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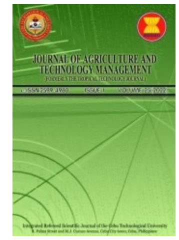

Original article

Growth and yield performance of rice *(oryza sativa* var. NSIC Rc222) as influenced by varying levels of nitrogen fertilizer

Marciano D. Tangpos

Cebu Technological University- Barili Campus

ABSTRACT

The appropriate nitrogen fertilizer application rate assures optimum net returns in rice production. Thus, this study was conducted to a.) evaluate the growth and yield performance of NSIC Rc222; b.) identify the best nitrogen fertilizer level, and c.) evaluate the profitability of NSIC Rc222 at different levels of nitrogen fertilizer. Field experiments were conducted during the dry season from January 31 to May 5, 2020. The area was laid out in Randomized Complete Block Design (RCBD) with three replications. Five nitrogen levels (0,150,120,100 and 75 kg N/ha) were designated as the treatments. Results showed that applying fertilizer at the rate of 75-60-60 NP205K2O significantly headed and matured earlier at 81.67 and 101 days after planting and grew at 89.10 cm tall but was comparable to other treatments, excluding no fertilizer application. Likewise, fertilizer application at 120-60-60 NP205K2O significantly increased its productive tillers, panicle length, percent filled spikelets, the weight of grains per hill, weight of 1000 grains, and lower unfilled spikelets. Further, the use of 120-60-60 NP205K20 produces a higher grain yield at 4.39 t/ha and has a net income of PHP 82,880, followed by 100, 75, 150 kg/ha, and 0 nitrogen with corresponding net income values of 72,895, 66,320, 54,070, and 26,900 pesos per hectare, respectively.

KEYWORDS: *agronomic characteristic, yield components, root-shoot parameters, economic analysis*

1 INTRODUCTION

Rice *(Oryza sativa L.)* is still the staple food for more than half of the population worldwide (Izawa and Shimamoto, 2021; Chris, 2014). According to the Philippine Statistic Authority (2019), rice production dropped from 3.93 metric tons in 2017 to 3.87 metric tons in 2018 due to the shrinking of 16 thousand hectares of rice from the previous year. The Philippines is among the nations still encountering a food crisis that requires the government to import more rice from the neighboring countries (Mendoza, 2008). The limited supply of rice could result in a price hike. Further, this creates a large portion of purchasing intensity of the poor people, including landless farmers and urban poor workers whose spending on rice comprises about 22% of their absolute family unit used (Balisacan et al., 2003). In this manner, rice production must be increased significantly to fulfill Filipinos' food needs.

As the population grows, more rice will be required (Clark and Curan, 2004; Hirzel et al., 2011) and numerous variables should be considered (Jing et al., 2008) to improve yield. One of the most significant factors is proper fertilization. Nitrogen, phosphorus, and potassium or NPK are the primary nutrients in rice production. Nitrogen is the main nutrient associated with economic yield (Jing et al., 2008 Hirzel et al., 2011). It is one of the significant macronutrients responsible for the development of rice, including essential characteristics related to yield (Danying et al., 2019).

Insufficient nitrogen (N) fertilizer is a significant limitation in accomplishing rice self-sufficiency. However, adding nitrogen fertilizer may improve yield, but excessive use of nitrogen may not always bring about yield enhancements, but it will create severe environmental issues (Shuangjie et al., 2016). Further, the sufficiency of nitrogen depends on soil health and topographic variation. In Carcar City, Cebu, particularly among rice farmers, fertilizer use is unstable with no meaningful information related to proper application. Hence, the study was conducted to determine the appropriate levels of nitrogen fertilizer and its economic profitability. Meanwhile, this undertaking will lead to the appropriate utilization of nitrogen fertilizer for rice farmers in Carcar City.

2 MATERIALS AND METHODS

A. Land Preparation and Soil Sampling Analysis

The experiment was conducted in a lowland irrigated at Brgy. Poblacion Carcar City Cebu. An area of 288 m2 was puddled twice using a two-wheeled hand

*corresponding author: marciano.tangpos@ctu.edu.ph
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tractor at weekly intervals. Final puddling was done a week before transplanting, leaving 2.5 cm standing water. Dikes around each treatment plot and the experimental area were constructed after the first puddling with a measurement of 4 m x 5 m, and canals were provided to facilitate water management. The site was moderately acidic with a soil pH of 6.0 and high in soil organic matter (4.42%) and total nitrogen (0.14%), available phosphorus (1.39 ppm), and exchangeable K potassium (0.11 me/g). Before land preparation, ten soil samples were randomly collected from the experimental area to a depth of 20-30 cm from the soil surface. The collected soil samples were thoroughly mixed after one (1) kg sample was composited, air dried, pulverized, and sieved using 2 mm wire mesh. Soil samples were submitted at the Central Analytical Service Laboratory (CASL), PhilRootCrops, Visayas State University, Visca, Baybay City, Leyte, for the analysis of soil pH, total N, available P, exchangeable K, available Na, Mg, Mn Ca, Fe, and Zn.

B. Experimental Design and Field Lay-out

The experiment was arranged in a Randomized Complete Block Design (RCBD) with five (5) treatments and three replications. Each plot measured 4 m x 5 m with 24 rows per plot spaced at 20 cm x 20 cm. A total of 15 plots were prepared for the entire experiment. Replication and treatment plots were separated by 1.5 meters and 1-meter alleyways, respectively, to prevent contamination of treatments and facilitate farm operations and data gathering. The different treatments were designated as; T1- No fertilizer application (Control), T2- 150-60-60 kg/ha N, P2 O5 K2 O, T3- 120-60-60 kg/ha N, P2 O5 K2 O, T4- 100-60-60 kg/ha N, P2 O5 K2 O, and T5- 75-60-60 kg/ha N, P2 O5 K2 O, respectively.

C. Seedling Preparation and Fertilizer Application

Forty (40) kilos per hectare of NSIC Rc222 was used in the study and was soaked for 24 hours and then incubated for 48 hours. After incubation, the pre-germinated seeds were sown in one seedbed measuring 1 meter x 3 meters. The seedbed was surrounded by dikes and covered with a net to protect the seeds from bird damage until they were ready for transplanting 21 days after sowing. For inorganic fertilizer treatment, complete and urea were used to satisfy the fertilizer recommendation of each treatment as to 150-60-60 kg/ha N, P2O5K2O, 120-60-60 kg/ha N, P2O5K2O, 100-60-60 kg/ha N, P2O5K2O, and 75-60-60 kg/ha N, P2O5K2O. Complete fertilizer at 850 grams per treatment plot was broadcasted eight (8) days after transplanting (DAT). The remaining N fertilizer was applied in each treatment at the panicle initiation stage. Dissection of the culm was done to determine if the panicle primordia initiated at the uppermost node of the culm. The actual rate and time of fertilizer application are shown below.

Table 1. Rate and time of application of the different treatment per plot.

Treatment	**Time of Application**	
	8 days After Transplanting (DAT) (g)	Panicle Initiation (P.I) (g)
No fertilizer application (Control)	0	0
T_2- (150-60-60 kg ha^{-1} N, P_2O_5 K_2O	850g Complete	390g Urea
T_3- (120-60-60 kg ha^{-1} N, P_2O_5 K_2O (Recommended Rate)	850g Complete	260.86g Urea
T^4- (100-60-60 kg ha-1 N, P2O5 K2O	850g Complete	173.92g Urea
T_5- (75-60-60 kg ha^{-1} N, P_2O_5 K_2O	850g Complete	65.22g Urea

D. Transplanting, Weeds and Water Management

Twenty-one (21) day old seedlings of the rice var. NSIC Rc222 were transplanted at two seedlings per hill spaced at 20 cm x 20 cm between hills and rows. Replanting was done seven days after transplanting to maintain the desired plant population of 500 hills per plot. Rotary weeding was done 15 days after transplanting (DAT). Afterward, hand weeding was done at 30 (DAT), while spot weeding was employed to remove weeds around each hill if necessary. The area was intermittently irrigated five days after transplanting to a depth of 2.5 cm by allowing the entry of water until the desired water level was attained. Irrigation and drainage canals were constructed to facilitate water management then, and immediately their outlets were closed to maintain the water level. This was imposed from panicle initiation until two weeks before harvest to facilitate harvesting.

E. Control of Insect Pests and Diseases

Twenty-five (25) grams of lanate (a.i. methomyl) insecticide dissolved in water suitable for 16 liters knapsack sprayer applied to control insect pests during vegetative to reproductive growth stages. Handpicking of Golden Apple Snail-GAS (Pomacea canaliculata L.) was done a day before transplanting and was followed after another two days. To control Maya (Lonchura atricapilla) and Gordon (Passer domesticus), bird repelling flags (‘’banderitas") and a net were installed to cover the standing crop at the milking stage.

F. Harvesting and Processing

Determined harvestable area (20 m2) was harvested, with approximately 85 % of the grains in each treatment plot ripened in the panicles. The grains were harvested when the grains turned to yellowish color. The panicles

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within the harvestable area were cut at the base of the plant using a sharp sickle. All sample panicles within the harvestable area were taken, excluding two border rows on each side of each plot and two end plants on both ends of each row. The sample panicles were threshed, dried for three days, attaining 14 % moisture content, tested using a handheld seed moisture meter, and cleaned before gathering the necessary data.

Data Gathered

The data gathered includes the number of days from sowing to heading and maturity, panicle length (cm), plant height (cm) at maturity, leaf area index (LAI), fresh straw yield (t/ha), number of nodal roots per plant, root axis length per plant (cm), root dry weight per plant (g), shoot dry weight per plant (g), the root-shoot ratio per plant, number of productive tillers per m2, percent of filled spikelets per panicle, the weight of 1,000 grains (g), and grain yield (t ha-1), and gross margin analysis, respectively.

Data Gathered

Statistical analysis was performed using the Statistical Tool for Agricultural Research (STAR version 2.0.1). All data were analyzed using one-way analysis of variance (ANOVA) in a Randomized Complete Block Design (RCBD). Significant differences between treatments were determined using Tukey's Honest Significant Difference (HSD) test at a 0.05 level of significance.

3 RESULTS AND DISCUSSION

I. Agronomic Characteristics

Results showed that nitrogen levels significantly influenced rice agronomic characteristics (NSIC Rc222). Among different treatment levels of N used, fertilizer application at the rate of 75-60-60 kg/ha N, P205, K2O significantly headed and matured earlier, increased heights, nodal root axis, lower root dry weight, and root-shoot ratio. The result is similar to 100-150 N kg/ha in terms of heading and maturity, plant height, and the number of nodal root axis. According to the National Seed Industry Council, NSIC Rc222 matures in 114 days and stands at 101 cm in height. This means, this variety could be harvested earlier than its typical maturity period under Carcar City conditions.

In relation to its root and shoot characteristics, 120 N kg/ha significantly had higher root density, root dry weight, shoot dry weight, and root shoot ratio. Because N has a direct role in plant proliferation (Nihorimbere et al., 2011), the quantity of available N present in the soil will vary its effects in either below or above-ground biomass (Fomara and Tilman, 2008). Cao et al. (2017) also stated that levels of available N in the soil might vary its effect on plants. However, according to Yuan et al. (2011) and Yuan et al. (2017), rice varieties with considerable above and below-ground biomass had better potentiality for a higher yield. Garnett et al. (2009) also noted that nitrogen fertilizers' effect on the root-shoot ratio's performance significantly complements its yield. Moreover, higher input of N increases the characteristic of below-ground biomass at a certain level. Also, Ma et al. (2010) concluded that higher root count and length could produce more cereal yield.

With regards to the fresh straw yield, application at the rate of 120 N kg/ha produces the highest fresh straw yield compared to another N level. Cakmak, 2009, stipulated that the increase in straw yield is attributed to its readily available fertilizer and higher accumulation of nutrients during the vegetative stage of the crops. Eagle et al. (2000) also concluded that the availability of nitrogen in the soil would increase the above-ground biomass of any plants.

Meanwhile, based on the result of the study, it is clear that the N level affects the agronomic characteristics of rice. Increasing rice morphological and yield characteristics as to the influence of N level may serve as determinants for a higher yield. Further, the result of the study implied and suggests that the application of 120 N kg/ha enhances and improves the field quality of NSIC Rc222 and should be adapted when cultivating under Carcar City condition.

II. Yield and yield components

The morphological characteristics of above-ground biomass are a function of the below-ground accumulation of nutrients and minerals. Results showed that nitrogen levels applied to rice (NSIC Rc222) significantly influence the number of productive tillers, panicle length, percent filled and unfilled spikelets, the weight of grains per hill, and 1000 grains. Among different treatments used, applying fertilizer at 120-60-60 kg/ha NP205K2O has significantly increased its productive tillers, panicle length, percent filled spikelets, the weight of grains per hill, and weight of 1000 grains. It lowers unfilled spikelets compared to other N levels. This means that the availability of N affects plant performance (Castels, 2008), but the performance of plants of N levels varies on geological location (Chen et al., 2010). Under Carcar City conditions, 120 kg/ha of N enhances yield and yield characteristics while decreasing when more or less of N is applied. This suggests that proper fertilization of N at specific locations helps improve rice yield and yield components.

However, the productivity of rice fields is associated with different factors, including genetic composition, environment, management, and their interactions. According to Liu et al. (2019), irrespective of the environment, rice yield is determined by the number of spikelets, filling quality, and panicle density, which is

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attributed mainly to N fertilizer application. Also, proper application of nitrogen fertilizer in rice had a direct effect on the number of panicles, filled grain, and weight of 1000 grains (Tadesse et al., 2018; Ghoneim, 2018; Meena, 2021).

Meanwhile, the result of the study concluded that under the Carcar City condition, the application of 120 N kg/ha enhances the capability of rice to produce higher yield characteristics. Further, this study implied that proper fertilization should be followed accordingly for a better yield.

Table 1. Agronomic characteristics of Rice (Oryza sativa L. var. NSIC Rc222) at varying levels of Nitrogen fertilizer application under Carcar City condition

Treatment	Number of days from Planting to		Plant height	No. of nodal roots	Nodal root axis length	Root dry weight	Shoot dry weight	Root shoot ratio	Fresh Straw yield (t/ha)
	Heading	Maturity	(cm)		(cm)	(g)	(g)		
T_1 Control	91.33_a	109.33_a	72.50_b	169.9_e	21.4_d	11.13_d	18.00_{de}	0.61_a	1.33_{de}
T_2 150-60-60	84.00_b	104.00_b	89.00_a	170.1_{cd}	21.27_{de}	12.13_c	19.47_c	0.64_a	1.43_d
T_3 120-60-60	84.33_b	105.00_b	88.50_a	175.5_{ab}	23.87_b	15.27_a	24.07_a	0.67_a	2.81_a
T_4 100-60-60	84.33_b	104.67_b	88.67_a	170.4_c	25.67_a	13.27_b	20.40_b	0.65_a	2.09_b
T_5 75-60-60	81.67_{bc}	101.00_c	89.10_a	176.8_a	22.93_c	10.6_{de}	19.20_{cd}	0.57_{ab}	2.05_{bc}
P Value	0.0001	0.0005	0.0013	0.9665	0.081	0.1743	0.27	0.44	0.2572
C.V (%)	1.35	1.18	4.1	9.25	7.83	17.87	15.76	10.57	24.79

Means with the same letter designation are not significantly different at 5 % level HSD test

Table 2. Yield and yield components of Rice (Oryza sativa var. NSIC Rc-222) at varying level of nitrogen fertilizer application

Treatment	No. of productive tillers	Panicle length (cm)	Percent filled spikelets	Percent unfilled spikelets	Weight of grains per hill (g)	Weight of 1000 grains (g)
T1 Control	11.17_e	25.02_e	81.29_e	17.90_a	11.83_e	20.00_e
T2 150-60-60	16.67_{bc}	29.58_{cd}	83.07_b	13.93_b	29.40_c	24.00_{ab}
T3 120-60-60	17.50_a	30.07_{ab}	88.32_a	11.68_e	34.03_a	24.33_a
T4 100-60-60	16.73_b	30.20_a	82.10_{cd}	12.08_{cd}	31.80_{ab}	23.33_c
T5 75-60-60	15.77_d	29.80_{abc}	82.37_c	12.63_{bc}	27.93_d	22.33_d
P Value	0.0179	<0.0009	<0.0035	0.0247	<0.0090	0.0396
C.V (%)	11.8	3.4	1.86	12.16	20.93	2.84

Means with the same letter designation are not significantly different at 5 % level HSD test.

III. Profitability Analysis

Among different treatments, the application of fertilizer at the rate of 120-60-60 NP205K20 (T3) produces a higher grain yield of 4.39 t/ha and net income (PHP 82,880), followed by T4, T5, T2, and T1 with corresponding net income value of 72,895, 66,320, 54,070, and 26,900 pesos per hectare, respectively. Nazareno et al. (2015) found that NSIC Rc222 has an average yield of 5.5 t ha-1 during the wet season and 8.9 t/ha during the dry season. This implied that under Carcar City conditions, this variety had lower grain yield even at its optimum fertilization level. Meanwhile, when this rice variety is applied with a high nitrogen level (150kg/ha N, P205, K20), it decreases its rice yield. At the same time, it is noted that the optimum nitrogen fertilizer application to be used in irrigated rice fields under Carcar city condition was 120 N per hectare. Also, below this recommended fertilizer would affect and decrease grain yield over time, reducing its net income. Thus, the study implied that under Carcar City conditions, applying fertilizer at 120-60-60 NP205K20 was the optimum level

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of fertilization to increase its yield and income.

Table 3. Profitability analysis of Rice (Oryza sativa var. NSIC Rc 222) production per hectare at varying levels of nitrogen fertilizer application

TREATMENT	Grain Yield t ha^{-1}	Gross Income $PhPha^{-1}$	Total Variable Cost $PhPha^{-1}$	Net Income $PhPha^{-1}$
T1-CONTROL	2.01_e	60,300	33,400	$26{,}900_e$
T2- 150-60-60	3.44_{cd}	103,200	49,130	$54{,}070_d$
T3- 120-60-60	4.39_a	131,200	48,320	$82{,}880_a$
T4-100-60-60	4.00_{ab}	120,000	47,105	$72{,}895_b$
T5- 75-60-60	3.67_c	110,100	43,780	$66{,}320_c$

Calculation of net income is based on the existing current price of dried palay @ Php. 30 kg^{-1}

4 CONCLUSIONS AND RECOMMENDATION

Agronomic characteristics, root morphology, and rice yield and yield components differed among fertilizer N kg/ha levels grown under Carcar City conditions. Application of fertilizer at the rate of 120-60-60 NP205K20 is the most optimum fertilizer to be used for NSIC Rc 222 grown under Carcar city conditions. Fertilizer rate of 120-60-60 NP205K20 gave the highest net income (PHP 82,880), followed by T4, T5, T2, and T1, with corresponding net income values of 72,895, 66,320, 54,070, and 26,900 pesos per hectare, respectively. Therefore, it is recommended that the rate of 120-60-60 NP205K20 is recommended for NSIC Rc 222 fertilization under Carcar City conditions for higher yield and net income.

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