Growth and Yield Response of NSIC Rc 204H (M20) to Nostoc (*Nostoc commune* Vauch) in Different Rates of Inorganic Fertilizer Application

Allen Mae Rodolfo
Central Luzon State University
Dionie S. Barrientos (dioniebarrientos@clsu.edu.ph)
Central Luzon State University

Research Article

Keywords: Biomass, Chlorophyll content, M20, Nostoc, Recommended Rate of Inorganic Fertilizer

Posted Date: June 7th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-590829/v1

Abstract

The study was conducted to evaluate the growth and yield response of M20 with the application of Nostoc and to determine the ideal combination of inorganic fertilizer and Nostoc. Based on the result of the study, in terms of growth parameters; application of 3 g Nostoc with 1/2 RRIF gave the best response among the treatment in plant height, while application of 3 g Nostoc with 3/4 RRIF was the best treatment when it comes to days to flowering. Furthermore, the application of full RRIF was the best in terms of chlorophyll content. In yield parameters, the application of 3 g Nostoc with 1/4 RRIF gave significance response to grain yield and biomass. While the application of no Nostoc with 1/4 RRIF had the heaviest 1000 grain weight. For the number of tillers per plant (14.7), the application of 3 g Nostoc with 3/4 RRIF gave the best response among the treatments. And for the number of filled grains, rice grown without Nostoc but fertilized only with 1/2 RRIF had the most number of filled grain. Overall, Nostoc treatment did not significantly alter the response of M20 based on all agronomic parameters tested in the study.

Introduction

Knowing the drawbacks of inorganic fertilizers makes it easier to mitigate the negative side effects they can cause. In most cases, the benefits of inorganic fertilizers outweigh their disadvantages when they are used correctly. Most problems with inorganic fertilizers occur when they are overused or applied incorrectly (Thompson, 2004).

Performing a soil test before using fertilizer is an accurate way to determine the right type and amount of fertilizer the soil needs (Thompson, 2004). Inorganic fertilizers became widely available and were welcomed as a major advancement resulting in higher yields. Over time and with their overuse, detrimental effects became evident to the soil that leads to compaction. The soil becomes hard, difficult to work, and roots have difficulty in penetration. The soil sheds the water rather than absorbing it, robbing plants of moisture (Puma, 2017).

With this emerging problem, alternative sources of fertilizer are needed. A possible source is Nostoc, a bluish-green, olive green or brown but in dry conditions, it becomes an inconspicuous, crisp brownish mat. It is also called blue-green algae. In Singapore, Nostoc is found growing on alkaline soils, in brackish water, in paddy fields, on cliffs, and wet rocks (Chin, 2012). It has a photosynthetic and nitrogen fixing ability that can fix atmospheric nitrogen (Hupeh Institute of Hydrology, 1997).

Pantastico and Gonzales (1976) revealed that through the application of Nostoc recorded an increase of 22.7% in the grain yield in several varieties compare to the non-fertilized one. This is of particular interest when one considers the small-scale farmers who are unable to invest in nitrogen fertilizers. In the study of Buenaventura and Barrientos (2018), the addition of 3 g Nostoc to ½ Recommended Rate of Inorganic Fertilizer (RRIF) did not improve grain yield of Basmati 370 rice but was able to improve agronomic traits such as plant height, number of tillers, the total number of grains per panicle, harvest index, the weight of 1000 grains and days to flowering relative to full RRIF.

Hybrid rice was used in the study hence the previous studies used special purpose rice. Moreover, Nostoc contains nitrogen and more amount of nitrogen is needed of hybrid rice than special purpose rice. M20 is one of the hybrids that it is more adaptable and yields higher than M1. It yields an average of 6.4 t ha^{-1} and can reach as high as 11.7 t ha^{-1}. It has an average maturity of 111 days after seeding with 112 cm height and 13 productive tillers. Although a hybrid cultivar requires high nitrogen application, it is imperative to consider other sources of nitrogen especially nitrogen source which is naturally available in our environment (Pinoy Rice Knowledge Bank, 2019). In this study, it aims to identify and recommend combination of Nostoc and inorganic fertilizer for growth and yield of M20.

Materials And Methods

Time and Place of the Study

The study was conducted from September 2018 to January 2019 at the Crop Science Department, College of Agriculture, Central Luzon State University, Science City of Muñoz, Nueva Ecija 3120 Philippines.

Source of Nostoc

The Nostoc that were used came from Brgy. Magapuy, Bayumbong, Nueva Vizcaya. It was found near the river and wet rocks.

Variety Used

M20 is public hybrid rice, an early maturing variety with 112 cm plant height, and 13 plant productive tillers. The variety has an average yield of 6.4 t ha^{-1} and a maximum of 11.7 t ha^{-1} and matures within 111 days after seeding.

Experimental Design

One hundred thirty-five (135) plastic pails were used to represent nine treatment levels with three replications each. Every treatment replication was represented by five plastic pails.

Treatments

The 3g of air dried Nostoc was based on the findings of Buenaventura and Barrientos (2018). Different treatment levels of Nostoc would be as follow:

Treatment 1 - Control

Treatment 2 – Three grams (3g) of air dried Nostoc *only*

Treatment 3 – Three grams (3g) of air dried Nostoc + 1/4 RRIF

Treatment 4 – ¼ RRIF

Treatment 5 – Three grams (3g) of air dried Nostoc + 1/2 RRIF

Treatment 6 – ½ RRIF

Treatment 7 – Three grams (3g) of air dried Nostoc + 3/4 RRIF

Treatment 8 – ¾ RRIF

Treatment 9 – Full RRIF (80-30-30)

Soil Preparation

In each pot, six (6) kg of soil was placed and thoroughly mixed with the different rate of Nostoc which depends on the assigned treatment level to the pot.

Planting

Ten (10) grams of seeds were soaked for 24 hours and then incubated for another 48 hours. On the fourth day, the pre-germinated seeds were directly seeded with a rate of three (3) seedlings per plastic pail and maintained.

Nutrient Management

The rate stated in the treatments was applied in the plastic pail using phosphate (0-18-0), muriate of potash (0-0-60) for basal application, and urea (45-0-0) for the second and third application.

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

FERTILIZER APPLIED	TREATMENT								
	T1	T2	T3	T4	T5	T6	T7	T8	T9
Basal Application (g)									
Phosphate	N/A	N/A	0.11	0.11	0.23	0.23	0.34	0.34	0.45
Muriate of potash	N/A	N/A	0.04	0.04	0.08	0.08	0.11	0.11	0.15
Second Application (g)									
Urea	N/A	N/A	0.07	0.07	0.13	0.13	0.20	0.20	0.26
Third Application (g)									
Urea	N/A	N/A	0.07	0.07	0.13	0.13	0.20	0.20	0.26

Water Management

To support the water needed by the Nostoc to live, three (3) cm depth of water in the pot was maintained.

Pest Management

The occurrence of pests and diseases were monitored. Manual picking of the insect-like rice caseworm attacking the plants was used 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.

Weed Control

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

Harvesting

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

Data Gathered

Plant height at maturity (cm) was taken by measuring the height of the 10 representative sample plants per treatment replication from the base up to the tip of the tallest leaves at the maturity stage of the plant. Numbers of tillers per plant were taken on its maximum tillering stage by counting the tillers of 2 representative sample plants per plastic pail.

Days to flowering was taken by counting the number of days from planting up to 50% of the plant population has headed.

Chlorophyll content was done once a week starting 21 DAP up to 50% of the flowering of the crop by the use of SPAD meter. This was taken in the 10 randomly selected sample plants from 10 am-1 pm of the day.

Number of filled grain per panicle was determined by counting the fully matured filled grains from sample panicles taken from sample plants.

Weight of 1000 grain (grams) 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:

$$1000\mathrm{grainweight(g)} = \frac{100 - MC}{86} x\mathrm{weightofsamplegrains}$$

Where: MC is the moisture content at the time of weighing

Grain yield (g) per plastic pail was taken by weighing the harvested grain of 15 sample plants in five plastic pails.

Biomass (g) was taken by oven drying the 2 sample plants per treatment replication at 70°C for three (3)

he weighing was done using a digital weighing balance. This was measured after harvest.

Statistical Analysis

The statistical analysis used was the STAR or the *Statistical Tool for Agricultural Research* developed by IRRI. Analysis of variance (ANOVA) for CRD was used in this study. A comparison among means was done using Highly Significant Difference (HSD) at a 5% level of significance. This was performed using the STAR (Statistical Tool for Agricultural Research) (version 2.0.1).

Results

The result of the plant height at maturity revealed that T5 (Nostoc + ½ RRIF) was comparable with T3 (Nostoc + ¼ RRIF), T4 (¼ RRIF), T6 (½ RRIF), T7 (Nostoc + ¾ RRIF), T8 (¾ RRIF) and T9 (full RRIF). The shortest plants were observed from T1 (Control) and T2 (Nostoc) (Fig. 1). This is a clear indication that using T3, T4, T5, T6, T7, and T8 will have the same result as T9 in terms of plant height. The analysis of variance showed significant differences among the treatments.

T7 (Nostoc + ¾ RRIF) produce the highest number of tillers per plant but was comparable with T3 (Nostoc + ¼ RRIF), T4 (¼ RRIF), T5 (Nostoc + ½ RRIF), T6 (½ RRIF), T8 (¾ RRIF) and T9 (full RRIF). On the other hand, T2 (Nostoc) has the least number of tillers which was comparable with T1 (Control) and T5 (Nostoc + ½ RRIF). Analysis of variance showed a significant difference among the treatments.

Figure 1 showed that T7 (Nostoc + ¾ RRIF) was observed the best in terms of flowering with a mean of 73.0 days after sowing (DAS) and the late flowering with a mean of 76.0 DAS was observed on the T1 (Control) and T2 (Nostoc).

T9 (full RRIF) had the highest chlorophyll content and were comparable with T3 (Nostoc + ¼ RRIF), T4 (¼ RRIF), T5 (Nostoc + ½ RRIF), T6 (½ RRIF), T7 (Nostoc + ¾ RRIF) and T8 (¾ RRIF). The T1 (Control) together with T2 (Nostoc) had the lowest chlorophyll content. Analysis of variance showed a significant difference among the treatments.

Figure 2 revealed that T6 (½ RRIF) gave the highest number of filled grain per panicle with a mean of 96.7 grains and was comparable with T3 (Nostoc + ¼ RRIF), T4 (¼ RRIF), T5 (Nostoc + ½ RRIF), T7 (Nostoc + ¾ RRIF), T8 (¾ RRIF), T9 (full RRIF) and T1 (Control). While T2 (Nostoc) has the least number of filled grains per panicle with a mean of 60.7 grains. Analysis of variance revealed a significant difference among the treatments.

The T4 (¼ RRIF) has the heaviest weight of 25.3 grams, while the T7 (Nostoc + ¾ RRIF) was the lightest weight of 23.7 grams.

T3 (Nostoc + ¼ RRIF) gave the highest grain yield per pot with a mean of 24.1 g followed by T4 (¼ RRIF), T5 (Nostoc + ½ RRIF), T6 (½ RRIF), T7 (Nostoc + ¾ RRIF) and T9 (full RRIF) while T1 (Control) gave the least number of grain yield per pot of 9.9 grams. Comparison among means revealed that T3 had the highest grain yield per pot and was comparable with T4. Moreover, plants on T5 was similar to T6. On the other hand, T7 had comparable results to T8. The T9 plants were recorded the same result to T3, T4, T5, T6, T7, and T8 were comparable to each other.

Analysis of variance showed a significant difference among the treatments. T3 (Nostoc + ¼ RRIF) gave the highest dry matter content with a mean of 21.8 g and was comparable by T4 (¼ RRIF), T5 (Nostoc + ½ RRIF), T7 (Nostoc + ¾ RRIF), T8 (¾ RRIF) and T9 (full RRIF). The T1 (Control) gave the least dry matter content with the mean of 8.0 g, close to the response of T2 (Nostoc) with a mean of 9 g.

Discussion

Based on the Standard Evaluation System for Rice (2014), all of the treatments were categorized as semi-dwarf (less than 90cm) for plant height. In the study of corn, indicates that the addition of Nostoc can increase plant height. The same result was found out in M20 rice variety. Nostoc fixes atmospheric nitrogen into ammonia, which may then be used or converted to a form available for plant growth. The analysis of variance showed significant differences among the treatments. The high tillering ability of rice in T3, T4, T5, T6, T7, T8, and T9 is important because it is one of the requisites for high yield. The result was indicative of the potential of Nostoc to supplement N needs and replace the T9 into Nostoc with ¼, ½ or ¾ RRIF. The tillering capacity of the plant is an important trait because the number of tillers determines a panicle number and directly affects the production (Zhang *et al.*, 2011). Flowering is one of the agronomic traits that contribute to the determination of rice yield as it affects biomass, number of tillers, panicle length and number of grains/panicle that greatly varied the final yield (Ranawake and Amarasinghe 2014). The color of the plants observed varied according to the amount of nitrogen applied. The more nitrogen applied in the plants there will be more chlorophyll content of it (Caňete 2004). This study shows that the application of T3, T4, T5, T6, T7, and T8 gave similar nitrogen content to T9. Application of ½ RRIF (T6) could supply the amount of NPK at a proper time compared to full RRIF (T9) that resulted in an increased number of filled grains per panicle. Grain weight is considered as a highly heritable trait. Since in this study it was not affected by the rate and kind of fertilizer applied and the amount of nutrients present in the soil or any environmental factors. Grain weight is an important yield component because it gives information on the size and density of the rice grains (Yoshida 1981). In grain yield, application of ¼ RRIF (T4), ½ RRIF (T6), or full RRIF (T9) were comparable might be due to the number of plants in a pail. The three plants planted in a pail might have high competition limiting the growth of the plants even when there is sufficient or high level of nutrients. Thus, the growth of plants in less nutrients (¼ RRIF) became comparable with full RRIF. The combination of Nostoc with ¼ RRIF (T3) had the highest biomass since according to (Sahu *et. al*, 2012) Nostoc can improve the plant biomass when decomposed after the life cycle.

Conclusion

In terms of growth parameters, application of 3 g Nostoc with 1/2 RRIF gave the best response among

 of 3 g Nostoc with 3/4 RRIF was the best treatment when it comes to days to flowering (73 days). Furthermore, the application of full RRIF was the best in chlorophyll content (34.2).

For yield parameters, the application of 3 g Nostoc with 1/4 RRIF gave the best response to grain yield (24.1 g) and biomass (21.8 g) among the treatments. While the application of 1/4 RRIF was the heaviest weight when it comes to the weight of 1000 grains (25.3 g). For the number of tillers per plant (14.7), the application of 3 g Nostoc with 3/4 RRIF gave the best response among the treatments. The number of filled grains (96.7), the application of 1/2 RRIF was the best response among the treatments. The result of this pot experiment will be a benchmark for future studies.

Since the study used 3 g of Nostoc as treatment together with inorganic fertilizer, it is recommended to conduct a similar study with increasing the rates of Nostoc. This will help to identify the actual potential nitrogen-fixing capacity of the Nostoc with the combination of inorganic fertilizer. It is also recommended to explore using 3 g of Nostoc and different public hybrids since it requires higher nitrogen.

Declarations

ACKNOWLEDGMENTS

The author would like to offer particular thanks to the Central Luzon State University – College of Agriculture, Philippines.

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Additional Table

Table 1. Growth and yield of M20 as influenced by Nostoc and different rates of of inorganic fertilizer application.

Treatments	**PH[a*]**	**NTP[b*]**	**CC[c*]**	**NFG[d*]**	**GYP[e*]**	**B[f*]**
T1 – Control	70^{b}	7^{bc}	29.17^{b}	62^{ab}	9.91^{d}	7.97^{c}
T2 – 3g Nostoc	70^{b}	6^{c}	29.60^{b}	61^{b}	12.33^{cd}	9.04^{c}
T3- 3g Nostoc + RRIF	81^{a}	12^{a}	32.60^{a}	89^{ab}	18.85^{a}	18.87^{a}
T4 - 1/4 RRIF	83^{a}	11^{ab}	33.47^{a}	95^{ab}	21.27^{ab}	18.99^{ab}
T5 - 3g Nostoc + 1/2 RRIF	82^{a}	15^{abc}	33.87^{a}	93^{ab}	18.97^{abc}	20.97^{ab}
T6 - 1/2 RRIF	79^{a}	11^{a}	32.57^{a}	89^{a}	21.13^{ab}	16.65^{b}
T7 - 3g Nostoc + 3/4 RRIF	81^{a}	13^{a}	33.13^{a}	97^{ab}	20.26^{ab}	19.48^{ab}
T8 - 3/4 RRIF	78^{a}	14^{a}	32.83^{a}	84^{ab}	16.25^{bcd}	18.17^{ab}
T9 - FULL RRIF	79^{a}	12^{a}	34.20^{a}	84^{ab}	20.03^{ab}	18.79^{ab}

[a*] Plant height mean (cm)

[b*] Number of Tillers per Plant

[c*] Chlorophyll content (SPAD UNIT)

[d*] Number of Filled Grains per Panicle

[e*] Grain Yield per Pot (g)

[f*] Biomass (g)

Figures

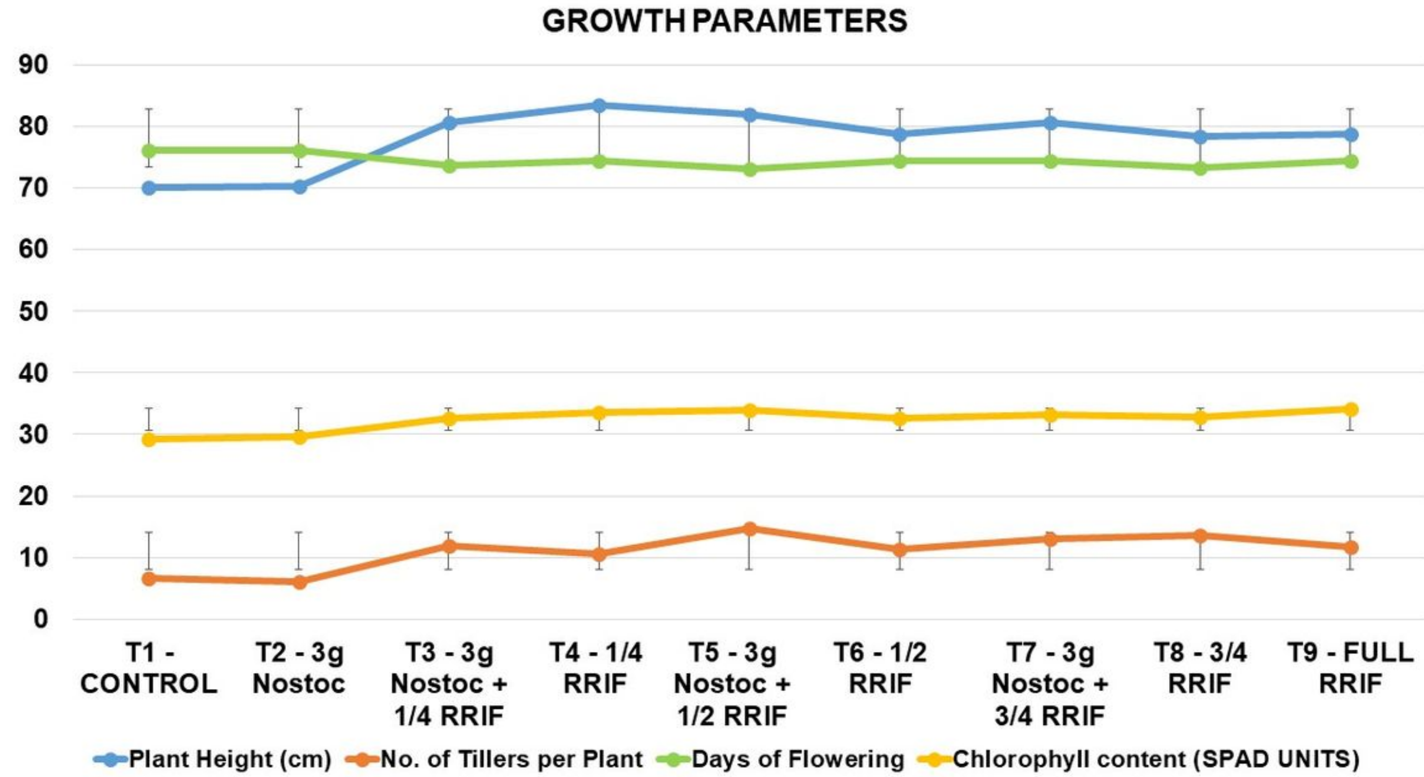

Figure 1

Growth parameters of M20 rice as influenced by Nostoc and different rates of inorganic fertilizer application.

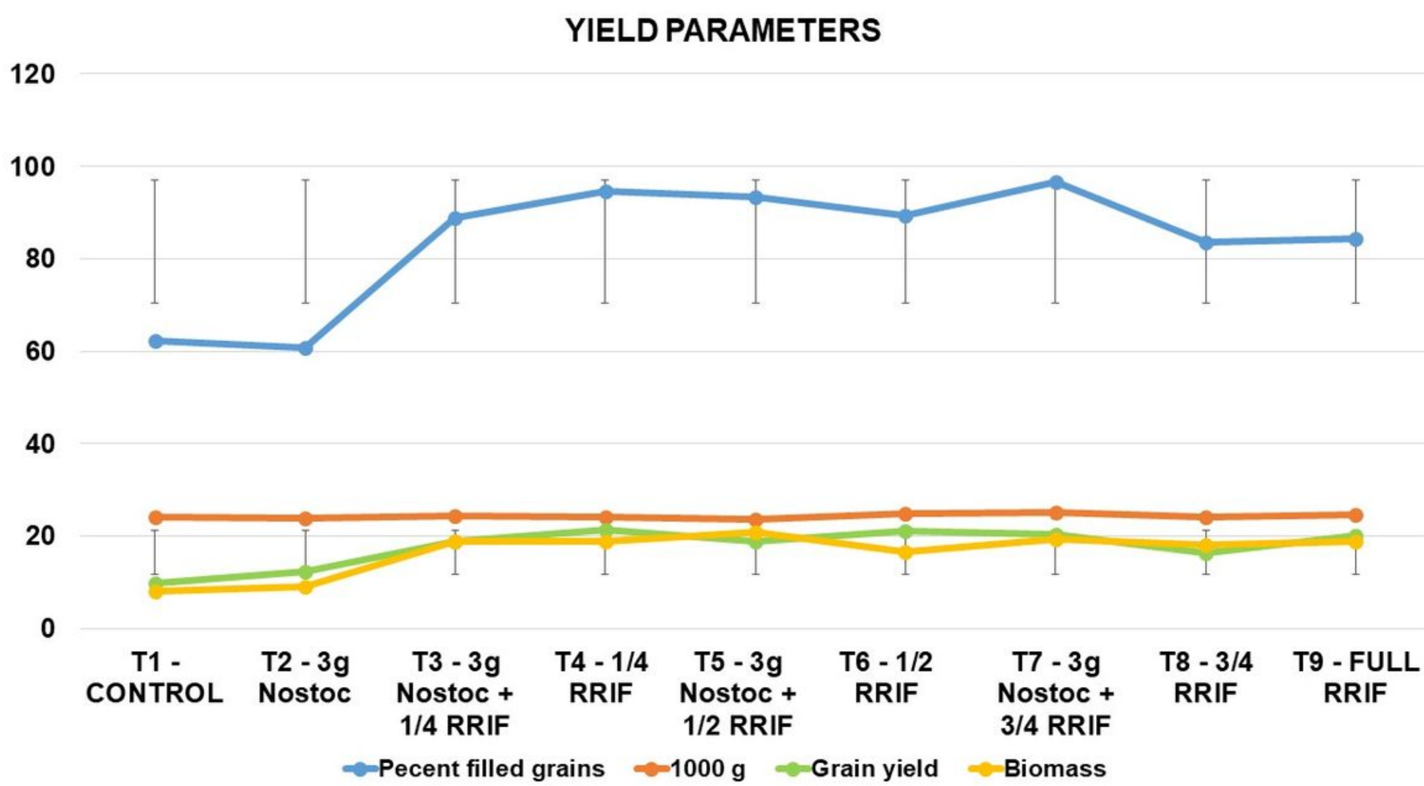

Figure 2

Yield parameters of M20 rice as influenced by Nostoc and different rates of inorganic fertilizer application.