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Response of *Oryza sativa* CL1 (Basmati 370) to *Nostoc commune* Vauch. as Fertilizer Supplement

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Abstract

The study was conducted to determine the growth and yield response of Oryza sativa CL1 and the ideal rate of Nostoc commune to be applied as fertilizer supplement. Based on the result of the study, application of 3 g of N. commune + ½ recommended rate of inorganic fertilizer (RRIF) gave the best response among the treatments in terms of the plant height, number of tiller and harvest index. With respect to weight of 1000 grains and the days to flowering, application of 9 g of N. commune + ½ RRIF was the best treatment. Moreover, concerning the number of productive tillers, days to maturity, chlorophyll content, filled grain percentage per panicle, grain yield per hectare, harvest index and biomass application of full RRIF appeared desirable. Regarding the growth and yield parameters of CL1, application of full RRIF was recommended. However, there is a need to verify further the response of CL1 to the application of the different rate of N. commune + ½ RRIF, especially the 3 g of N. commune + ½ RRIF, for it can increase the yield through continuous application.

***Keywords**:* biofertilizer, CL1, cyanobacteria, *N. commune*, recommended rate of inorganic fertilizer

1. Introduction

Application of inorganic fertilizer has become a trend in supplying efficient nitrogen needed by the crop (Hunt, 2015). Nitrogen plays an important role in growing rice plant. It promotes rapid plant growth, improves grain yield and grain quality, leaf area development, grain formation and filling, and protein synthesis (International Rice Research Institute [IRRI] Rice Knowledge Bank, 2007). On the contrary, excessive application of inorganic fertilizer can cause a chemical burn in crops, air and waterway pollution, and mineral depletion. Improper management of fertilizer application can be a detrimental factor not only in the environment but also in the crop. Application of biofertilizer can lessen the use of inorganic fertilizer – the former can give a satisfactory effect in the rice production (Hunt, 2015).

Biofertilizer is considered as a microorganism that helps the nutrient uptake of the crop by their interaction in the rhizosphere. It is a cost-effective way in the nutrient management of the plant in addition to the chemical fertilizer. *N. commune* is grouped as nitrogen (N_2)-fixing biofertilizer. It is a cyanobacterium under the family of *Nostocaceae*; a filamentous heterozygous blue-green algae (BGA) that has a photosynthetic and nitrogen-fixing ability that can fix atmospheric nitrogen. It also contains pigments for photosynthesis and pigments that absorb ultraviolet radiation, which enables it to survive in places with high radiation. The nitrogen-fixing BGA supports the early recovery of transplanted seedlings and prolongs the number of the tillering period that results to the increase to the number of ear and grains per panicle (Hupeh Institute of Hydrology, 1977). Acting as biofertilizer, BGA has a major role on the rice production due to its nitrogen-fixing ability to lessen the supplementation of inorganic fertilizer. In the study of Pantastico and Gonzales (1976), there was an increase of 22.7% in the grain yield in several varieties compare to the non-fertilized one and less effective input of commercially available nitrogen (N), phosphorous (P), and potassium (K).

The CL1 or commonly known as Basmati 370 is an aromatic rice with a semi-dwarf characteristic and less photoperiod sensitive variety. Due to its exquisite aroma, flavor and soft texture, aromatic rice became popular in international and domestic trade (Corpuz, 2015). It has a potential yield up to 3-5 tons per hectare for the wet season and 4-5 tons per hectare during the dry season. This type of rice has a maturity of 105 days. Basmati 370 has a long and slender grain that measure 6 mm in length (Lagliva, 2016). The variety is commercially produced in the research area of Central Luzon State University (CLSU) with the use of inorganic fertilizer rate of 90.5-45.5-45.5 NPK/ha (Avedoza, 2014). In order to reduce the input of chemical fertilizer in the area, a positive result of this study could help.

2. Methodology

2.1 Time and Place of the Study

The study was conducted from December 2017 to April 2018 at the Crop Science Department, College of Agriculture, CLSU, Science City of Muñoz, Nueva Ecija 3120 Philippines.

2.2 Source of Cyanobacteria

The cyanobacterium used was taken from Barangay Magapuy, Bayombong, Nueva Vizcaya, Philippines.

2.3 Variety Used

CL1 is considered semi-dwarf variety (85-95 cm). CL1 has a potential yield of 3-4 tons per hectare in the wet season while 4-5 tons per hectare during the dry season, matures within 105 days, and nonphotoperiod sensitive.

2.4 Experimental Design and Treatment Levels

The experiment was laid out in a complete randomized design. Ninety pots were used to represent six treatment levels with three replications each. Every treatment replication was represented by five pots.

What follows are the different treatment levels of *N. commune*.

Treatment 1 (T_1)	-	Control (No inorganic fertilizer and *N. commune*)
Treatment 2 (T_2)	-	Full Recommended Rate of Inorganic Fertilizer (RRIF) (110-7-60 kg of N_2-P_2O_5-K_2O)
Treatment 3 (T_3)	-	3 g (1000 kg/ha) of dried *N. commune* + 1/2 RRIF
Treatment 4 (T_4)	-	6 g (2000 kg/ha) of dried *N. commune.* + 1/2 RRIF
Treatment 5 (T_5)	-	9 g (3000 kg/ha) of dried *N. commune* + 1/2 RRIF
Treatment 6 (T_6)	-	3 g (1000 kg/ha) of dried *N. commune* only

2.5 Soil Preparation and Planting

In each pot, 6 kg of soil was placed and thoroughly mixed with the different rate of *N. commune*, which depends on the assigned treatment level to the pot.

Seeds were soaked in water for 24 h and incubated for another 24 h. On the third day, pre-germinated seeds were direct seeded with a rate of three seeds per pot and maintained.

2.6 Nutrition and Water Management

The rate stated in the treatments was applied in the pots using complete (14-14-14), urea (46-0-0), and muriate of potash (0-0-60) for basal application and urea for topdressing. This was employed five days before panicle initiation.

Table 1. Method of application of fertilizer using different fertilizer and rates

Fertilizer*	Basal Application		Topdress	
	Full RRIF	½ RRIF	Full RRIF	½ RRIF
Urea	0.15 g	0.07 g	0.45 g	0.22 g
Complete	0.30 g	0.15 g	N/A	N/A
Muriate of potash	0.26 g	0.13 g	N/A	N/A

*Based on Region 3 BSWM soil analysis result with recommended rate of 110-7-60 per hectare

In order to support the water needed by the *N. commune* to live, 3 cm depth of water in the pot was maintained.

2.7 Pest Management and Weed Control

The occurrence of pest and diseases was observed and recorded. Manual picking of the insect attacking the plants was done to prevent infestation. The presence of grasshopper, green leafhopper, green horned caterpillar, rice bug, rice caseworm, and stem borer was observed in the different stages of the rice plant. The existence of these insects was also controlled by the use of oregano leaves that undergone infusion; the oregano leaves served as a biopesticide.

Manual removal of grown weeds was done to prevent the light, water and nutrient competition among the plants.

2.8 Harvesting

Harvesting was taken when 85% of grains in panicle became golden yellow. It was cut above the ground and threshed manually with the use of the net. Weight and moisture were determined after threshing.

2.9 Data Gathering

The plant height at maturity (cm) was obtained by measuring the height of the two representative sample plants per pot from the base up to the tip of the tallest leaves at the maturity stage of the plant. The number of tillers per plant was the maximum tillering stage by counting the tillers of two representative sample plants per pot. The number of productive tillers per plant was the average number of panicle-bearing tillers counted from two sample plants per pot.

The days to flowering were taken using the number of days from planting up to 50% of the plant population has heading. The days to maturity was obtained by counting the number of days from sowing to grain ripening.

Measuring the chlorophyll content was done once a week, starting 21 DAS up to 50% of the crop flowering using the Soil Plant Analysis Development (SPAD) meter. This was taken from the 10 randomly selected sample plants from 10:00 AM – 1:00 PM. Percent filled grains per panicle was computed using the formula:

$$Percent\ filled\ spikelets = \frac{Number\ of\ filled\ spikelets}{Total\ number\ of\ spikelets} \times 100 \qquad (1)$$

The weight of 1000 grain (g) was determined by counting 1000 sample grains from each entry and weighed using a digital weighing scale and adjusted to 14% moisture content using the formula below:

$$1000\ grain\ \ weight\ (g) = \frac{100 - MC}{86} \times weight\ of\ sample\ grains \qquad (2)$$

where:

MC = the moisture content at the time of weighing

The grain yield (g) per pot was taken by weighing the harvested grain per pot. Harvest index computed using the formula:

$$Grain\ yield = \frac{Weight\ of\ grains}{Biomass} \qquad (3)$$

The biomass (g) was taken by oven drying the two sample plants per treatment replication at 70 °C for three consecutive days or until a constant weight is attained. After harvest, weighing was done using a digital weighing balance.

2.10 Statistical Analysis

The statistical analysis used was Statistical Tool for Agricultural Research (STAR) developed by IRRI. Analysis of variance (ANOVA) for completely randomized design (CRD) was used in this study. Comparison among means was done using highly significant difference (HSD) at 5% level of significance. This was performed using STAR (Version 2.0.1).

3. Results and Discussion

3.1 Plant Height at Maturity

The plant height of CL1 was influenced by the application of the different rate of *N. commune* application. The result of the plants with 3 g of T_3 was comparable with the plants with T_2, 6 g of T_4 and 9 g of T_5. The shortest (60 and 65 cm) plants were observed from the T_1 and to the treatment with 3 g of T_6 (Figure 1).

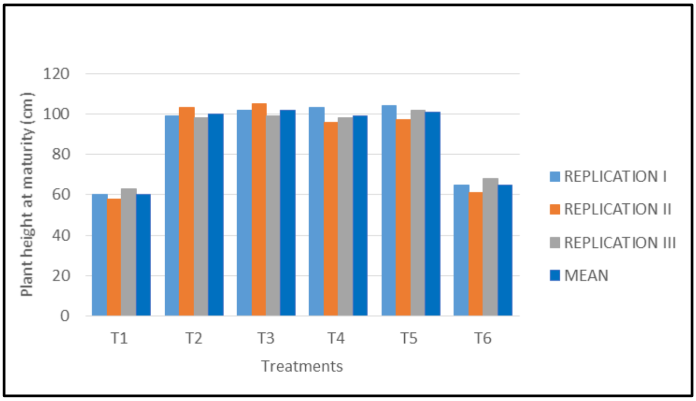

Figure 1. Plant height at maturity (cm) of rice as influenced by the different rate of *N. commune* application

This is a clear indication that using 3 g, 6 g or 9 g of T_3, T_4, and T_5 will have the same result to T_2 in terms of plant height. From the analysis of variance, it showed significant differences among the treatments.

3.2 Number of Tillers per Plant

The number of tillers of the CL1 was affected by the application of the different rate of *N. commune*. The plants with 3 g of T_3, 6 g of T_4, 9 g of T_5 and T_2, produced the highest number (11.7-13.7) of tillers among all treatments. On the other hand, the plant with T_1 and 3 g of T_6 had the least number (4.3-5) of tillers (Figure 2).

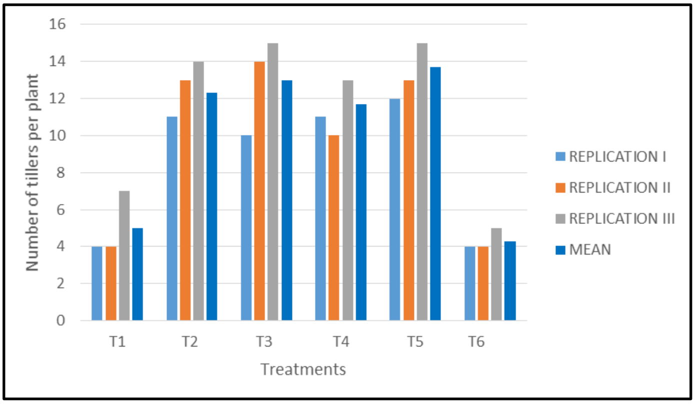

Figure 2. Number of tillers as influenced by the different rate of *N. commune* application

3.3 Number of Productive Tillers per Plant

The number of the productive tiller of the CL1 was impacted by the application of the different rate of *N. commune*. The plants with T_2 had the highest number of productive tillers with a mean of 11 tillers – comparable with the plants with 3 g of T_3, 6 g of T_4 and 9 g of T_5. The least number of productive tiller with a mean of four tillers were observed from the plants with 3 g of T_6 and from the T_1 (Figure 3).

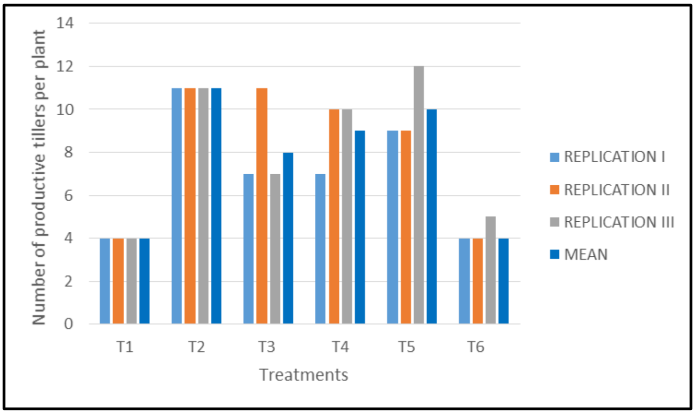

Figure 3. Productive tillers as influenced by the different rate of *N. commune* application

3.4 Days to Flowering

The days to flowering of the CL1 was influenced by the application of the different rate of *N. commune*. The plants with 9 g of T_5 was observed to be the earliest to flower with a mean of 68.3 days followed by the plants with T_2, 6 g of T_4 and with 3 g of T_3. The late flowering was observed on the T_1 (102 days) and plants with 3 g of T_6 (101 days) (Figure 4). Analysis of variance showed a significant difference among the treatments.

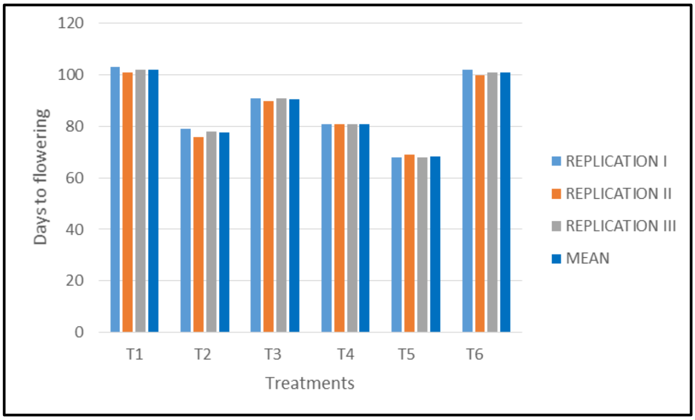

Figure 4. Days of flowering as influenced by the different rate of *N. commune* application

3.5 Days to Maturity

The days to maturity of CL1 which ranged from 98-116 days was affected by the application of the different rate of *N. commune*. Early maturity was observed from the plants with T_2, 3 g of T_3, 6 g of T_4 and 9 g of T_5. While plants with 3 g of T_6 and T_1 showed delay maturity (Figure 5).

Analysis of variance showed a significant difference among the treatments. Results revealed that a plant in T_2 matured seven days earlier on the recorded maturity date of 105 days. According to Tapic *et al.* (2011), early maturity is considered as a desirable trait for rice for it can possibly shorten the period of exposure to the risk of unpredictable environmental factors by early harvesting. Early maturity can maximize the use of land by more cropping per year.

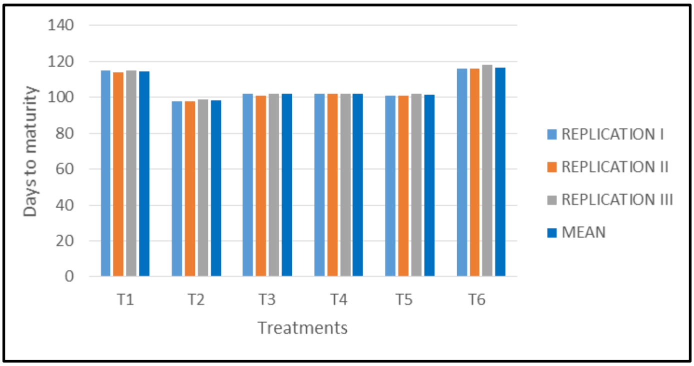

Figure 5. Days to maturity as influenced by the different rate of *N. commune* application

3.6 Chlorophyll Content

The chlorophyll content of the CL1 was influenced by the application of the different rate of *N. commune*. The plants with T_2 has the highest chlorophyll content (29.8); they were comparable by the plants with 9 g of T_5, 6 g of T_4, and 3 g of T_3. The T_1 (24.8) together with plants with 3 g of T_6 (25.3) has the lower chlorophyll content (Figure 6).

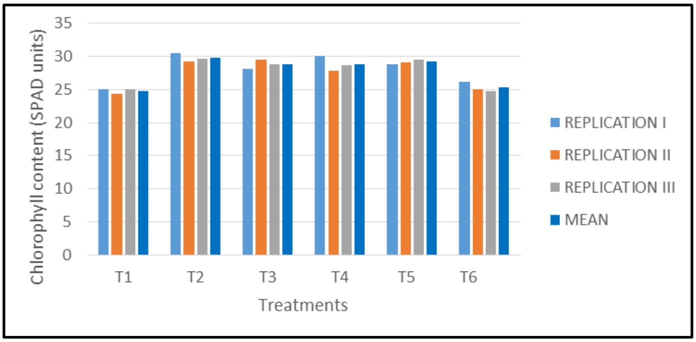

Figure 6. Chlorophyll content as influenced by the different rate of *N. commune* application

Analysis of variance showed a significant difference among the treatments. This study showed that application of T_3, T_4, and T_5 resulted similar nitrogen content to the plants applied with T_2. It further presented that application of *N. commune* + ½ RRIF provided similar nitrogen content to the plants applied with full RRIF. Chlorophyll content, which is related to the nitrogen concentration, is significant to managing chemical and fertilizer application as an indicator of photosynthetic activity (Haboudane *et al.*, 2002). The ability to accurately estimate plant chlorophyll content may provide growers information in making decisions for nitrogen management (Peterson *et al.*, 1993).

3.7 Percent Filled Grains per Panicle

The percent of filled grain per panicle of the CL1 was impacted by the application of the different treatment. Plants that were applied with 3 g of T_6, resulted with the highest number of filled grain per panicle mean of 79.6% – comparable with T_2 and T_1. While the T_1 plants, T_2, 3 g, 6 g, and 9 g of T_3, T_4, and T_5 were found comparable (Figure7).

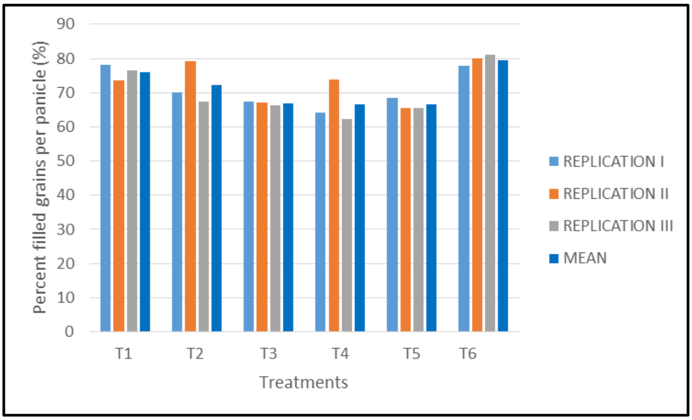

Figure 7. Percent filled grains as influenced by the different rate of *N. commune* application

Analysis of variance revealed a significant difference among the treatments. The high temperature at anthesis may cause a higher percentage of sterility (Yoshida, 1981).

3.8 Grain Weight

The weights of 1000 grains of the CL1 were affected by the different rate of *N. commune* with inorganic fertilizer. The plants with 9g of T_5 gave the heavier weight with a mean of 26.5g – comparable with the plants treated with 6 g of T_4, 3 g of T_3 and 3 g of T_6. While plants treated with T_2, 3 g of T_6 and T_1 were comparable to each other (Figure 8).

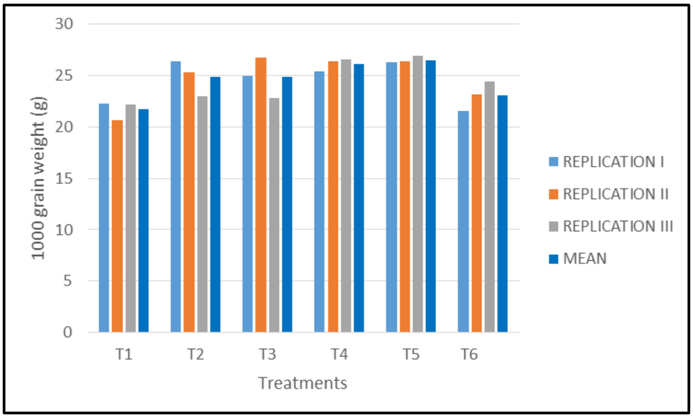

Figure 8. 1000 grain weight (g) as influenced by the different rate of *N. commune* application

Analysis of variance revealed significant differences among the treatments. Grain weight is an important yield component because it gives information on the size and density of the rice grains (Yoshida, 1981).

3.9 Grain Yield per Pot

The plants with T_2 contributed the highest grain yield per pot with a mean of 58.1 grams followed by the plants with 3 g of T_3, 6 g of T_4 and 9 g of T_5. On the other hand, the T_1 (6.3 grams) and 3g of T_6 (9.2 grams) only gave the least number of grain yield per pot (Figure 9).

Comparison among means revealed that the plants with T_2 had significantly the highest yield per pot over the T_1. However, the plants with 3 g of T_3, 6 g of T_4 and 9 g of T_5 exhibited comparable yield with each other. Analysis of variance showed a significant difference among the different treatments.

An increase of grain yield of plants with 3 g of T_6 from the T_1 conforms to the study of Pantastico and Gonzales (1976), who reported that application of pure *N. commune* can give an increase of 22.7% in the grain yield in several varieties compare to the non-fertilized one. 0.5 kg dry alga + 214.5 kg NPK treatment give an increase of 23.1% over the control.

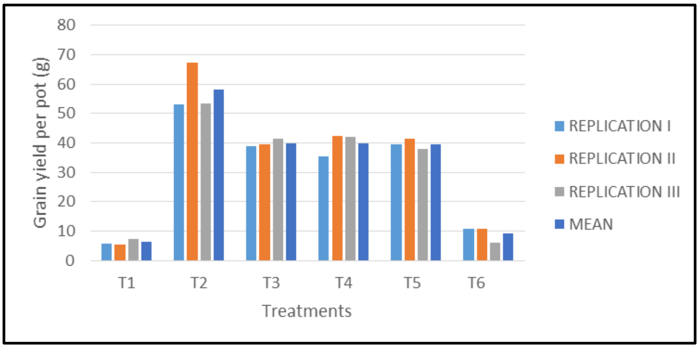

Figure 9. Grain yield (grams) as influenced by the different rate of *N. commune* application

3.10 Harvest Index

The harvest index of CL1 was influenced by the application of the different rate of *N. commune*. The plants with T_2 and 3 g of T_3 provided the highest response with a mean of 0.44. The result was comparable to the plants with 6 g of T_4 and 9 g of T_5. On the other hand, the T_1 (0.16%) and 3 g of T_6 (0.20%) gave the least response – comparable also to the plants with 6 g of T_4 and 9 g of T_5 (Figure 10).

Comparison among means revealed that the plants with T_2 and 3 g of T_3 had highly significant difference from the T_1 and plants with 3 g of T_6; however, it is comparable to the result of the plants with 6 g of T_4, and 9 g of T_5. Analysis of variance showed a significant difference among the different treatments.

From the results of this study, application of 3 g of T_3 gave a productivity response similar to the plants with T_2.

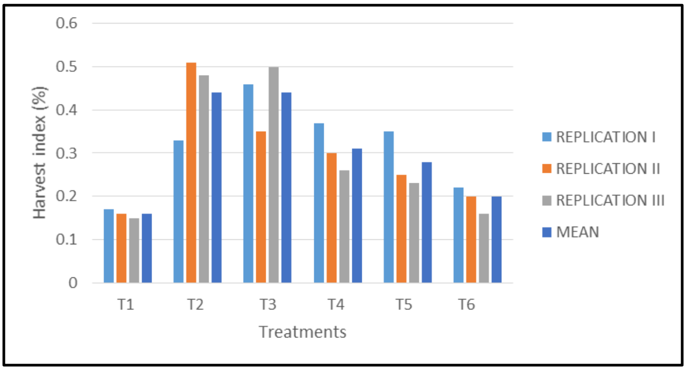

Figure 10. Harvest index as influenced by the different rate of *N. commune* application

3.11 Biomass

The biomass of the CL1 was affected by the application of the different rate of *N. commune*. Results showed that the plant applied with T_2 gave the highest dry matter content with the mean of 45.1 g and was comparable by the plants with 6 g of T_4, 9 g of T_5 and 3 g of T_3. The T_1 obtained the least dry matter content with the mean of 15.1 g – close to the response of the plants with 3 g of T_6 (17.4 g) (Figure 11). Analysis of variance showed a significant difference among the treatments.

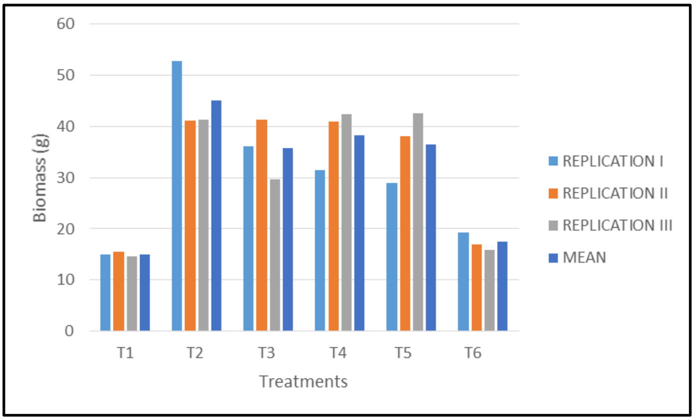

Figure 11. Biomass of the plant as influenced by the different rate of *N. commune* application

4. Conclusion and Recommendation

The study revealed that in terms of plant height, number of tillers and harvest index, application of 3 g of T_3 provided the best response among the treatment, while application of 9 g of T_5 was the best treatment when it comes to weight of 1000 grains and to the days to flowering. Furthermore, application of T_2 appeared desirable in the number of productive tillers, days to maturity, chlorophyll content, filled grain percentage per panicle, grain yield per hectare, harvest index and biomass.

In terms of the growth and yield parameters of CL1, application of T_2 was recommended. However, the response of the CL1 to the application of the different rate of *N. commune* + ½ RRIF, especially the 3 g of T_3 can be verified further for it could increase its yield through continuous application.

Since the study was conducted as a pot experiment, it is recommended to conduct a similar study under normal field condition with the application of recommended treatments for the further verification of the results. It is likewise recommended to explore the different rates of RRIF with *N. commune* and the use of other varieties that require higher N to identify the actual potential nitrogen-fixing capacity of the *N. commune* with the combination of inorganic fertilizer.

5. Acknowledgement

The authors would like to extend their gratitude to Central Luzon State University.

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