Effects of Chemical and Bio-fertilizers on Selected Growth Attributes of 'Bg 250' Rice (Oryza sativa L.) Cultivar

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Abstract - Heavy usage of chemical fertilizers creates varieties of economic, environmental and ecological problems. Bio-fertilizers are one of the alternative means which include beneficial microorganisms to reduce harmful effects to human and environment. Considering this an experiment was conducted at the Rice Research Station, Sammanthurai, Sri Lanka in the 'Yala' 2017 to assess the effects of chemical and bio-fertilizers on plant height, Leaf Area Index, chlorophylls a, b and total chlorophyll contents and yield of rice cultivar 'Bg 250'. The treatments were T1 - No fertilizer (Control), T2- 100% Recommended chemical fertilizer, T3-50% Chemical fertilizer + 50% Bio-fertilizer, T4-50% Bio-fertilizer, T5-100% Bio-fertilizer. Bio-fertilizer consisted of Azotobacter chrocooccum, Azospirillum brasilense, Bacillus polymyxa, Bacillus megaterium and other Bacillus spp. in liquid based medium. The experiment was laid out in the Randomized Complete Block Design with five treatments and four replications. The application of chemical and bio-fertilizers has significantly ($p<0.05$) affected the tested growth parameters and yield of 'Bg 250' rice cultivar. The combined application of 50% chemical and 50% bio-fertilizer has given the highest plant height (58.2cm), the highest Leaf Area Index (2.5), the highest chlorophyll contents (Chl. a - 1.7 mgg-1, Chl. b-1.4 mgg-1 and total Chl. - 3.1 mgg-1) and yield (2500 kgha-1) compared to the other treatments. The control treatment where no fertilizers were added showed the lowest growth attributes and yield. Based on these results it was concluded that the combined application of 50% chemical and 50% bio-fertilizers has produced the highest growth performance and yield in the rice cultivar 'Bg 250'. It could therefore be stated that bio-fertilizer in combination with chemical fertilizer could be used as an alternative way in the production of rice to boost the yield with reduced hazards to human health and environment.

Keywords: Bg 250, Bio-fertilizer, Chlorophyll content, Leaf Area Index, Plant height, Yield

I. INTRODUCTION

Rice *(Oryza sativa* L.) is one of the main and most important cereal crops of many countries of the world such as Asia, Africa, South America and Australia. Rice production depends on several factors such as climate, physical conditions of the soil, soil fertility, water management and so on. With increase in rice production, application and need of chemical fertilizers are also increasing simultaneously as they can give more reliable supportive boosts to increment of crop yield [1].

The greatest challenge of today's agriculture is to feed the growing population and restore the natural resources. Fertilizer is a key input for increasing crop yield. Chemical fertilizers are used extensively in modern agriculture to improve crop yield. However, nutrient leaching from agricultural soil into ground water and surface water causes a major environmental and public health concern.

Organic farming has emerged as an important priority area globally in view of the growing demand for safe and healthy food and long term sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals. Though the use of chemical inputs in agriculture is inevitable to meet the growing demand for food in the world, there are opportunities in selected crops and niche areas where organic production can be encouraged to tap the domestic export market.

Bio-fertilizers being an essential component of organic farming are the preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic organisms used for the application to seeds, soil or composting areas with the objective of increasing the number of such organisms and accelerate different processes which augment the availability of nutrients that can be easily assimilated by plants. Bio-fertilizers by overall produce higher growth rates and yield in rice production compared with chemical fertilizers [2].

Hence, the present study was conducted with the objectives of determining the effects of chemical and bio-fertilizers on the growth attributes and yield of 'Bg 250' rice cultivar and to select the most appropriate fertilizer input to increase the growth and yield of rice.

MATERIALS AND METHODS

Rice cultivar 'Bg 250' seeds (100g) were collected from the Rice Research Station, Sammanthurai and were water soaked for 24 hours and incubated for 48 hours and the sprouted seeds were transferred to seedling trays. Twelve days old healthy and uniform seedlings were transplanted in sand filled plastic pots (12 plants/pot) having the height (30cm) and diameter (40cm). The seedlings were watered daily and the water level was maintained to the top of the pot. The fertilizers were applied based on the treatments. Chemical fertilizer (Urea-225 kgha-1, TSP-55 kgha-1 and MOP-60 kgha-1) was applied in three split doses and Bio-fertilizer (500 mlha-1) was applied in two split doses.

1. Preparation of bio-fertilizer

The trade name 'GRO BIO-FERTILIZER' was used for this study. Bio-fertilizer was prepared by mixing the culture with cow dung (10kg), cow urine (5 litres) and fresh water (10 litres). This set up was incubated for three days under the shade. Bio-fertilizer was applied during the late evening.

This experiment was laid out in the Randomized Complete Block Design with five treatments and four replications and the treatments were as follows:

T1-No fertilizer (Control)

T_2-100% Chemical fertilizer (Urea-225 kgha^{-1}, TSP-55 kgha^{-1}, MOP-60 kgha^{-1})

T_3-50% Chemical fertilizer (Urea - 113 kgha^{-1}, TSP-28 kgha^{-1}, MOP-30 kgha-1) + 50% Bio-fertilizer (250 mlha^{-1})

T_4-50% Bio-fertilizer (250 mlha^{-1})

T_5-100% Bio-fertilizer (500 mlha^{-1})

2. Growth attributes

Three plants were randomly selected and numbered from each replicate of the treatments for the measurement of plant height. The plant height was measured in cm from the surface of the soil to the apex of the top most leaf. These plants were then uprooted and the leaves were separated from the base of the basal sheath and the leaf area was measured by a leaf area meter (LI-3100C). The Leaf Area Index (LAI) was calculated using the following formula:

$$LAI = \frac{\textit{Total leaf area of the individual plant}}{\textit{Soil area occupied by the plant}}$$

3. Chlorophyll determination

Three leaves representing three plants were randomly collected from each replicate of the treatments. A quantity of 500mg of fresh leaf sample was repeatedly ground with fresh 30ml aliquot of 80% acetone and the final volume was adjusted to 100ml. The optical density of the chlorophyll extract was recorded by a Spectrophotometer (BK-V1600).

mg 'chlorophyll a' present / g sample

$$= \frac{(12.7 \times OD663) - (2.69 \times OD645) \times V}{1000 \times W}$$

mg 'chlorophyll b' present / g sample

$$= \frac{(22.9 \times OD645) - (4.68 \times OD663) \times V}{1000 \times W}$$

mg total chlorophyll / g sample

$$= \frac{(22.9 \times OD645) - (4.68 \times OD663) \times V}{1000 \times W}$$

Where,

OD : Optical density

V : Final supernatant volume (ml)

W : Fresh weight of the sample (g)

4. Yield

Tree plants were randomly collected from each replicate of the treatments at the time of harvest and the seeds were collected, sun dried and the yield was determined.

5. Statistical Analysis

The data were statistically analyzed and the difference between treatment means was compared using DMRT.

III. RESULTS AND DISCUSSION

There were significant ($p<0.05$) differences between treatments in the plant height, Leaf Area Index, chlorophyll contents (Chl. a, b and total) and yield of rice cultivar 'Bg 250'.

1. Plant height

The combined application of 50% chemical and 50% bio-fertilizers has given the highest plant height and the lowest was found in plants without any fertilizer treatment (Control) (Table 1). However, there was no significant ($p>0.05$) difference in the heights of plants treated with a combination of 50% chemical and 50% bio-fertilizer and 100% chemical fertilizer. Hence, it is beneficial and economical to use50% chemical and 50% bio-fertilizer rather than 100% chemical fertilizer.

TABLE 1

Effects of chemical and bio-fertilizers on the plant height and Leaf Area Index (LAI) of rice cultivar 'Bg 250'

Treatments	Plant height (cm)	LAI
T_1	31.8^{d}	0.8^{e}
T_2	56.1^{a}	2.3^{b}
T_3	58.2^{a}	2.5^{a}
T_4	46.1^{c}	1.2^{d}
T_5	50.7^{b}	2.0^{c}

*Values in the same column followed by the same letter do not differ significantly ($p<0.05$).

*Values are the means of 12 plants in 4 replications.

The highest plant height observed in the treatment where combined application of 50% chemical and 50% bio-fertilizers was given would have been due to the continuous supply of nutrients to the rice plants through chemical and bio-fertilizers. Similar results were observed by [3] on rice. In this study, the highest plant height was observed in the treatment receiving inorganic fertilizers with Azotobacter and Phosphate Solubilizing Bacteria due to continuous supply of nutrients through all growth stages with beneficial association between chemical and bio-fertilizers.

2. Leaf Area Index

The highest Leaf Area Index was observed in plants treated with 50% chemical and 50% bio-fertilizers and the lowest was found where no fertilizers were added. The continuous supply of nutrients through these chemicals would have

enhanced vital processes such as enzyme and chlorophyll synthesis along with associated metabolic activities. As a result, photosynthesis and assimilation would have increased leading to cell division and elongation followed by increased growth. Hence, the highest LAI was found in this treatment.

As pointed out by [4], Leaf Area Index was influenced significantly ($p<0.05$) when Azotobacter was applied along with organic and chemical fertilizers. Leaf Area was much lower at lower level of organic and chemical fertilizers while these were significantly higher with medium to high levels of chemical fertilizers. Further they indicated that LAI was increased with the increasing levels of chemical fertilizers in combination with *Azotobacter*.

3. Chlorophyll contents

The highest amounts of chlorophylls a, b and total were found in the treatment where 50% chemical and 50% bio-fertilizer were added and the lowest was found in the no fertilizer treatment (Table 2).

Increased chlorophyll content would have been attributed to the increased supply of N and Mg through the application of these fertilizers. These elements are known to be the major components of chlorophyll molecule.

TABLE 2

Effects of chemical and bio-fertilizers on the chlorophyll contents of rice cultivar 'Bg 250'

Treatments	Chlorophyll contents (mgg^{-1})		
	Chl. a	Chl. b	Total Chl.
T_1	0.3^{e}	0.3^{d}	0.5^{e}
T_2	1.6^{b}	1.1^{b}	2.7^{b}
T_3	1.7^{a}	1.4^{a}	3.1^{a}
T_4	0.7^{d}	0.6^{c}	1.3^{d}
T_5	1.1^{c}	0.9^{c}	2.0^{c}

*Values in the same column followed by the same letter do not differ significantly ($p<0.05$).
*Values are the means of 12 plants in 4 replications.

As reported by [5] chlorophyll data taken during the critical period of rice growth proved the effect of bio-fertilizer application with chemical fertilizer as the chlorophyll values increased with the treatments. Among the treatments, higher values were found for the bio-fertilizer and chemical fertilizer combination than the other treatments.

4. Yield

The combined application of 50% chemical and 50% bio-fertilizers has given the highest yield and the lowest was found without any fertilizer addition (Control) (Table 3). Hence, combined application of fertilizers has boosted the rice yield compared to the other treatments.

TABLE 3

Effects of chemical and bio-fertilizers on the yield of rice cultivar 'Bg 250'

Treatments	Yield (tha^{-1})
T_1	1.0^{d}
T_2	2.0^{b}
T_3	2.5^{a}
T_4	1.7^{c}
T_5	1.9^{b}

*Values in the same column followed by the same letter do not differ significantly ($p<0.05$).
*Values are the means of 12 plants in 4 replications.

Studies by [6] indicated that the grain yield of rice was significantly ($p<0.05$) influenced by different treatment combinations of chemical and bio-fertilizers. The maximum grain yield was obtained in the treatment where combined application of chemical and bio-fertilizers was given compared to the control one. Accordingly, the combined application has increased the grain yield by 12 percent.[5] have suggested that the use of chemical N and P fertilizer can be minimized by 50 percent and improve rice yield with the supplement of bio-fertilizers.

IV. CONCLUSIONS

The application of 50% chemical and 50% bio-fertilizers has given the highest growth performance with respect to plant height, Leaf Area Index, chlorophylls a, b and total contents and yield in rice cultivar 'Bg 250' compared to the other treatments. Production of rice grains therefore could be steadily raised through the application of bio-fertilizers to sustain agricultural production. Environmental pollution especially saline soils and health hazards would be greatly reduced by the usage of bio-fertilizers.

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