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Use of Biofilm Biofertilizer for Rice Cultivation in Anuradhapura, Sri Lanka: A Case Study

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Abstract:

Combined application of biofilm biofertizers (BFBFs) and 65% of Department of Agriculture (DOA) recommended chemical fertilizers (CF) showed higher rice grain yields in several districts of Sri Lanka i.e. Plonnaruwa, Amapra and Mahiyanganaya but no reported indications in Anuardhapura. Therefore, present study was undertaken to test the potential of BFBFs (Biofilm –R) for rice in Anuradhapura. A field experiment was conducted in a farmer field at Nachchaduwa which belongs to Anuradhapura district in later of Dry (Yala) season 2021. The treatment of 100% CF mixture recommended by the DOA was tested against the reduced dosage CF (65% DOA CF)+ BFBF-R recommended by the National Institute of Fundamental Studies (NIFS) for the biofilm application. Soil alone without amendments was served as the control. All treatments were replicated three times and arranged in a Completely Randomized Block Design (RCBD) in fields. The basic soil characteristics were analyzed prior to initiate the field trial with the rice variety of BG 352. After 14 weeks at the harvest, root and shoot dry mass, panicle length and plant heights were measured as plant growth parameters. Final grain yield and certain soil parameters (soil pH and microbial biomass C) were analyzed. Results of the field trial, revealed that the BFBF-R added NIFS recommendation showed no significance effect against the 100% DOA CF in root dry mass, plant height and panicle lengths while 100% DOA CF recorded significantly highest shoot dry mass at harvest. The most prominent results for final grain yield was also recoded with 100% DOA CF compared to BFBF-R added NIFS recommendation by showing the higher nutrient releasing capacity of CF full dosage (100%) rather than the reduced dosage (65%) even coupled with the biofilms. However, 65% DOA CF+ BFBF-R significantly contributed to enhanced soil microbial community compared to other treatments reflected by the elevated microbial biomass C content at the harvest. Overall, it can be conclude that; Biofilm added NIFS recommendation showed no added advantage over the full dosage of DOA recommendation to rice grain yield for selected filed in Nachchaduwa but significantly contributed to enhanced soil quality, compared to other treatments. Therefore, further studies are needed to optimize CF rate to be coupled with BFBF to get an acceptable rice grain yield.

Keywords: Biofilm biofertilizers, Chemical fertilizer, Grain yield, Rice cultivation.

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the dominant food crops grown in Sri Lanka. It occupies approximately 34% (0.77 million ha) of total cultivated lands in Sri Lanka [9]. On average, 560,000

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ha of lands in *Maha* and 310,000 ha of lands in *Yala* are cultivated to reach average annual extent of rice about 870,000 ha of lands.

Improvement of rice productivity is the one the major objective in agriculture. In 1960, with the green revolution concept, enhanced chemical fertilizer application has been introduced as an option for rice yield improvement. Most farmers use synthetic chemical fertilizer for nutrient supplement in rice cultivation. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP) are commonly applied synthetic fertilizers in rice cultivation [14]. However, continuous application of synthetic chemical P fertilizers acts adversely on the environment. It consists several adverse impacts on the environment in terms of eutrophication, soil fertility depletion etc. [17]. Further it has been reported that some imported synthetic fertilizer samples are contaminated with high concentration of Al, Cr, Ni and Cd like trace elements [13]. In 2009, Chandrajith *et al.,* revealed that chemical fertilizer applied paddy fields in Sri Lanka has notable content of trace elements such as AS, Al, Cr, Ni, Cd, Pb and U. In this regard, application of biofilm biofertilizers (BFBFs) in rice cultivation which leads to cut down chemical fertilizer usage while enhancing the biodiversity and ecosystem functioning, which eventually lead to sustainable systems [15].

National Institute of Fundamental Studies (NIFS) tested an eco-friendly biofertilizer, by introducing the biofilm technology for the first time in the world, named Biofilmed Biofertilizer (BFBFs) for about six years in field experiments [16]. Biofilm biofertilizer developed for rice (Biofilm-R) has been successfully utilized at various paddy growing regions across the country and it has been very successful as a fertilizer and reduces the application of DOA recommended Chemical fertilizer (CF) (2013 recommendation) for rice by 35% [1]. Further this biofilm -R is known as an effective nutrient solubilizer specially for N,P and K [20]. At present, BFBF-R are extensively practiced in paddy fields of *Plonnaruwa, Amapra and Mahiyanganaya*. But the BFBF concept is still novel for *Anuradhapura* since there was no any evidence with its application. Hence this study was conducted to test the potential of Biofilm biofertilizer (Biofilm – R) for rice in *Anuradhapura.*

METHODOLOGY

Location and Site Characteristics

The field experiment was carried out in a farmer field at *Nachchaduwa* in *Anuradhapura, Sri Lanka* which belongs to the DL_1 agro-ecological region with an average annual temperature of 27 ^{o}C and average annual rainfall of 1,368 mm during latter part of *Yala* 2021 season. Soils belongs to Aluthwewa soil series under the great groups of Reddish Brown Earth (RBE) and Low Humic Gley (LHG).

Field Experiment and Analyses

Fields were ploughed, harrowed and leveled according to the recommendations by the DOA. Rice variety BG 352 which is the most popular rice variety in the area was used. Crop was established by broadcasting the water soaked pre-germinated seeds at the recommended rate. The experimental design was a Randomized Complete Block Design (RCBD), with three replicates. The plot size was 20m x 20m. The soils collected from the experimental plots at the commencement of the trial were analyzed for pH [2], Available N [3], Available P [11], exchangeable K [2], organic matter content [11] and microbial biomass C [7],[18].

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Commercially available biofilm formulation developed for rice cultivation (BFBF-R) was collected from Lanka Biofertlizers (PVT) Ltd and the CF and CF+ BFBF-R treatments were added into plots (Table 1) by following the DOA and NIFS recommendations. All other practices such as weeding, pest and disease management etc. were carried out according to the DOA recommendation.

TABLE 1: THE TREATMENTS USED IN THE FIELD EXPERIMENT.

	Treatments
T1	DOA recommended chemical fertilizer formulation for rice -(DOA 100% CF)(2013 fertilizer recommendation- 100%)
T2	NIFS recommendation (65% DOA CF+ Biofilm-R) for rice
T3	Control (without any fertilizers)

After 14 weeks at the harvest, root and shoot dry mass, panicle length and plant heights were measured as plant growth parameters by taking 5 random plants excluding the boarder rows from each plot. Plots were harvested excluding the borders in each sub plot and grain yield was recorded after air drying. Apart from certain soil parameters; soil pH and microbial biomass C were analyzed at the harvest.

Statistical Analysis

Statistical analysis was performed using one way ANOVA in SAS software and means were separated using Tukey's HSD test. Microsoft excel was used to prepare the graphs.

RESULTS AND DISCUSSION

Site Characteristics

The soil was low in organic matter (1.65%), neutral in soil reaction (pH= 7.3) and it had a moderate level of available N. Available P content was close to critical or deficient level while K was at the sufficient level, but not int the optimum range for rice plant growth [12]. Further, soil microbial biomass content was also very low at initially.

TABLE 2: INITIAL PROPERTIES OF SOILS COLLECTED FROM A FARMER FIELD, *NACHCHADUWA, ANURADHAPURA.*

Soil property	Mean ±SD
pH	7.3±0.09
Total P (%)	0.08 ±0.002
Available P (mg kg^{-1})	14.31 ± 1.75
Total N (%)	0.16 ± 0.02
Available N (mg kg^{-1})	77.32 ± 0.34
Exchangeable K (mg kg^{-1})	102.6 ± 1.5
Organic matter (%)	1.65± 0.02
Microbial biomass C (mg g^{-1})	0.48± 0.06

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Plant Growth Parameters; Shoot and Root Dry Mass

At 14 weeks, shoot and root dry masses of the randomly collected rice plants from each plot are given in Figure 1.

In shoot dry masses, the significantly highest dry mass was recorded with DOA 100% (2013) CF treatment while lowest was recorded with control. For root dry masses, the significantly lowest dry mass was observed with control while 100% DOA CF and NIFS recommendations showed no any significance among the root dry masses.

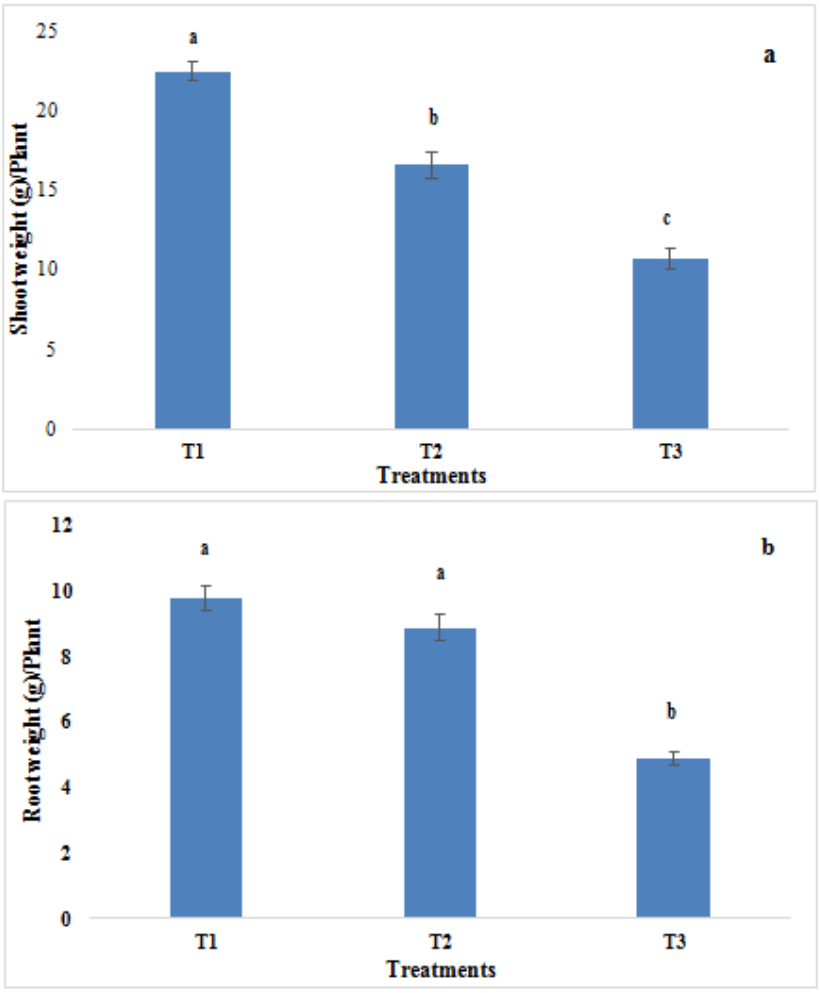

Figure 1: (a) Shoot dry mass and (b) Root dry mass of rice plants at 14 weeks in the field. Different letters indicate statistically significant differences at 5% probability level according to the Tukey's HSD test.

T1- DOA 100% 2013 CF recommendation

T2- NIFS recommendation (65% DOA CF+ Biofilm-R) for rice
T3- Control (without any fertilizers)

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Plant Growth Parameters; Plant Height and Panicle Length

Better plant performances in plant heights and panicle lengths were observed in both DOA 100% CF and NIFS recommendations. Further, they were no showed any significance difference. The control recorded the significant lowest performance for both panicle length and plant heights at the harvest (Figure 2).

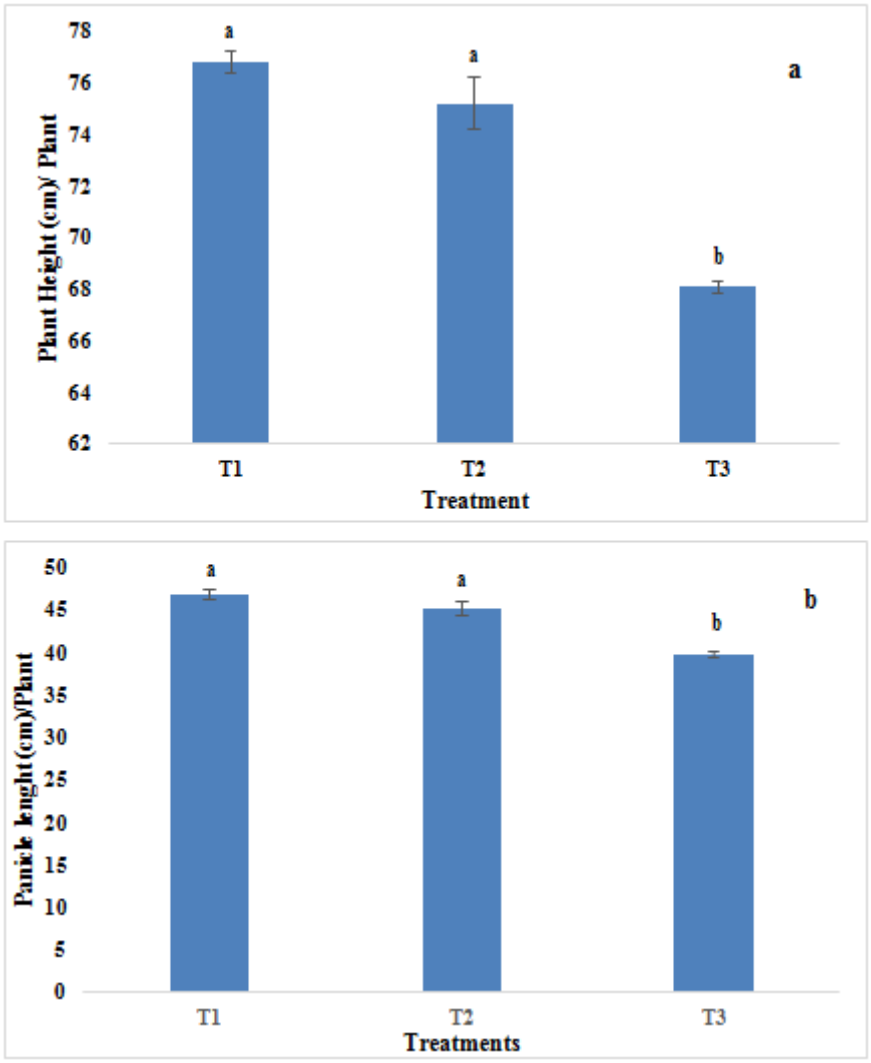

Figure 2: (a) Plant height and (b) Panicle length of rice plants at 14 weeks in the field. Different letters indicate statistically significant differences at 5% probability level according to the Tukey's mean comparison test.

T1- DOA 100% 2013 CF recommendation (DOA 100% CF)

T2- NIFS recommendation (65% DOA CF+ Biofilm-R) for rice

T3- Control (without any fertilizers)

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Plant growth parameters were significantly the highest with the application of DOA recommended CF. The DOA 100% CF performed better for all measured growth parameters (i.e root &shoot dry mass, panicle length and plant height) in comparison to other treatments (Figure 1 and 2).

Root & shoot dry masses, plant height and panicle lengths are considered as important indexes for measuring the plant growth. Many studies have shown that the plant growth parameters are mainly affected by genotype [8] and the role of exogenous nutrient supply should not be neglected. For example, He, (2015) reported that increasing K level in the soil resulted in overall uptake of N, K, Cu and Zn and reduced P, Ca, Mg, Fe and Mn concentrations in cacao plants. Cai, (2017) reported that N addition significantly increased *Arabidopsis thaliana* shoot diameter while phosphorus addition significantly increased the shoot thickness. These findings indicated that different plants have different optimal ranges of nutrient demands, different concentrations, different ratios, and even different nutrient availability can have quite different effects on plant growth and development.

Grain yield

The grain yields at the harvest are showed in figure 3. The significantly the highest *($p<0.05$)* grain yields (1884 kg ha^{-1}) were recorded in DOA 100% CF. The control plots recorded the significantly *($p<0.05$)* lowest yield.

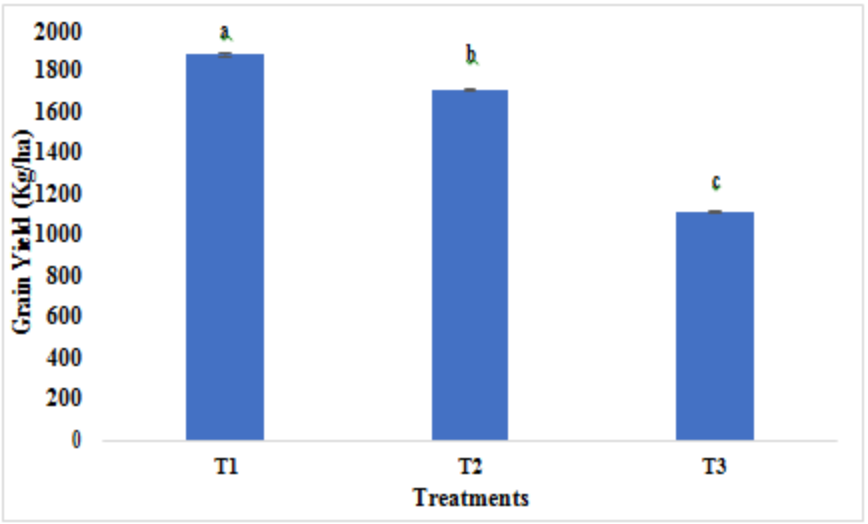

Figure 3: Grain yield at the end of 14 weeks at harvest. Different letters indicate statistically significant differences at 5% probability level according to the Tukey's mean comparison test.

T1- DOA 100% 2013 CF Recommendation (DOA 100% CF)

T2- NIFS recommendation (65% DOA CF+ Biofilm-R) for rice

T3- Control (without any fertilizers)

Application of developed biofilms can increase the grain yield significantly by improving the nutrient use efficiency in plants [19]. But it could not be attributed with this study that; the significantly highest rice grain yields were recorded with DOA 100% CF. Nutrients releasing

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capacity of DOA 100% CF is significantly higher over the NIFS recommendation is consisted with reduced DOA fertilizer dosage+ biofilm application.

Soil Analyses At Harvest; Soil Microbial Biomass and pH

The collected soils initially contained 0.48 mg $g^{-1}$of soil microbial biomass and neutral soil reaction. At the harvest soil microbial biomass C and pH of the treatments were recorded as follows;

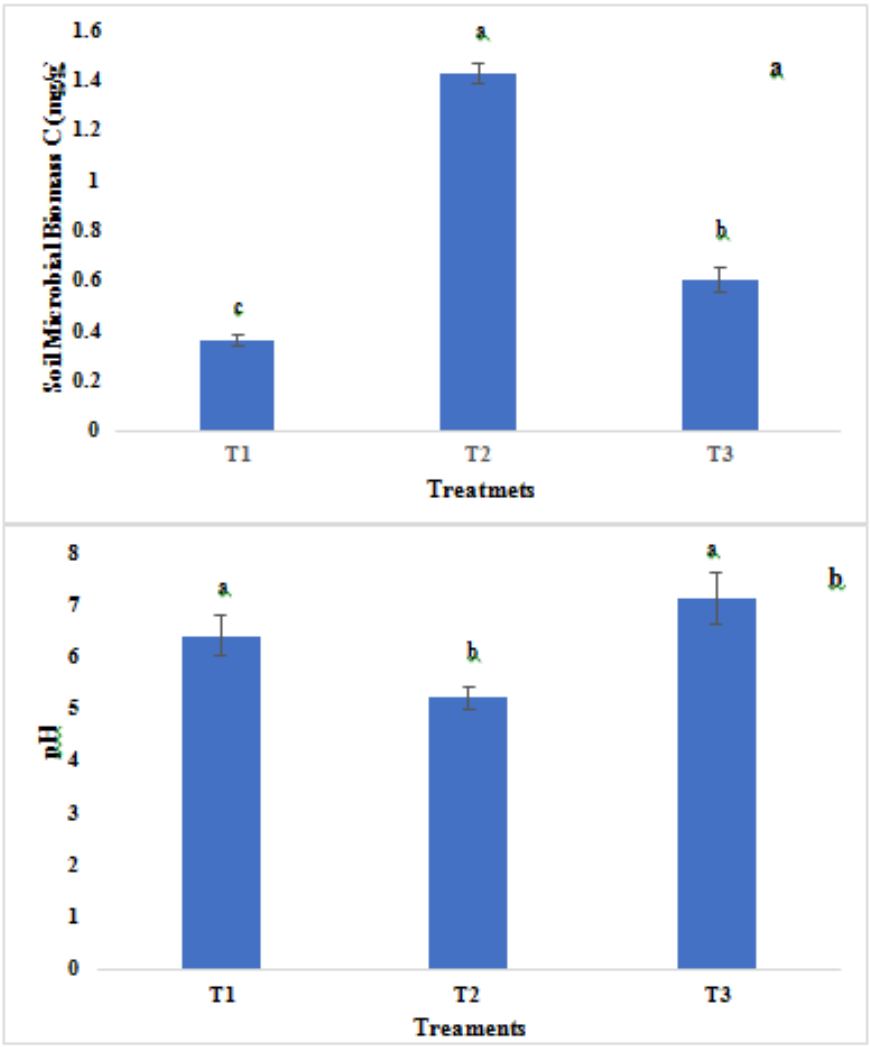

Figure 4: Soil microbial biomass C and pH at the harvest. Different letters indicate statistically significant differences at 5% probability level according to the Tukey's mean comparison test.

T1- DOA 100% 2013 CF Recommendation (DOA 100% CF)

T2- NIFS recommendation (65% DOA CF+ Biofilm-R) for rice

T3- Control (without any fertilizers)

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At the harvest, the significantly ($p<0.05$) highest soil microbial biomass was recorded with NIFS recommendation. Developed biofilms are good environmental pool for enhancing soil microbial communities of fungi, bacteria, cyanobacteria etc. [6]. The NIFS recommendation consisted with biofilms

showing higher acidic pH due to organic acids produced by biofilm microbes during the nutrient solubilization processes.

CONCLUSION AND SUGGESTION

Biofilm added NIFS recommendation showed no added advantage over the full dosage of DOA recommendation to rice grain yield for selected filed in *Nachchaduwa*. However, NIFS recommendation significantly contributed to enhanced soil microbial community compared to other treatments. Repeated studies should be conducted in future to identify the effect of biofilms on yield and needed to optimize CF rate to be coupled with BFBF to get an acceptable rice grain yield.

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