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Agronomic, Yield, and Yield Potential of Rainfed Lowland Rice Varieties under Masbate Conditions

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Abstract. The increasing demand for rice as a staple food for Filipinos is important to sustain the country's self-sufficiency in rice. Masbate is an agricultural province of the Bicol region, Philippines, where rice is a staple food and a primary crop produced. Adaptability of improved rice varieties to different locations is important to increase productivity. This study evaluated the agronomic, yield, and yield potential of different rainfed rice varieties under Masbate conditions. The study used a Randomized Complete Block Design (RCBD) with four treatments, replicated three times. Data such as plant height at maturity, days to flowering, productive tillers, number of spikelets per panicle, number of filled grains, the weight of hundred grains in grams, and yield per hectare in tons were gathered. Data were analyzed using the ANOVA in RCBD and a post-hoc analysis using Tukey's HSD test for observed significant differences. The result showed a significant difference in plant height in centimeters, number of spikelets, and percentage of filled grains. However, a nonsignificant difference was obtained in the days to flowering, the number of productive tillers, the weight of a hundred grains, and yield per hectare in tons. Regarding yield and yield potential of different rainfed varieties, the NSIC Rc 272 and NSIC Rc 278 obtained the highest yield performance among the four varieties. The study's findings highlight the potential of different rainfed rice varieties as a new option for rice production. Further research is recommended using different rice varieties developed and fertilizer management practices for better yield output.

Keywords: Agronomic; yield potential; varieties; adaptability; performance

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INTRODUCTION

In the Philippines, rice is the most important staple food, providing almost half the calories the growing population needs. Currently, the domestic supply of rice is inadequate to meet local demand, making the country one of the top five rice-importing countries in the world (Mamiit et al., 2021). Because of its importance, rice has become the most socially, culturally, economically, and politically sensitive commodity in the Philippines, and ensuring an adequate, stable, and affordable supply is significant to every Filipino. Data shows that the country recorded 4.81 million hectares of area harvested for rice and a total production of 19.96 million metric tons, with a value of Php 403.89 billion (PSA, 2021). However, even with this level of rice production in the Philippines, rice is still ranked as the 3rd most imported agricultural item in the country. Accordingly, due to the high input costs of synthetic fertilizers, labor, land rent, transport, and milling costs, among others (Wu et al., 2024), rice production in the Philippines is constrained by the low yield and quality of rice produced by some local farmers (Serd, 2024).

To increase rice varieties' quality and yield potential, plant breeders from the private and public sectors continuously develop new and improved varieties that will withstand erratic climatic conditions. These varieties are approved by the National Seed Industry Council (NSIC) before they are released to ensure quality and high-yield potential. The Department of Agriculture has identified and recommended new rice varieties with a high-yielding capacity that will boost farmers' production output. According to Wang et al. (2021), food security would depend on an improved yield per unit area. Thus, breeding varieties that are high-yield, stable-yield, and resilient to climate change is important to increase or maintain rice yields in the country. Palanog et al. (2021) also mentioned that introducing modern rice varieties with high-yielding potential positively impacted rice production, which resulted in a dramatic increase in the production volume in the Philippines. However, local rice production is not enough to meet growing demand due to challenges brought about by climate change, growing population, declining land area, high cost of inputs, poor drainage, and irrigation. They added that breeding institutions such as the International Rice Research Institute (IRRI), the Philippine Rice Research Institute (PhilRice), the University of the Philippines-Los Baños (UPLB), and private companies continue to develop varieties that can overcome constraints and challenges to rice production. In addition, farmers invested the most in rice varietal trait improvements that offered opportunities to reduce losses caused by lodging, insects, and diseases (Maligalig et al., 2020).

In the Bicol region, despite the widespread utilization of modern rice varieties (85%) in rainfed areas, yields are still low - less than 2.0 t/ha, 60% of irrigated rice yields, which was far lower from the national average yield of 4.0 t/ha (Oxales, S., & Castro, R., 2017). With that, the DA-Bicol Field Operation encourages Bicolano farmers to plant new and improved rice varieties to boost rice production in the region by conducting seminars and field days for farmers (*DA-Bicol Rice Program Intensifies Promotion of Hybrid Rice Technology to Boost Rice Production | DA Regional Field Office 5*, 2023). Ibañez et al. (2024) also added that the lower production yield of rice farmers was due to their limited access to farming technologies, especially in the utilization of new and improved rice varieties. With the implementation of the Rice Competitiveness Enhancement Fund for the rice farmers of the Bicol region, farmers now have better access to new rice and improved rice varieties that they can use for planting. However, testing for adaptability must be conducted for a suitable variety that will give a higher yield in a specific location (Abao et al., 2022).

The Masbate province is considered the third producer of rice in the region (D*A Regional Field Office 5*, 2020), and it utilized 17, 170 hectares for rice production in 2019. 70% is rainfed, 28% is irrigated, and the remaining 2% is upland rice production (PAO-Masbate, 2021). Most of the local farmers are concentrated in lowland rainfed rice production as the source of palay production in the province, with a cultivated area of 1.5 hectares of rice fields per farming family (PSA, 2024). R. Y. Ibañez Jr et al. (2023) revealed that rice farmers in Masbate province used their previous harvest as their source of seeds for their next planting. This practice shows that some of the local farmers of Masbate do not have easy access to new and improved rice varieties. The importance of planting new varieties will allow local farmers to enhance their production to have better income. Furthermore, this study evaluated the agronomic, yield, and yield potential of different rainfed rice varieties under Masbate province to allow local farmers to use newly developed inbred varieties with promising yield potential adapted to local climatic conditions.

METHOD

Field Layout and Experimental Design

The different NSIC-approved rice varieties were arranged in a Randomized Complete Block Design (RCBD). A total land area of 172.38 sq. m. was divided into three blocks to represent the replications. Each block was divided into four plots with an area of 3 x 4 meters, representing the four treatments. A 60-centimeter pathway was provided between blocks and plots. In addition, the different varieties used in the study were PSP Rc 14, NSIC Rc 274, NSIC Rc 278, and NSIC 272.

Gathering and Recording of Data

Height of the plant at maturity in centimeters. The height of the plant was measured from the base of the plant to the apex of the plant. It was measured at the maturity period of each variety.

The number of days to flowering was counted from sowing until 50 percent of the rice crop reached the flowering stage.

Number of productive tillers/panicles/hills. The average number of productive tillers was counted per panicle per hill in the 10 representative samples during the panicle initiation period.

Percentage of filled grains per panicle. The number of filled grains was counted from the same panicle used to determine the number of grains per panicle. The percentage of filled grains per panicle was computed using the formula.

$$\text{PFS} = \frac{Number\ of\ filled\ grains}{Total\ number\ of\ grains}\ x\ 100$$

Weight of 100 grains (grams). The weight of one hundred grains was determined using the sample seeds obtained from the harvested grains for yield determination. The weighed and cleaned grains were thoroughly mixed, and one hundred

(100) grains were taken for weighing. There were three (3) one-hundred grains to be weighed. The average of the three weights was considered as the weight of one hundred grains for every replication.

Grain yield(ton/ha). The grain yield was taken from a quadrant (1 m^2) harvest area from the middle of each plot. The harvested crop was manually threshed, dried, and cleaned. The grain yield was expressed in tons per hectare using the formula below.

$$\text{Grain Yield(ton/ha)} = \frac{10{,}000m2}{ASP} \text{X} \frac{GW}{1000}$$

Where: ASP = area of sample plot; Gw= grain weight from the sampling area

General Procedure in the Conduct of the Experiment

The experimental area was prepared by plowing it twice, then it was harrowed two (2) times to eliminate and decompose the weeds. The final harrowing was done one day before transplanting. After the first plowing, the field was completely flooded with water. The field was drained and appropriately levelled for planting preparation on the last harrowing. The wet bed method was adopted to raise the rice seedlings (Agustin et al., 2023). The seeds were soaked for 24 hours and incubated for 36 hours before sowing them uniformly on their respective seedbed. After 20 days from sowing, the seedlings were pulled with the utmost care to ensure quality seedlings.

Seedlings were planted at a distance of 20x20 centimeters at the rate of three (3) seedlings per hill. A straight-row planting using a planting fork was used to maintain uniform plant density. After transplanting, it was applied with inorganic fertilizer at a rate of 90-40-40 kg/hectare as a general recommendation for rice production. Likewise, harvesting and post-harvest handling were done when 80% of the grains were straw-color. The crop was harvested with the use of a scythe. It was carefully handled to avoid a mixture with other varieties. This was done by separating the yield for every treatment and block.

Statistical Tools

The data was analyzed using the analysis of variance (ANOVA) in RCBD to evaluate significant differences among rice varieties. The data was processed using STAR software. A post hoc Test using Tukey's Honestly Significant Difference (Tukey's HSD) test was performed to determine significant differences among treatment means.

RESULTS AND DISCUSSION

Agronomic Parameters

Table 1 presents the growth parameters such as plant height at maturity in centimeters, number of days to flowering, number of productive tillers (pcs), and number of spikelets per panicle (pcs) of the four rice varieties tested for the adaptability trial under Masbate conditions. The results of the study revealed that the four rice varieties tested had a significant difference in terms of height at maturity in centimeters. As presented in the table, the PSB Rc 14 rice variety obtained the highest mean height among the four varieties, significantly different from the NSIC Rc 274 rice variety with the shortest height at maturity. In addition, rice varieties such as NSIC Rc 272 and NSIC Rc 274 were statistically comparable with the NSIC Rc 278 variety. However, a contrasting result was found in the height performance of PSB Rc14, with a mean height of 71.90 centimeters (Baliuag & Casauay, 2016). Likewise, Xu et al. (2024) also explained that variation in height is affected by the nutrients absorbed by the plants, primarily nitrogen, which is essential in plant growth. Also, the difference in height performance was attributed to the different climatic conditions of the tested locations, which affect the physiological process in plants that contribute to differences in crop performance.

The days to flowering of the four rice varieties tested showed a nonsignificant result based on the variance analysis (ANOVA) conducted. As shown in the table, days to flowering were closely similar, which resulted in a nonsignificant difference. Likewise, a shorter number of days to flowering was obtained by NSIC Rc 278 and NSIC Rc 272, while the longest days to flowering were observed in rice varieties NSIC Rc 274 and PSB Rc 14. Furthermore, the environmental factors did not significantly affect the days to flowering of the different rice varieties tested. Accordingly, the results of the study were similar to the characteristics of the rice varieties published by the National Seed Industry Council (2012). In addition, differences in days to flowering of the different rice varieties are influenced mainly by the genetic characteristics of each variety (Wiyono et al., 2024). In this study, the different rice varieties were planted in the open rice field, where uncontrolled environmental growth factors had a uniform contribution to the test crop planted.

Table 1. Agronomic Characteristics of different rainfed rice varieties

Treatments	Agronomic Characteristics Means			
	Plant Height at Maturity (Cm)	Days to Flowering (Days)	Number of Productive Tillers (Pcs)	Number of Spikelets per panicle (Pcs)
PSB Rc 14	98.25^{a}	73.75^{a}	9.50^{a}	79.70^{a}
NSIC Rc 272	70.40^{ab}	65.15^{a}	13.55^{a}	93.40^{ab}
NSIC Rc 274	65.65^{b}	73.00^{a}	11.50^{a}	63.65^{a}
NSIC Rc 278	78.10^{b}	65.30^{a}	11.90^{a}	100.5^{b}

*-Means followed by the same letter were not significantly different from each other.

Tillering is considered shoot branching in rice and is regarded as a fundamental trait for producing sufficient panicle numbers. Effective tillering in rice crops guarantees successful panicle production, which is vital for high crop yields (Takai, 2023). The number of productive tillers of the different rice varieties tested for adaptability showed comparable results among treatment means despite the differences obtained. The table shows that the NSIC Rc 272 variety obtained the highest number of productive tillers. However, it is statistically comparable with the other rice varieties like PSB Rc 14, NSIC Rc 274, and NSIC Rc 278. Both rice varieties had a lower number of productive tillers as compared to the study of Buarao (2023), which showed that improved rice varieties have an average of 18 tillers per plant. Findings of the study contradicted the results of the study of Senguttuvel (2021), which showed that a higher number of productive tillers is significantly associated with crops with taller plant height. In our study, the different rice varieties as a test crop showed that taller height varieties obtained fewer productive tillers per panicle, which explained that plant height does not significantly contribute to a higher number of productive tillers.

According to Liu et al. (2024), increasing the number of spikelets per panicle and total spikelets of the rice crop will significantly affect the rice yield. The number of spikelets produced per panicle showed significant differences among the varieties tested. Based on the study's results, NSIC Rc 278 marked the highest number of spikelets produced per panicle, which was statistically comparable with PSB Rc 14 and NSIC Rc 272 rice varieties. However, a significant difference was observed between NSIC Rc 278 and NSIC Rc 274, which obtained the lowest number of spikelets produced per panicle. In addition, the number of spikelets produced in the study was slightly lower than that of the rice crop tested by Mai et al. (2021), which produced about 203 spikelets per panicle. As observed, differences in the number of spikelets produced can be attributed to the unique genetic characteristics and their performance in prevailing environmental conditions.

a **b**

Figure 1. Data gathering on plant height in centimeters of the different NSIC rice (a) varieties and sample yield (b) per plot of the different NSIC rice varieties after harvesting.

Yield Parameters

The yield and yield potentials of different rainfed rice varieties tested were presented in Table 2. The result of the study shows that the percentage of filled grains of the different rice varieties was statistically significant from each other. The highest number of filled grains among varieties was obtained by NSIC Rc 278 with 97.51 percent filled grains, statistically different from NSIC Rc 274 with the lowest number of filled grains obtained (58.19%). However, Varieties like PSB Rc 14, NSIC Rc 272, and NSIC Rc 274 were statistically comparable regarding the percentage of filled grains produced. The data showed that rice varieties produced a different response in percentage of filled grains despite the uniform application of fertilizers and uniform environmental conditions. In addition, the genetic characteristics greatly influenced the percentage of filled grains produced by each variety. According to Okamura et al. (2018) and Meng et al. (2025), factors like temperature, water content, and fertilizer application influenced the crop performance in terms of the percentage of rice-filled grains.

The 100-grain weight of rice, also known as the 100-grain or 100-grain weight, refers to the weight of 100 randomly selected rice grains. It measures grain size and weight and is widely used in rice research for quality assessment. The table also shows that the weight of a hundred grains produced in grams by the different rice varieties was nonsignificant based on the analysis of variance. NSIC Rc 274 obtained the highest weight of 8.73 percent, while NSIC Rc 278 had the lowest weight of 7.07 percent. The result further emphasized the significant differences in the percentage of filled grains of rice varieties, and their weight per hundred grains in grams is significantly similar. Hariyono and Zaini (2018a) elaborated that the genetic nature of the plant greatly influenced the significant differences in weight in grams of rice crop, which contradicted the result of the study that showed a nonsignificant result despite varietal differences. Likewise, the weight of 100 grains in grams in the study was generally lower compared to the result of the study of Hariyono and Zaini (2018b), which showed that the weight in grams of NSIC Rc 274 planted in other locations was 12.50 and 12.68 for NSIC Rc 278 variety, respectively.

In terms of yield per hectare in tons produced by the different rainfed rice varieties, no significant differences were observed based on the variance analysis. The result showed that the NSIC Rc 272 and NSIC Rc 278 varieties produced 3 tons of rice per hectare. However, PSB Rc 14 and NSIC Rc 274 produced the lowest yield in tons, with only 2 tons per hectare. The result further explained that the yield performance of the different tested varieties had lower yield results than the yield trial conducted by other locations (Lagasca et al., 2024). The lower yield produced by the tested varieties signifies that the prevailing environmental conditions during planting up to harvesting significantly affect the yield performance (Zhang et al., 2024). However, the yield produced by the different varieties was comparable with the average rice yield produced by the province of Masbate, with a maximum yield of 2.84 tons per hectare (Bicol Palay and Corn Production Attain 4.01% and 3.81% Growth in 2021 | DA Regional Field Office 5, 2022). Furthermore, the yield variation of rice varieties produced could be attributed to the different climatic conditions of each province, which also affect the potential yield performance of the crop. The result of our study further explained that the different rice varieties produced a higher yield comparable to other varieties planted in the province. Hence, these varieties are adaptable and suited for wider production.

Table 2. Yield Parameters of Different Rice Varieties.

Treatments	Yield Parameter Means		
	Percentage of Filled Grains	Weight of Hundred Grains in Grams	Yield per Hectare in Tons
PSB Rc 14	71.70^{a}	7.56^{a}	2.26^{a}
NSIC Rc 272	79.26^{ab}	8.02^{a}	3.95^{a}
NSIC Rc 274	58.19^{a}	8.73^{a}	2.16^{a}
NSIC Rc 278	97.51^{b}	7.07^{a}	3.81^{a}

*-Means followed by the same letter were not significantly different from each other.

This study is important and provides new insight into using newly developed rice varieties that can be a reliable source of seeds for rice production in the province of Masbate. These varieties will add to the existing varieties that show higher yield potential. With the result of this study, farmers in the province will now have wider options to use varieties with higher yield potential that can thrive in different climatic conditions, especially in Masbate province.

Accordingly, the study results showed several potential benefits in the farming community in the province of Masbate. Providing additional knowledge and a wider variety of options in crop production is one of the primary purposes of this study. Lastly, the findings of this study clearly showed that new knowledge has been generated by adding new agronomic and morphological results of the varieties tested on how they performed in the different climatic conditions.

CONCLUSIONS

Based on the result of the study, the four rainfed rice varieties tested had significantly different responses in terms of plant height in centimeters, number of spikelets, and percentage of filled grains. However, a nonsignificant difference was obtained in the days to flowering, number of productive tillers, weight of hundred grains, and yield per hectare in tons. Regarding the yield and yield potential of different rainfed varieties, the NSIC Rc 272 and NSIC Rc 278 obtained the highest yield performance among the four varieties. Therefore, it is highly recommended that these two rainfed rice varieties be used for rice production by farmers in the province of Masbate. Likewise, further study should be conducted using different rice varieties, fertilizer management strategies, and other cultural management practices to enhance rice yield potential in the province.

AUTHOR CONTRIBUTION STATEMENT

M.D.D.: Introduction, methodology, field experiment, discussion, statistical analysis, E.B.B.; interpretation, review, B.B.D.; editing, and visualization. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to this research. Likewise, they had no personal or financial relationships that could influence our research.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript.

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