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APPLICATION OF BIOFILM BIOFERTILIZER TO INCREASE GRAIN YIELD VIA ENHANCED RHIZOSPHERE NUTRIENT AVAIALBILITY IN LARGE SCALE RICE CULTIVATION OF SRI LANKA

A.T.D. Rathnathilaka*[1, 2], G. Seneviratne[1] and H.M.S.P. Madawala[2]

[1]National Institute of Fundamental Studies, Hantana Road, Kandy, Sri Lanka
[2]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka.
* *thilinirathnathilaka@gmail.com*

Summary

Indiscriminate use of chemical fertilizers (CFs) adversely affects soil health in rice cultivation. Therefore, improving soil biology, while sustaining rice yields through innovative biotechnologies is essential. Biofilm biofertilizer (BFBF) is a novel product which can be used effectively to increase soil fertility. Present study investigated the effect of BFBF on nutrient availability in the rhizosphere and rice yield under large scale rice cultivation. Farmer fields were applied with BFBFs with 50% CFs and CFs only, respectively. Rhizosphere soil and plant samples were analyzed for chemical, growth and yield parameters. The results showed that the application of BFBF + 50% of farmers' CF significantly increased the available soil nutrients and yield ($p<0.05$) over the farmers' CF alone practice.

Keywords: Biofilm biofertilizer, Chemical fertilizer, Rice, Soil health, Soil nutrients

Introduction

Agricultural sustainability is adversely affected by indiscriminate use of chemical fertilizers (CFs), because farmers tend to believe high application of CFs increases the yeild. The high rates of CFs lead to deposit their harmful ingredients in the soil and the environment causing several health and other issues (Rodriguez et al., 2004). In Sri Lanka, the extent of rice cultivation in 2018 was 560,000 ha and 310,000 ha in *Maha* and *Yala* seasons, respectively. Current rice production is 2.7 million tons per year and annual increment of the demand for rice is 1.1% (Department of Agriculture, 2018). To achieve this demand, the productivity of rice needs to be increased. High production target should be achieved with the minimal use of CFs, but maintaining the required level of available soil nutrients in the rhizosphere.

Currently, farmers tend to give their attention to the application of organic fertilizers and biofertilizers. The driving force behind this is declining of the soil fertility and soil health. Biofertilizer is a substance containing living microorganisms and can be applied to seeds, plant surface or soil, allowing to colonize the rhizosphere or in the plant, thus promoting growth by improving the availability of primary nutrients to the host plant (Vessey, 2003). Biofertilizers may also decrease the soil pH, which leads to increase availability of trace elements that enhance plant growth (Mahfouz and Eldin, 2007).

Biofilm biofertilizer (BFBF) is one of the effective and novel products in agriculture. Biofilm is consisting of microbial cells and extracellular polymeric substances (EPS), which are secreted by themselves to have structural and biochemical protection. The use of BFBF can reduce chemical fertilizer application, improve the crop growth and soil quality, while recovering soil livability that has been damaged by conventional agriculture practices (Seneviratne et al., 2011; Seneviratne et al., 2008). Application of BFBFs with reduced rates of CFs has shown improved results over the application of the reduced dosages of CFs alone in rice and tea cultivations under small-scale field experiments in Sri Lanka (Seneviratne et al., 2011). Currently Sri Lankan farmers use BFBFs in some parts of rice growing areas including Ampara, Nikaweratiya, Polonnaruwa and Ambalantota. Thus, the use of BFBFs can reduce the chemical fertilizer usage in rice cultivation of Sri Lanka. This study was carried out to investigate the effect of BFBFs on the rhizosphere soil nutrient availability and the rice yield under large scale cultivation in Sri Lanka.

Materials and methods

Soil and plant samples (5 samples from each field) were collected from twelve farmer fields which growing At 307, At 308, At 362, Bg 94-1, Bg 358 and Bg 300 rice varieties in Samanthurei, Kalmune and Chadayanthalawa in Ampara district at tillering stage during Maha season in 2018. Rice grain yields were also recorded at the time of harvesting. The samples were collected from farmer-managed paddy fields where the farmers' maintained separate fields for BFBF + 50% CFs (90 kg/ac CF NPK + 1000 ml/ac BFBF application) and 100% CF (180 kg/ac CF total NPK application - 18 kg/ac TSP, 150 kg/ac Urea, 12 kg/ac

MOP). Soil (pH, organic carbon, available phosphorous, ammonium and nitrate content and plant analyses (total dry weight and leaf chlorophyll content) were conducted at the National Institute of Fundamental Studies, Kandy, Sri Lanka.

The soil pH was measured in distilled water at a 1:2.5 soil-to-water volume ratio with a pH meter (Orion Star A215). Soil organic carbon, available phosphorous, ammonium and nitrate content were measured using the standard methods (Anderson and Ingram, 2013). For the plant analysis, debris was removed carefully from roots and total dry weights were determined after keeping them in an oven at 55 °C. Chlorophyll content was determined using SPAD chlorophyll meter. Crop yields were recorded at the harvest. Statistical analysis of the experimental data was done using two sample t-test and ANOVA with R software at a probability level of 0.05.

Results and Discussion

The results showed that there were significant increases in grain yield, total dry weight and chlorophyll content in rice treated with BFBF + 50% CF than CF alone ($p < 0.05$) (Table 1). Growth improvement in rice plants applied with BFBF may be due to the production of growth promoting compounds and growth hormones such as Indole Acetic Acid that stimulate the overall growth of plants (Wibowo, 2007).

Table 1. Comparison of plant growth parameters at tillering stage and grain yields at harvesting stage.

	Treatment	Grain Yield (g/m^2)	Total Plant Dry weight (g)	Leaf Chlorophyll (SPAD value)
T1	BFBF+50% CF	786.6[a]	97.5[a]	40.51[a]
T2	100% CF	625.3[b]	49.2[b]	29.4[b]

Means denoted by the same letters in a column represent non-significant differences at 0.05 probability levels.

The grain yield was significantly higher in BFBF + 50% CF than that of CF alone practice. The application of BFBF showed a significant increase in chlorophyll contents of the rice leaves, indicating an accelerated rate of the photosynthesis that will eventually enhance growth and yield of rice (Althuhaish et al., 2014).

Table 2. Soil parameters at tillering stage.

Treatment	Total Organic Carbon (%)	Available Phosphorous (mg/kg)	Available Nitrate (mg/kg)	Available Ammonium (mg/kg)	pH
T1 –BFBF + 50%CF	2.01[a]	6.01[a]	1.311[a]	0.198[a]	5.08[a]
T2- 100% CF	1.45[b]	2.99[b]	1.169[b]	0.129[b]	5.56[a]
Control (Initial soil)	1.26[b]	1.52[c]	0.752[c]	0.006[c]	5.82[a]

Means denoted by the same letters in a column represent non-significant differences at 0.05 probability levels;

The results showed that there were significant increases in soil organic carbon, available P, nitrate and ammonium in the fields applied with BFBF and the reduced dosage of CFs (Table 2). Similar observations have also been made by Seneviratne et al. (2009), where organic carbon content in tea growing soil increased significantly with the use of BFBF. According to Wu et al. (2005), application of biofertilizer has shown the ability to maintain organic matter content and total nitrogen in soil. Available soil P content may have increased with the increased microbial action in the soil. The use of BFBF has increased the soil acidity, though not significantly. It may have created favorable conditions for the P solubilization in the soil.

Conclusions

It can be concluded that the application of BFBFs together with a reduced dosage of CFs has the potential to increase the soil available nutrients and rice yield in comparison to CFs alone, thus showing promising potential of BFBFs in large-scale rice cultivation in Sri Lanka.

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