, achieving its production with environmentally friendly products (bioproducts) is a challenge. The objective of the research was to evaluate the effect of the application of the biofertilizer CBFert® in two rice production systems with low fertilizer input. The experiment was established under field conditions in two cropping systems, one by direct seeding and the other by mechanized transplanting following a separate scheme in a Randomized Block Factorial Experimental Design, factor 1: dose (1.44, 2.16 and 2.88 L ha^{-1}) factor 2: frequency of application (7, 14 and 21 days), with a single control. Rice (cv. INCA LP-5) was grown and agricultural yield was evaluated at 14 % grain moisture. Foliar application of CBFert® with 20 % background mineral fertilization showed lower yields than the control fertilized with 100 % fertilization. In both seeding methods, foliar application of CBFert® at 2.88 L ha^{-1} every 7 days showed higher yields. Based on these results, the application of CBFert® biofertilizer is suggested as a complementary nutritional alternative in rice cultivation, with an application interval of 21 days.

Key words: Fertilizer, biostimulants, *Oryza sativa*, foliar spray, yield.

RESUMEN: El arroz constituye un alimento esencial en la dieta del cubano. Es por ello que, lograr su producción con productos (bioproductos) amigables con el medio ambiente es un reto. La investigación tuvo como objetivo de evaluar el efecto de la aplicación del biofertilizante CBFert® en dos sistemas de producción de arroz con bajo insumo de fertilizante. Se estableció el experimento en condiciones de campo en dos sistemas de cultivo, uno por siembra directa y otro por trasplante mecanizado siguiendo un esquema por separado en un Diseño Experimental Factorial en Bloques al Azar, factor 1: dosis (1,44, 2,16 y 2,88 L ha^{-1}) factor 2: frecuencia de aplicación (7, 14 y 21 días), con testigo único. Se cultivó el arroz (cv. INCA LP-5) y se evaluó el rendimiento agrícola del mismo al 14 % de humedad del grano. La aplicación foliar de CBFert® con el 20 % de fertilización mineral de fondo mostró rendimientos inferiores al testigo fertilizado con el 100 % de la fertilización. En ambos métodos de siembras, la aplicación foliar de CBFert® a 2,88 L ha^{-1} cada 7 días mostró rendimientos superiores. A partir de estos resultados, se sugiere la aplicación del biofertilizante CBFert® como una alternativa complementaria nutricional en el cultivo del arroz, con intervalo en su aplicación de 21 días.

Palabras clave: Abono, bioestimulantes, *Oryza sativa*, pulverización foliar, rendimiento.

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Authors' contribution: Michel Ruiz Sánchez: Generated the research, set up experiments, processed data and prepared article. **Guillermo S. Día López:** Set up the experiment and contributed in the analysis of the results. **Yaumara Muñoz Hernández:** Contributed in the analysis of the results. **Roselys Rodríguez Pérez:** Contributed in the analysis of the results. **Alexander Miranda Caballero:** Contributed in the analysis of the results. **Calixto Domínguez Vento:** Contributed in the analysis of the results. **Alberto Rolando Gil Olavarrieta:** Provided the biofertilizer and contributed in the analysis of the results.

INTRODUCTION

Rice (*Oryza sativa* L) is an indispensable part of the Cuban diet, its per capita is over 60 kg and its production is carried out throughout the island. The latest FAO forecast for world cereal production in 2022, had a reduction of 1.7 million tons since September. Rice production is currently forecast to be in the order of 512.8 million t (milled rice). This is 2.4 % less than the all-time high of 2021, but still an above-average crop (1). According to estimates by the Organization for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO) for the next decade, world rice production is projected to reach 582 Mt in 2029, an increase of 15 %, with Asia contributing most of this increase, with an additional 61 Mt (2). To achieve these goals, natural resources (water and soil) are needed, in addition to fertilizer products.

In Cuba, there are two production systems for rice cultivation: direct sowing of the grain and the establishment of seedbeds for transplanting (3). Both systems consume soil mineral fertilizers to a lesser or greater extent. However, in recent years there has been a trend towards the use of bioproducts and foliar fertilizers to replace edaphic fertilizers or as a complement. Non-compliance with technological regulations for this crop, as well as the low availability of inputs (fertilizers and pesticides) are among the causes that have had a negative impact on the decrease in yields of this crop.

The Chemical Engineering and Research Center of the Chemical Industry Business Group, in Havana, developed the ecological liquid fertilizer CBFert®, with the objective of reducing the use of chemical products in agriculture through the incorporation of a cyanobacteria of national production (4). This biofertilizer has a favorable environmental effect based on the reduction of nutrient loss when applied to the soil, as it causes greater assimilation of nutrients immediately. The production of this product in 2020 rose from 10 000 L to more than 100 000 L, according to Cuba's results report for the United Nations (5).

Among the strategies for rice production in Ciego de Avila, Laibono, Codafol and Bayfolan are applied, due to the lack of Urea and other edaphic fertilizers (6). According to the Cuban News Agency (7), farmers in Las Tunas use CBFert® as a foliar fertilizer, which provides nutrients that can be assimilated by direct absorption, stimulates plant growth and increases plant resistance to adverse conditions. However, there is no clear picture of the use of CBFert® in rice cultivation. Taking into account the above, the objective of the research was to evaluate the effect of the application of the biofertilizer CBFert® in two rice production systems with low fertilizer input.

MATERIALS AND METHODS

The research was carried out at Scientific and Technological Base Unit "Los Palacios" (UCTB "Los Palacios"), Cuba, at 22°34'32.73" N and 83°14'11.95.95" W, belonging to the National Institute of Agricultural Sciences (INCA) from January to June 2021 under field conditions.

Rice cv. INCA LP-5, indica type, semi-dwarf, short cycle, excellent agricultural and industrial yield and better tolerance to diseases under field conditions was used. The soil was classified as petroferric Ferruginous Nodular Gleysol (8), and it was characterized by a slightly acid pH (6.11); low organic matter (OM) content (2.52); exchangeable bases with typical contents for this type of soil and considered low and low assimilable phosphorus (P) (10.28 mg kg^{-1}) (9).

Prior to sowing, the seed was classified by the density method, which consisted of submerging the rice seeds in irrigation water and eliminating all the seed that floated (3). First, direct sowing was carried out (120 kg ha^{-1} of seed) and sowing of the technified seedbed was started, with the purpose of making the mechanized transplanting coincide with the same cycle in the field as the direct sowing.

Before the last pass of mudding and smoothing in the preparation of soil in each plot, a background fertilization was carried out in the entire experimental area, with 20 % of the total dose of urea, 100 % of the total dose of triple superphosphate and 30 % of potassium chloride. After the emergence of the rice, a population count was carried out and a population between 150 and 200 plants per m2 was achieved, as recommended by the technical norms for rice cultivation (3). In the specific case of transplanting, the transplanting machine was adjusted to deliver two and three plants per site, with a planting frame of 0.30 m between rows x 0.12 m between plants. CBFert® applications were initiated 7 days after germination and transplanting.

In the period from January to July 2021 the average temperature was 25.6 ºC, the relative humidity was 79.6 % and the accumulated rainfall in the last three months averaged 746.7 mm, according to data provided by the Meteorological Station "Paso Real de San Diego", # 317, in Los Palacios, which is located 5 km from the research area (Figure 1).

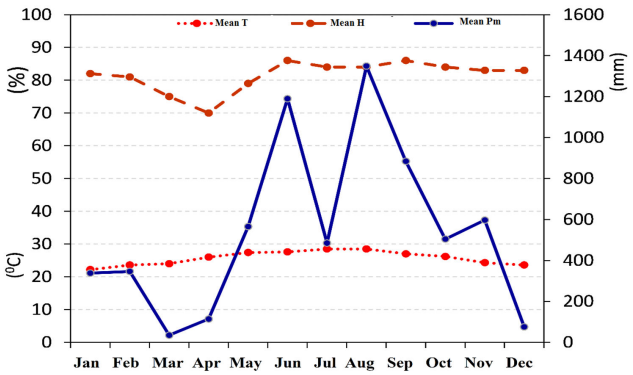


Figure 1. Performance of prevailing meteorological variables during the research period, year 2021. Meteorological Station "Paso Real de San Diego", # 317, in Los Palacios

The experiment consisted of the foliar application of CBFert® on rice (cv. INCA LP-5), which was tested in two cropping systems, one sown by direct seeding and the other by mechanized transplanting, with a previous technified seedbed (3). The foliar application of CBFert® was compared with a control treatment with 100 % NPK fertilization.

Both systems had a surface area of 3 200 m^2 and were subdivided into blocks (subplots of 288 m^2 with intermediate aisles of 0.5 m), where the treatments were established, following a Randomized Block Factorial Scheme (3x3+1), factor 1: dose (1.44, 2.16 and 2.88 L ha^{-1}) factor 2: frequency of application (7, 14 and 21 days), with a single control (Table 1).

Evaluations and data processing

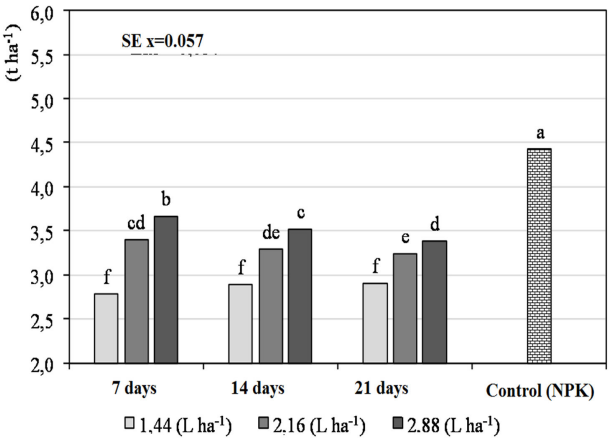
At 133 days after sowing and 113 days after transplanting, rice was harvested (20 % grain moisture) per treatment. Four samples of 9 m^2 per plot were collected, dried in the sun and weighed when the moisture content was 14 % (10). The data obtained were analyzed for better understanding by cropping systems. Factorial analysis of variance was performed for the factors CBFert® dose and application interval, and when there was a significant difference, the means were compared according to Duncan's Multiple Range Test (p≤0.05), for which the SPSS program on Windows, version 22, was used.

RESULTS AND DISCUSSION

The yield of cv. INCA LP-5 in the no-tillage system showed differential behavior as a function of CBFert® application and application rate. The control treatment was significantly superior to the other treatments evaluated (Figure 2). However, there was significant interaction (p<0.05) between the factors dose and interval. It is important to note that in the treatments with biofertilizer, the agricultural yield was higher in the treatment of 2.88 L ha^{-1} every 7 days (T3) compared to the other treatments combined (Figure 2).

When analyzing the applications of CBFert® with an interval of 7 days in rice by direct seeding, the highest values of agricultural yield were observed when the maximum dose (2.88 L ha^{-1}) was applied in each application. A similar behavior was found with an interval of 14 and 21 days. It is important to note that the lowest yield values were obtained with the lowest dose of CBFert® biofertilizer.

In the transplant production system, the application of CBFert® with an interval of 7 days (Figure 3), showed a similar behavior to that observed in the direct seeding rice production system for each moment. However, with 21-day intervals, it was observed that there were no differences



Means with equal letters do not differ significantly (p≤0.05) according to Duncan's Multiple Range Test

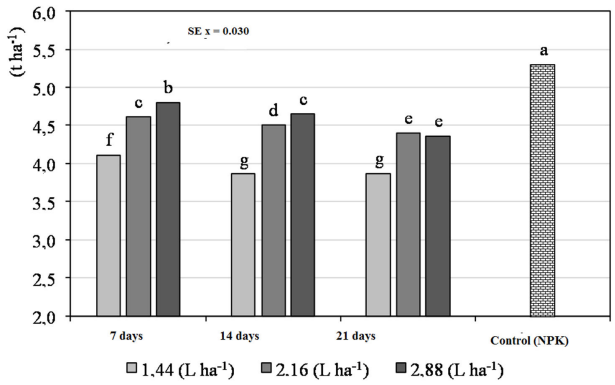
Figure 2. Agricultural yield of rice cv. INCA LP-5, grown by no-tillage, with the application of different doses and timing of the biofertilizer CBFert®

when the medium (2.16 L ha^{-1}) and higher (2.88 L ha^{-1}) doses of CBFert® were applied. These results suggest that the essential element is the application rate of CBFert®, represented by the timing of application.

Importantly, CBFert® contributes to the supply of assimilable nutrients that are directly absorbed by the plant. It simultaneously provides amino acids, vitamins and minerals that optimize metabolic processes, acting as a plant growth stimulant (3). In both production systems, it was found that agricultural yields did not exceed the control regardless of the dose or time of application of CBFert®. This result indicated that the amounts of the biofertilizer did not replace the amounts of nutritional carriers (mineral fertilizers) Urea (N_2), triple Superphosphate (P_2O_5) and Potassium Chloride (KCl) that were applied to the crop, according to the recommendations of their technical standards (3). Nevertheless, the agricultural yields, with the exception of the control, were in the order of the national production average of the last five years for the direct seeding production system (11). In the case of transplanting rice, the values were congruent to those obtained by this technology in the control treatment, when different water managements were evaluated (12).

Table 1. Treatments, total applications and total dose

Treatments			No. Application
No.	Dose	Frequency	
T1	1.44 L ha^{-1}	7 days after	12
T2	2.16 L ha^{-1}		12
T3	2.88 L ha^{-1}		12
T4	1.44 L ha^{-1}	14 days after	6
T5	2.16 L ha^{-1}		6
T6	2.88 L ha^{-1}		6
T7	1.44 L ha^{-1}	21 days after	4
T8	2.16 L ha^{-1}		4
T9	2.88 L ha^{-1}		4
Control	Doses (300 kg Urea. 100 kg de Superphosphate and 100 Kg Potassium Chloride) ha^{-1}		



Means with equal letters do not differ significantly (p≤0.05) according to Duncan's Multiple Range Test

Figure 3. Agricultural yield of rice cv. INCA LP-5, grown by transplanting, with the application of different doses and timing of the biofertilizer CBFert®

These agronomic results in terms of agricultural yield can be explained by the chemical composition of CBFert® and its contribution when applied to the crop. It is known that nutritional macroelements such as phosphorus and nitrogen are directly involved in vegetative development and fruit formation and, therefore, in agricultural yield. From microelements found in the biofertilizer in the highest concentration, Fe, Mg and Zn are involved in the formation of chlorophyll and plant morphology; on the other hand, Mn is essential for photosynthesis, forming part of enzymes responsible for protein synthesis (13). Essentially, according to the manufacturer, NPK contributions are: Nitrogen (N): 11 % v/v. Phosphorus P_2O_5: 8 % v/v. Potassium K_2O: 6 % v/v (3).

This biofertilizer contributes to yield increase between 35 and 65 % in different crops (5). However, in the rice crop, the response of the plants is different, due to the characteristics of the crop, which is demanding to high doses of fertilizer, as well as to its fractionation. In the direct seeding system, to achieve high yields, it is necessary to guarantee a minimum of 150 plants per square meter (3) and in the transplant production system, the same or higher production is obtained with 25 to 30 plants per square meter (3). Therefore, there may be a greater efficiency in the absorption of fertilizers in the transplanting system than in direct sowing, in addition to less competition among plants for the acquisition of minerals. In rice production by any sowing method, fertilizer leaching or washing occurs, due to the presence of the water sheet and its drainage (14).

In this regard, it has been reported that foliar fertilizers are more expensive per unit of nutrient in comparison with equivalent amounts of fertilizers applied to the soil, since foliar application nutrients provide a response of quality, specificity and speed, which cannot be equivalent to the one obtained with soil applications (15). Similar results were obtained by other authors when they affirmed that foliar application is a more efficient and effective way of providing nutrition to the plant (16). This implies that the efficiency of foliar fertilizer can sometimes be interpreted in terms of its benefit to local or total processes in the plant and in relation to the mobility of nutrients, which, among other factors, can be affected by the plant species, varieties or organs of the plant (15;17;18). The response found with the application of CBFert® in the rice crop, as well as the frequency of application, may condition a nutritional status of the plant without deficiency, an element that should be investigated in depth.

On the other hand, the number of applications made with an interval of 7 days and 14 days is unsustainable in specialty rice production. As a general rule, in this crop, in addition to the application of herbicides, four phytosanitary applications are made according to the appearance of pests, and two of these are made compulsorily in the protection of the panicle (3). Even when the results point to the application with an interval of 7 days, it has the technological negative in its application. Also the total volumes to apply CBFert® in the crop cycle make it unsustainable.

CONCLUSIONS

Foliar application of CBFert® with 20 % background mineral fertilization showed lower yields than the control fertilized with 100 % fertilization. In both planting methods, foliar application of CBFert® at 2.88 L ha^{-1} every 7 days showed higher yields. The results of this study suggest the application of the biofertilizer CBFert® as a complementary nutritional alternative in rice cultivation, with an application interval of 21 days, taking into account the production technology.

BIBLIOGRAPHY

1. FAO. Nota informativa de la FAO sobre la oferta y la demanda de cereales. [Internet]. 2022. [cited 23/12/2022]. Available from: https://www.fao.org/worldfoodsituation/csdb/es/
2. OECD/FAO. Perspectivas Agrícolas 2020-2029. [Internet]. 2020 [cited 22/09/2021]. OECD Publishing: Paris. Available from: https://www.oecdilibrary.org/agriculture-and-food/oc-de-fao-perspectivas-agricolas-20202029_a0848ac0-es
3. MINAG. Instructivo Técnico del Arroz. La Habana, 2020. 142 p. ISBN: 978-959-285-065-1.
4. DICA. Desarrollan fertilizante líquido ecológico. Dirección de Innovación y Calidad. El salvador. [Internet]. 2016. [cited 23/12/2022]. Dirección de Innovación y Calidad. El salvador. Available from: http://dica.minec.gob.sv/inventa/noticias/10287-inicio-ciencia-desarrollan-en-cuba-fertilizante-liquido-ecologico.html
5. ONU. Reporte de resultados 2020, Cuba a las Naciones Unidas. [Internet]. 2020. [cited 23/12/2022]. Available from: https://cuba.un.org/sites/default/files/2021-04/Reporte%20de%20Resultados%2C%20VERSI%C3%93N%20FINAL.pdf
6. Sosa-Barceló, S. Biofertilizantes y abonos orgánicos tendrán que dejar de ser alternativas y convertirse en norma en Ciego de Ávila. Periódico el Invasor, julio 2020. [Internet]. 2020. [cited 27/12/2022]. Available from: http://www.invasor.cu/es/opinion/agricultura-en-ciego-de-avila-dar-y-recibir
7. Gómez-Amaró, Y. Beneficiados campesinos de Cienfuegos con medidas para producción agrícola. Agencia Cubana

de Noticias (ACN), 10 Septiembre 2021. [Internet]. 2021. [cited 27/12/2022]. Available from: http://www.acn.cu/economia/84544-beneficiados-campesinos-de-cienfuegos-con-medidas-para-produccion-agricola

8. Hernández, J. A., Pérez, J. J. M; Bosch, I. D y Castro, S. N. Clasificación de los suelos de Cuba. Ediciones INCA, Cuba, 2015. 93. ISBN: 978-959-7023-77-7. http://ediciones.inca.edu.cu/ y http://www.inca.edu.cu
9. Pozo, C., Cabrera, J.R., Márquez, E., Hernández, O., Ruiz-Sánchez, M. y Domínguez, D. Características y clasificación de suelos Gley nodular ferruginoso bajo cultivo intensivo de arroz en Los Palacios. Cultivos Tropicales, [Internet]. 2017 [cited 27/12/2022]; 38(4):58-64. Available from: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0258-5936201700040 0011
10. Ruiz-Sánchez, M., Echeverría-Hernández, A., Muñoz-Hernández, T., Martínez-Robaina, AY., Rodríguez-Pérez, R., Cruz-Triana, A., Encalada-Córdova M. Aplicación de dos cepas de *Trichoderma asperellum* S. como estimulante de crecimiento en el cultivo del arroz. Cultivos Tropicales, [Internet]. 2022 [cited 27/12/2022]; 43(1):e10. Available from: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1010-27522019000200 004
11. ONEI. Anuario Estadístico de Cuba 2022. CAPÍTULO 9: Agricultura, Ganadería, Silvicultura y Pesca. [Internet]. 2018. [cited 27/12/2022]. Available from: https://www.onei.gob.cu/anuario-estadistico-de-cuba-2022
12. Rivera R, Felix F, Martinez L, Cañizares P, Yakelín R, Ortega E, et al. 2020. Manejo, integración y beneficios del biofertilizante micorrízico EcoMic® en la producción agrícola. Available from: https://www.researchgate.net/publication/340223155_Manejo_integracion_y_beneficios_del_biofertilizante_micorrizico_EcoMicR_en_la_produccion_agricola
13. Ruiz-Sánchez, Muñoz, Y., Dell´Amico, J.M. y Polón P. Irrigation water management in rice crop (*Oryza sativa* L.) by transplant, it's effect on the agricultural and industrial performance. Cultivos Tropicales. [Internet]. 2016 [cited 27/12/2022]; 37(3):178-186. Available from: https://www.researchgate.net/publication/305904109_Irrigation_water_management_in_rice_crop_Oryza_sativa_L_by_transplant_it%27s_effect_on_the_agricultural_and_industrial_performance?channel=doi&linkId=57a4d9d108aefe6167b05aa0&showFulltext=true
14. González-Hurtado, M. Quintana-Amador, I. y Rodríguez-Acosta C. Comparación química entre dos fertilizantes ecológicos de origen natural: CBFert® y BIOPLASMA. Revista CENIC Ciencias Químicas, [Internet]. 2002 [cited 23/12/2022]. 33(1):11-13. Available from: https://revista.cnic.edu.cu/index.php/RevQuim/article/download/1534/1202/3029
15. Hu Y, Bellaloui N, Kuang Y. Editorial: Factors affecting the efficacy of foliar fertilizers and the uptake of atmospheric aerosols, volume II. Front Plant Sci. 2023 Feb 10;14:1146853. https://doi-org/10.3389/fpls.2023.1146853
16. Fernández, V., Sotiropoulos T., and P. Brown. Fertilización Foliar: Principios Científicos y Práctica de Campo. Primera edición, versión revisada, IFA, Paris, Francia, Copyright 2015 IFA. ISBN 979-10-92366-03-7. [Internet]. 2022. [cited 27/12/2022]. Available from: https://www.researchgate.net/publication/283908842_Fertilizacion_Foliar_Principios_Cientificos_y_Practicas_de_Campo
17. Hong, J., Wang, C., Wagner, DC., Gardea-Torresdey, JL., He, F., Rico, CM. Foliar application of nanoparticles: Mechanisms of absorption, transfer, and multiple impacts. Environmental Science: Nano. [Internet]. 2021. [cited 27/12/2022]. Available from: https://pubs.rsc.org/en/content/getauthorversionpdf/d0en01129k
18. INTAGRI. La Absorción de Nutrientes en Fertilización Foliar. [Internet]. 2022. [cited 27/12/2022]. Available from: https://www.intagri.com/articulos/nutricion-vegetal/la-absorcion-de-nutrientes-a-traves-de-la-fertilizacion-foliar