



RESEARCH PAPER

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**Preliminary yield and growth performance of rice (var nsic rc222) applied with *Bacillus* spp. based bio-fertilizer**

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**Key words:** *Bacillus* spp. Bio-fertilizer, PalayCheck system, Early tillering stage, Growth, Yield

**Received:** 17 February, 2026    **Accepted:** 01 March, 2026    **Published:** 06 March, 2026

**DOI:** <https://dx.doi.org/10.12692/jbes/28.3.39-48>

**ABSTRACT**

This study aimed to find out and document the performance of NSIC Rc 222 rice variety as influence by application of Bio-fertilizer. Particularly, it aimed to find out the determine the growth and yield performance of the rice applied with bio-fertilizer at 10 days after first application, and to determine the profitability of NSIC Rc 222 rice variety . The study was conducted from July to December 2025 in Barangay Antonino, Balaoan, La Union to evaluate the performance and profitability of NSIC Rc 222 rice applied with a *Bacillus*-based biofertilizer at 10 days after transplanting (DAT). Using a Randomized Complete Block Design (RCBD) with three replications and following the PalayCheck system, standard soil analysis, fertilizer recommendations, crop establishment, irrigation, and integrated pest management practices were implemented to ensure reliable results. Biofertilizer application at 10 DAT significantly increased panicle length and the number of filled grains, indicating improved grain filling and overall yield performance. Although reductions in unfilled grains and slight differences in 1000-grain weight were observed, these were not statistically significant. The treatment also enhanced vegetative growth and tiller productivity, suggesting that early application supports better crop establishment and development. Economically, despite higher production costs, the 10 DAT treatments generated higher gross and net income, resulting in the highest return on investment among the treatments. Early application of *Bacillus*-based biofertilizer at 10 DAT proved to be the most agronomically effective and financially viable strategy for improving the productivity and profitability of NSIC Rc 222 rice.

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## INTRODUCTION

Rice (*Oryza sativa*) production in the Philippines considered as the most important crop as it is the primary staple food for around 80% of Filipinos and forms the foundation of the typical Filipino diet (Jane-Atilano-Sabalberino, 2023). But the Philippines' rice yield seems to be impacted by an extensive range of variables. The nation's severe issues with rice crop output shortfall were addressed by the use of various technologies as a result of recent concerns about rice self-sufficiency. Using high-quality inbred rice seeds and managing nutrients with organic fertilizers and seeds are two ways that local farmers are increasing their rice production.

Combining different production elements, such as land, manpower, fertilizers, seeds, pesticides, and other required inputs, is crucial to increasing agricultural crop production.

Fertilizers give plants the vital nutrients they need to develop and produce more. The best fertilization techniques can boost output; allowing farmers to satisfy the growing need for food supply from the world's expanding population (Fahmid *et al.*, 2022).

One of the four most popular rice types among Filipino farmers in irrigated lowland fields across the country, both during the dry and rainy seasons, is NSIC Rc 222, which was bred by the International Rice Research Institute (IRRI). NSIC Rc222 is a high-yielding inbred that may produce up to 10t/ha (transplanted) and has an average yield of 6.1t/ha.

According to Shrestha *et al.* (2020), an essential component of the soil and plant management as stated by Kumar (2024) enhancing soil health and crop productivity are essential for sustainable rice production. However, poor soil health can result from imbalanced nutrient management and inappropriate establishment techniques, which can have an adverse effect on crop quality and production. Moreover, as mentioned by Ammar *et al.* (2022), the degree of fertility has a significant impact on agricultural success. The foundation of organic farming systems is

healthy soil. Fertile soil provides the essential nutrients that plants need, as well as a diverse and active biotic population that helps the soil withstand environmental deterioration.

Concerns have been raised, meanwhile, regarding the loss of soil organic matter and the decline in the soils' ability to supply nutrients as a result of the increasing planting intensity in the rice-rice rotation and excessive application of inorganic fertilizer. Another strategy or intervention for enhanced profitability of rice is the utilization of bio-fertilizer.

In general, the word "bio-fertilizer," or more accurately, "microbial inoculate," refers to a preparation that contains either living or latent cells of effective strains of cellulolytic, phosphate-solvating, or nitrogen-fixing microorganisms that are applied to speed up microbial processes that increase the availability of nutrients that are readily available to seed or composting areas in order to increase the number of these microorganisms and their assimilation by crops (Tiwari, 2023).

Bio-fertilization is an environmentally friendly method of farming that involves applying bio-fertilizers to increase the amount of nutrients in the soil, leading to increased output (Suleiman *et al.*, 2020); revolutionize agricultural output due to the beneficial microorganisms present on it (Gu *et al.* 2020); can prevent the emergence of linked soil-borne diseases (Liu *et al.*, 2022); boosting soil fertility and plant growth (Gao *et al.*, 2020) and sustainable and reasonably priced sources of vital plant nutrients that work in tandem with agrochemicals (Kumwat and Kumari, 2024): improved lowland rice performance, including growth, development, and yield (Patriyawaty *et al.*, 2022). Thus, this attempt to evaluate the performance of NC222 applied with *Bacillus*-based biofertilizer.

*Bacillus* species are rod-shaped, gram-positive, endospore-forming bacteria that are ideal candidates for commercial use as bacterial biocontrol agents because they have the capacity to create endospores and a variety of bioactive chemicals ((Patriyawaty *et al.*, 2022).

According to Hashem *et al.* (2019), *Bacillus subtilis* enhance solubilization of soil phosphorus, promote nitrogen fixation and produces indole acetic acid and siderophore which improves plant growth and development. It facilitates the solubilization and mobilization of nutrients essential for plant growth by providing a return for organic molecules obtained by plants, including acids, amino acids, sugars, and phenolics. Additionally, *Bacillus subtilis* can become an endophyte in plant tissues, which enhances the health of the plant. Thus, plant-associated beneficial microorganisms like *Bacillus subtilis* can promote quicker plant growth and shield plants from a variety of rice illnesses.

Generally, this study aimed to find out and document the performance of NSIC Rc 222 rice variety as influence by application of Bio-fertilizer.

Specifically, it aimed to find out the determine the growth and yield performance of the rice applied with bio-fertilizer at 10 days after first application, and to determine the profitability of NSIC Rc 222 rice variety.

#### **MATERIALS AND METHODS**

The study was conducted using a Randomized Complete Block Design (RCBD) with three replications. Crop management followed the PalayCheck system for inbred rice production.

A composite soil sample (1 kg) was collected from the experimental area and analyzed for pH and NPK at the Office of the Provincial Agriculturist in San Fernando City, La Union, with fertilizer rates based on the Bureau of Soils Recommendation (BSR). Land preparation was done conventionally through plowing and harrowing to ensure proper weed control, residue incorporation, leveling, and uniform water distribution. NSIC Rc 222 seeds were soaked for 24 hours, incubated for 12 hours, and broadcasted in a prepared seedbed. Urea was applied 10 days after sowing to promote healthy seedling growth. Seedlings were transplanted 21 days after sowing at a spacing of 20 × 20 cm with two seedlings per hill.

Inorganic fertilizers were applied according to BSR recommendations, while bio-fertilizer (200 ml/16 L) was applied 10 days after transplanting. Irrigation followed an alternate wetting and drying method during the vegetative stage, with a 5 cm water level maintained during panicle initiation and booting. Integrated Pest Management (IPM) practices recommended by PhilRice were implemented, including regular monitoring, manual weeding, and control of major insect pests such as brown planthoppers, green leafhoppers, stem borers, and rice stink bugs using appropriate measures. Harvesting was done manually at 113 days after sowing when 85% of the panicles turned golden yellow. Harvested crops were properly labeled and stacked by treatment and block to avoid bias in fresh weight measurements. Threshing was carried out immediately after harvest using a pedal thresher, ensuring accurate collection and separation of grains according to treatment combinations and replications.

#### **Data to be gathered**

##### *Mean plant height*

This was taken by measuring the height of the rice plant from the bottom up to the tip of the rice plant 7 DAT, 30 DAT and 60 DAT from 10 samples.

##### *Mean number of productive and unproductive tillers*

These were taken by counting the number of productive and unproductive tillers of the rice plant from 10 sample plants.

##### *Mean length of panicle*

This was taken by measuring the length of the panicle from panicle base to panicle tip of the 10 sample plants.

##### *Mean number of filled and unfilled grains per panicle*

These were taken by counting the number of filled and unfilled grains per panicle of the rice plant from 10 samples.

##### *Mean Weight of 1000 grains*

This was taken by getting the weight in grams of 1,000 grains per plot.

*Mean weight of fresh and dry weight of grains per kg/plot and kg/ha*

The weight of fresh grains were gathered after cleaning the newly thresh grains and the dry weight were also recorded after drying for three consecutive days. These were taken by weighing the grains kg/per plot using weighing scale and computed for kg/ha.

#### *Cost and return analysis*

All the expenses incurred in the conduct of the study on per treatment basis were properly recorded, summarized and deducted to the gross value equivalent of the yield per unit area in the determination of the net income. The result will be converted into per hectare basis.

#### **Analysis of data**

All data gathered from the ten sample plants selected randomly from the middle rows were collated, organized, summarized, presented and analyzed employing the Analysis of Variance (ANOVA) in RCBD using Statistical Tool for Agricultural Research (STAR) 2.0.1, 2013. Mean differences were

determined employing the Least Significant Difference (LSD) Test.

## **RESULTS AND DISCUSSION**

### **Plant height (cm)**

The effects of the treatments on plant height and tillering performance are presented in Table 1. Results showed that plants treated at 10 days after transplanting (T1–10 DAT) consistently exhibited significantly greater plant height at all observation periods compared with the negative control. At 7 DAT, T1 recorded a mean height of 31.69 cm, markedly higher than the control (23.89 cm). This growth advantage was maintained at 30 DAT (66.23 cm vs. 52.80 cm) and 60 DAT (101.70 cm vs. 86.52 cm). The consistent increase in plant height across growth stages suggests that the treatment applied at 10 DAT enhanced early vegetative development and sustained growth performance, possibly through improved nutrient uptake and physiological activity. Similar to findings of Rahman *et al.* (2021), that bio-fertilizer effect on rice plant height become noticeable only after sufficient root-microbe interaction has occurred.

**Table 1.** Growth performance of rice sprayed with bacillus-based bio fertilizer

Treatments	Plant height (cm) at days after planting (DAT)			No. of productive tillers	No. of unproductive tillers
	7	30	60		
No biofertilizer Control)	23.89	52.80	86.52	13.09	2.52
T1- 10 DAT	31.69	66.23	101.70	25.82	0.56
Significance	**	**	**	**	**

\*\*Highly Significant

In terms of tillering, T1–10 DAT significantly increased the number of productive tillers (25.82) compared with the negative control (13.09). Since productive tillers are directly associated with yield formation, this result indicates a strong positive influence of the treatment on yield potential. Moreover, T1 markedly reduced the number of unproductive tillers (0.56) relative to the control (2.52), suggesting more efficient assimilates partitioning and reduced intra-plant competition. The presence of highly significant differences ( $p \leq 0.01$ ) across all measured parameters confirms that the observed improvements were attributable to the treatment effect rather than random variation. Overall, the application at 10 DAT proved effective in enhancing

vegetative growth and optimizing tiller productivity, thereby indicating its potential to improve crop performance. According to Fageria *et al.*, 2020, that production of tiller is highly influenced by genotype, spacing and nitrogen availability during early tillering stage rather than the timing of bio-fertilizer alone.

### **Yield components**

The results show that biofertilizer application at 10 DAT (T1) significantly improved all measured yield components compared with the untreated control. Panicle length was markedly increased under T1 (24.86 cm) relative to the control (21.20 cm), indicating enhanced reproductive growth and better panicle development (Table 2).

**Table 2.** Yield components performance of rice sprayed with *Bacillus*-based biofertilizer

Treatments	Panicle length (cm)	No. of filled grains	No. of unfilled grains	Weight of 1000-grain (g)
No biofertilizer (Control)	21.20	110.01	109.62	19.89
T1- 10 DAT	24.86	143.33	64.06	23.37
Significance	**	**	**	**

\*\*Highly significant

**Table 3.** Growth performance of rice sprayed with *Bacillus*-based bio fertilizer

Treatment	Plant height (cm) days after planting (DAT)			No. of productive tillers	No. of unproductive tillers
	7	30	60		
Positive control	31.43	59.58	98.70	20.84	1.22
10 DAT	31.61	66.23	101.70	25.82	0.56
Significance	ns	**	ns	*	**

\*\*Highly significant, \*Significant, ns= not significant

Similarly, the number of filled grains per panicle was substantially higher in T1 (143.33) than in the control (110.01), reflecting improved pollination efficiency and grain filling. In contrast, the number of unfilled grains was considerably reduced in T1 (64.06) compared with the control (109.62), suggesting that biofertilizer application minimized spikelet sterility and improved nutrient utilization during grain development.

Moreover, the weight of 1,000 grains was significantly heavier in T1 (23.37 g) than in the control (19.89 g), indicating better assimilate translocation and grain maturation.

The presence of highly significant (\*\*) differences across all parameters confirms that biofertilizer application at 10 DAT had a strong positive effect on yield components. Overall, the treatment enhanced grain filling, reduced sterility, and improved grain weight, which collectively contribute to higher potential grain yield compared with the non-treated control.

### Growth performance of rice as compared to synthetic fertilizer

Table 3 presents the growth performance of rice sprayed with a *Bacillus*-based biofertilizer at different timings of application, as measured by plant height at 7, 30, and 60 days after planting (DAT), and by the number of productive and unproductive tillers.

At 7 DAT, plant height did not significantly differ (ns) between the positive control (31.43 cm) and the biofertilizer applied at 10 DAT (31.61 cm). This indicates that early vegetative growth was not immediately influenced by the biofertilizer application. Similarly, at 60 DAT, plant height remained statistically comparable (ns) between treatments, with values of 98.70 cm for the positive control and 101.70 cm for the 10 DAT application. Although the biofertilizer treatment numerically produced taller plants at this stage, the difference was not statistically significant; suggesting that final plant height was not markedly affected by application timing.

However, at 30 DAT, a highly significant difference (\*\*) was observed. Rice plants treated with the biofertilizer at 10 DAT attained a significantly greater height (66.23 cm) compared with the positive control (59.58 cm). This result suggests that the biofertilizer exerted its strongest influence during the active vegetative growth phase, possibly due to enhanced nutrient availability and improved root activity associated with *Bacillus* species.

In terms of tillering, the number of productive tillers was significantly higher (\*) in the 10 DAT treatment (25.82) compared with the positive control (20.84). This indicates that biofertilizer application at 10 DAT promoted more effective tiller development, which is a critical determinant of yield in rice. Moreover, the number of unproductive tillers was highly

significantly reduced (\*\*) in the biofertilizer treatment (0.56) relative to the positive control (1.22). This reduction suggests improved nutrient use efficiency and better partitioning of assimilates toward productive tiller formation.

Overall, the results demonstrate that spraying the *Bacillus*-based biofertilizer at 10 DAT significantly enhanced mid-vegetative growth and improved tiller productivity, while having no marked effect on early or final plant height. The significant increase in productive tillers and reduction in unproductive tillers indicate that application at 10 DAT is an effective timing strategy to improve growth performance and potentially increase yield.

#### Yield performance of rice as compared to synthetic fertilizer

The results indicate that the timing of biofertilizer application influenced several yield components of rice, particularly panicle length and grain filling (Table 4). Application at 10 DAT (days after transplanting /planting) produced a longer panicle length (24.86 cm) compared to the Positive Control (23.58 cm). Since this parameter is marked with “\*” (significant), the increase in panicle length

due to application at 10 DAT is statistically significant. This suggests that early vegetative-stage application enhanced reproductive development, possibly by improving nutrient uptake during active tillering and panicle initiation. Similarly, the number of filled grains was higher in the 10 DAT treatment (143.33) than in the positive control (133.23), and this parameter is also marked as significant (“\*”). The increase in filled grains indicates better grain filling efficiency, which may be attributed to improved nutrient availability and enhanced physiological activity during the critical stages of flowering and grain development.

In contrast, the number of unfilled grains decreased from 85.76 (Positive Control) to 64.06 (10 DAT). However, since this parameter is labeled “ns” (not significant), the reduction, although numerically substantial, was not statistically different. This means that variability among replicates may have been high, preventing confirmation of a true treatment effect. Similarly, IRRI highlights that early bio-fertilizer administration predominantly influences vegetative vigor, while grainfilling depends mostly on assimilate availability and nutrient translocation during later stages of crop growth (IRRI, 2013).

**Table 4.** Yield performance of rice sprayed with *Bacillus*-based bio fertilizer

Treatment	Panicle length (cm)	No. of filled grains	No. of unfilled grains	Weight of 1000-grain (g)
Positive control	23.58	133.23	85.76	23.56
10 DAT	24.86	143.33	64.06	23.37
Significance	*	ns	*	ns

\*Significant, ns= not significant

Likewise, the weight of 1000 grains was slightly higher in the Positive Control (23.56 g) compared to 10 DAT (23.37 g), but this difference was also not significant (“ns”). Therefore, timing of application did not significantly influence grain weight, suggesting that grain size was relatively stable across treatments.

Overall, the findings demonstrate that applying the biofertilizer at 10 DAT significantly improved panicle length and increased the number of filled grains, which are important yield components. Although reductions in unfilled grains and slight differences in

1000-grain weight were observed, these were not statistically significant. Thus, early application at 10 DAT appears to be a favorable timing strategy for enhancing grain productivity primarily through improved grain filling rather than changes in grain size.

Thus this study demonstrated that microorganisms such as *Bacillus subtilis*, *Serratia odorifera*, and *Arbuscular mycorrhizae* fungi can be exploited extensively in agricultural output in recent years. Since, nowadays, microbial compound fertilizer

which is made by mixing fertilizer and microorganisms is also used in agricultural production. It was shown that *Bacillus subtilis* (AUBS1) increased the levels of pathogenesis-related (PR) protein in rice leaves as well as the activities of phenylalanine ammonia-lyase (PAL) and peroxidase (PO) (Lu *et al.*, 2022). Plant-associated beneficial microorganisms like *Bacillus subtilis* can promote quicker plant growth and shield plants from a variety of rice illnesses. The nitrogen-fixing bacteria receives sugars from the plant in order to fix nitrogen, and in return, the microbe gives the host plant fixed nitrogen for growth. *Bacillus subtilis* and other beneficial bacteria have proven to be superior in their capacity to colonize, multiply, adapt, and support plant growth. Through the secretion of secondary metabolites, this bacterium can regulate plant pathogens (Zhu *et al.*, 2022).

### Cost and return analysis

The cost and return analysis clearly demonstrates the economic advantage of applying a *Bacillus*-based

biofertilizer, particularly when sprayed at 10 days after transplanting (DAT) (Table 5).

The negative control (C-) incurred the lowest production cost (Php 26,928.80), generating a gross income of Php 93,759.72 and a net income of Php 66,830.92, with an ROI of 248.18%.

Although production expenses were minimal, income was also comparatively lower, reflecting the absence of yield-enhancing inputs.

The positive control (C+), which presumably followed recommended inorganic fertilization practices, had a higher production cost (Php 39,094.37).

This resulted in increased gross income (Php 129,881.89) and net income (Php 90,787.52). However, the ROI (232.23%) was slightly lower than the negative control. This suggests that while income increased, the proportional return relative to investment declined due to higher input costs.

**Table 5.** Cost and return analysis of rice sprayed with *Bacillus*-based bio fertilizer

Treatment	Production cost (Php)	Gross income	Net income	ROI (%)
C(-)	26,928.80	93,759.72	66,830.92	248.18
C(+)	39,094.37	129,881.89	90,787.52	232.23
T1 (10 DAT)	40,694.37	164,271.89	123,577.52	303.01

In contrast, T1 (10 DAT), where rice was sprayed with a *Bacillus*-based biofertilizer at 10 DAT, recorded the highest production cost (Php 40,694.37). Despite this, it achieved the highest gross income (Php 164,271.89) and net income (Php 123,577.52). Most importantly, it registered the highest ROI (303.01%). This indicates that the additional investment in biofertilizer application was economically justified, as the yield improvement more than compensated for the increased production cost.

Overall, the data suggest that early application (10 DAT) of a *Bacillus*-based biofertilizer significantly enhances profitability in rice production. Although production costs increased, the substantial gains in gross and net income led to superior return on investment. From an economic standpoint, T1 (10 DAT) is the most viable and

financially rewarding treatment among the options evaluated.

### CONCLUSION

This study demonstrated that the application of *Bacillus* spp.-based biofertilizer at 10 days after transplanting (DAT) significantly improved both the growth and yield performance of NSIC Rc 222 rice. The treatment enhanced key agronomic parameters, including plant height during the vegetative stage, number of productive tillers, panicle length, and number of filled grains per panicle. These improvements indicate better nutrient uptake, efficient assimilate partitioning, and enhanced physiological activity of the crop.

Although reductions in unfilled grains and slight variations in 1000-grain weight were observed, these

differences were not statistically significant, suggesting that the primary effect of the treatment was on grain filling rather than grain size.

Economically, the application of biofertilizer at 10 DAT resulted in higher production costs; however, these were offset by substantially higher yields, leading to increased gross and net income. The treatment recorded the highest return on investment (ROI), confirming its economic viability.

Early application of *Bacillus*-based biofertilizer at 10 DAT is an effective agronomic practice that enhances crop performance and profitability of NSIC Rc 222 rice.

### RECOMMENDATIONS

Based on the findings of the study, the following recommendations are proposed:

1. Farmers cultivating NSIC Rc 222 rice should adopt the application of *Bacillus*-based biofertilizer at 10 days after transplanting to improve growth performance, yield, and profitability.
2. Agricultural practitioners and extension workers should promote the use of biofertilizers as a sustainable and environmentally friendly alternative or supplement to conventional inorganic fertilizers.
3. Future studies should be conducted across different agro-climatic conditions and soil types to validate the consistency and adaptability of the results.
4. Further research is recommended to evaluate different application rates, frequencies, and combinations with inorganic fertilizers to optimize nutrient management strategies.
5. Long-term studies should also be undertaken to assess the impact of continuous biofertilizer use on soil health, microbial activity, and sustainability of rice production systems.

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