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ENHANCING RAINFED LOWLAND RICE PRODUCTION: INSIGHTS FROM PARTICIPATORY VARIETAL SELECTION IN CENTRAL LUZON

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Abstract

Rainfed lowland rice farming in the Philippines, covering about 4.5 million hectares, faces significant challenges, resulting in lower yields compared to irrigated systems. This study aimed to enhance rainfed rice production through Participatory Varietal Selection (PVS) in Central Luzon. Despite extensive breeding efforts, adoption of new varieties by farmers remains slow due to a mismatch between breeder objectives and farmer needs. PVS offers a solution by involving farmers in the selection process, ensuring the varieties meet practical requirements. The research was conducted over the 2019 and 2020 wet seasons across four provinces in Central Luzon, employing a Randomized Complete Block Design. Farmers assessed various agronomic traits, including yield, palatability, and maturity period, leading to the identification of farmer-preferred varieties. NSIC Rc416 emerged as the most favored variety, consistently outperforming others in both preference scores and yield, due to its early maturation, high tillering capacity, and resistance to pests and lodging. The study underscores the importance of aligning breeding objectives with farmer preferences to enhance adoption rates and productivity in rainfed areas. Recommendations include promoting high-performing varieties like NSIC Rc416, further evaluating promising but less consistently preferred varieties like NSIC Rc480, and continuing the participatory approach to ensure new varieties meet the practical needs of farmers. Implementing these strategies can improve food security and the resilience of rainfed rice systems.

Keywords: Rainfed Lowland Rice, Participatory Varietal Selection (PVS), Rice Yield Improvement Central Luzon, Farmer Preferences' Agronomic Traits, Variety Adoption, Rice Breeding, Agricultural Extension, Food Security.

1. INTRODUCTION

Rainfed lowland rice production in the country is primarily characterized by subsistence farming, resulting in lower yields compared to irrigated lowland rice. Despite this yield disparity, rainfed rice production remains significant, covering approximately 4.5 million hectares, or 30% of the total harvested area. Enhancing the agro-ecosystem within these rainfed areas has the potential to substantially boost national rice production (PSA, 2016). Although most breeding efforts in rice are concentrated on irrigated ecosystems, the development of new rainfed rice varieties continues to be a critical pursuit (Lalican et al., 2017).

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Rice variety development is spearheaded by several key research institutions, including the Philippine Rice Research Institute, the International Rice Research Institute, the University of the Philippines Los Baños, and various private companies. Each of these entities employs distinct breeding strategies aimed at addressing the unique challenges of rainfed rice cultivation. The breeding process is a long-term endeavor, typically taking 10-12 years from initial breeding to the release of a new variety. Over 300 rice varieties have been developed and released, tailored to suit diverse ecosystems (Palanog et al., 2020). Breeding new varieties is seen as a vital strategy to achieve rice self-sufficiency.

However, rainfed rice farmers are often slow to adopt new varieties due to several challenges, which are more related to extension services than breeding itself. Many farmers, especially those in remote rainfed areas, have limited access to information about new seed varieties. Additionally, the criteria and needs of farmers often do not align with those considered by plant breeders. Varieties selected at research stations may not outperform traditional varieties under farmers' management conditions or may lack characteristics that are unexpectedly important to farmers, such as palatability, maturity period, or ease of threshing. Furthermore, improved varieties may not always meet farmers' requirements for end-use and cooking quality (Sié et al., 2010).

Participatory Varietal Selection (PVS) emerges as a more rapid and cost-effective method for identifying farmer-preferred varieties when a suitable selection of cultivars is available (Witcombe et al., 1996). PVS also aids in developing varieties that are well-suited to marginal soils and cater to farmers' interests (Singh et al., 2014). The adaptability of a variety can be either wide or specific, generally depending on grain yield and yield stability across various environments. Varietal trials play a crucial role in selecting appropriate varieties that are both suitable and adaptable to specific environments (Palanog et al., 2014).

In light of these considerations, a project was initiated to establish varietal trials in selected provinces of Central Luzon. The primary objectives were to determine the preferences of farmers and to validate the adaptability and agronomic performance of newly released rainfed rice varieties through the Participatory Varietal Selection approach. Additionally, a preferential analysis was conducted to identify the rice varieties most favored by farmers. By engaging farmers directly in the selection process, the project aims to bridge the gap between breeders' selections and farmers' needs, thereby enhancing the adoption of improved varieties and contributing to greater productivity in rainfed rice systems.

2. OBJECTIVES

The general objective of the study was to contribute to national food security by increasing the productivity and stability of rainfed rice production systems to bridge the gap between rice breeders and farmers, ensuring that the development and dissemination of new rainfed rice varieties are both scientifically sound and practically relevant to the needs of the farming community.

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1) Assess the yield, growth characteristics, and overall agronomic performance of newly released rainfed rice varieties in different environmental conditions within Central Luzon.
2) Identify the specific traits and characteristics that are most valued by farmers, including yield, palatability, maturity period, and ease of threshing.
3) Engage farmers directly in the selection process through Participatory Varietal Selection (PVS) to ensure the selected varieties meet their practical needs and preferences.
4) Evaluate the adaptability and yield stability of the new rice varieties across a range of rainfed environments to determine their suitability for broader adoption.
5) Increase the adoption rates of improved rainfed rice varieties by aligning breeding objectives with farmers' needs and preferences through participatory approaches.
6) Perform a preferential analysis to systematically identify and document the most preferred rice varieties among farmers in the selected provinces.
7) Improve the dissemination of information about new rainfed rice varieties to farmers, especially in remote areas, through effective extension services and farmer outreach programs.
8) Provide feedback to breeding programs on farmer-preferred traits and performance under real-world conditions to guide future rice breeding efforts.
9) Encourage sustainable farming practices by developing and promoting rice varieties that are resilient to the specific challenges of rainfed agriculture, such as drought tolerance and nutrient use efficiency.
10) Assess the socio-economic impact of adopting new rice varieties on farmers' livelihoods, including income, food security, and overall well-being.
11) Enhance the capacity of farmers to evaluate and select appropriate rice varieties through training and participatory learning sessions.

3. METHODOLOGY

Research Trials and Treatments

The Participatory Varietal Selection (PVS) trials were conducted following the International Rice Research Institute's protocol on management practices for PVS in specific ecosystems (Paris et al., 2011). These trials were carried out during the wet cropping seasons of 2019 and 2020 in the provinces of Aurora, Bulacan, Tarlac, and Zambales, which are characterized by sandy loam rainfed lowland conditions. The rice varieties used in the experiment were recommended by the International Rice Research Institute (IRRI), Philippine Rice Research Institute (PhilRice), and the University of the Philippines Los Baños (UPLB). Detailed agronomic information about the varieties is presented in Table 1.

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Table 1: Rainfed Rice Varieties Agronomic Information

Varieties	Local Name	Year Released	Breeder	Maturity Days	Yield (mt/ha)
					AVE
NSIC Rc346	Sahod Ulan 11	2013	PhilRice	105	3.3
NSIC Rc416	Sahod Ulan 13	2015	PhilRice	116	3.4
NSIC Rc418	Sahod Ulan 14	2015	UPLB	113	3.8
NSIC Rc478	Sahod Ulan 25	2016	IRRI	113	3.8
NSIC Rc480	GSR 8	2016	IRRI	107	3.2
NSIC Rc27 (chk)	Katihan 3	2014	IRRI	107	2.7
IR64 (chk)	IR64	1985	IRRI	113	3.1

Source: National Seed Industry Council (NSIC)

Data Collection and Statistical Analysis

PVS trials were set up during the wet cropping seasons of 2019 and 2020 using a Randomized Complete Block Design (RCBD) with three replicates on selected farmers' fields. When the majority of the varieties reached 85% maturity, a Preferential Analysis was conducted to evaluate and select the preferred varieties according to farmers' criteria based on physical and growth characteristics.

Farmers were asked to choose their most and least preferred varieties using a prescribed scorecard. In total, 210 farmers participated in the activity over the two wet seasons, with 60% of them being male and 40% female.

The preference scores (PS) for each variety were calculated using the following formula:

$$PS = \frac{\text{Total Number of Positive Votes} - \text{Total Number of Negative Votes}}{\text{Total Number of Positive \& Negative Votes}}$$

After tallying the votes, the results were presented to the farmers, who were then asked to discuss their choices, especially the reasons behind their high positive and negative votes. Researchers recorded the traits of the preferred and least preferred varieties as identified by the farmers.

The agronomic characteristics of the test varieties, such as actual days to maturity after sowing (DAS), plant height, number of productive tillers, and grain yield, were validated and evaluated. Seedlings were transplanted 21 DAS across all sites. The yield was computed using the following formula:

$$\textit{Yield, kg/ha} = \textit{plot yield x } ((100\text{-}MC) \div 86) * (10000 \div \textit{harvest area})$$

Analysis of variance (ANOVA) was performed to determine the significance of the mean yields and agronomic traits of the different rainfed rice varieties using the Statistical Tool for Agricultural Research (STAR 2.0.1). Tukey's Honest Significant Difference (HSD) test was conducted at p<0.01p < 0.01p<0.01 to determine the mean differences. Descriptive analysis was used to determine the ranking of the varieties based on the preferential analysis.

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4. RESULTS AND DISCUSSION

Farmer's Preferred Rainfed Rice Variety

Table 2 details the preference scores and rankings of different rainfed rice varieties based on the farmers' evaluations during the 2019 and 2020 wet cropping seasons. In the 2019 season, NSIC Rc416 stood out as the most preferred variety, achieving the highest preference score of 0.103 and securing the first rank. Farmers appreciated this variety for its early maturation, resistance to lodging, semi-dwarf stature, high tillering capacity, concealed and elongated panicles, pest and disease resistance, and overall high yield. NSIC Rc346 was the second most preferred variety in 2019, with a preference score of 0.039. This variety demonstrated good performance but did not quite match the overall appeal of NSIC Rc416. NSIC Rc418 followed closely in third place with a preference score of 0.011, suggesting moderate acceptance among the farmers. In contrast, NSIC Rc478 and NSIC Rc480 received negative preference scores of -0.014 and -0.045, respectively, indicating less favorable performance in the eyes of the farmers. NSIC Rc27, one of the check varieties, had the lowest preference score of -0.116, ranking seventh. Farmers observed that NSIC Rc27 had low tillering ability, exposed panicles, and high susceptibility to pests and diseases, which contributed to its poor ranking. During the 2020 wet season, NSIC Rc416 again topped the list with an increased preference score of 0.117, reaffirming its consistent performance and farmer preference. NSIC Rc480 and IR64, another check variety, both achieved a preference score of 0.016, tying for the second rank. This marked an improvement for NSIC Rc480 compared to its 2019 performance.

NSIC Rc346, however, saw a decline in its preference score to -0.063, dropping to the seventh rank. NSIC Rc418 and NSIC Rc478 both had a neutral preference score of -0.008, sharing the fourth rank. Meanwhile, NSIC Rc27 slightly improved its score to -0.031 but remained in the lower ranks, specifically sixth, still reflecting farmers' dissatisfaction with its agronomic traits. The preference scores and rankings indicated that NSIC Rc416 consistently met the farmers' expectations over both years, making it the most favored variety. Conversely, NSIC Rc27 consistently ranked low due to its less desirable traits. This analysis underscored the importance of characteristics such as yield, resistance to lodging and pests, and early maturity in determining farmer preferences. The participatory approach used in this study ensured that the selected rice varieties were aligned with the practical needs and preferences of the farmers, enhancing the likelihood of their adoption and success in rainfed lowland areas.

Table 2: Preference Scores and Ranking of Different Rainfed Rice Varieties

Varieties	2019 wet season		2020 wet season
	Preference Score (n=4)	Ranking	Preference Score (n=2)
NSIC Rc346	0.039	2	-0.063
NSIC Rc416	0.103	1	0.117
NSIC Rc418	0.011	3	-0.008
NSIC Rc478	-0.014	4	-0.008
NSIC Rc480	-0.045	5	0.016
NSIC Rc27 (chk)	-0.116	7	-0.031
IR64 (chk)	-0.052	6	0.016

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Agronomic Traits and Grain Yield Performance

The collection of agronomic characteristics of the varieties validated the performance of the different rainfed rice varieties in the farmers' fields. In the 2020 wet season, NSIC Rc27 had the shortest maturity of 103 days.

This was in line with Manigbas (2016), who emphasized the importance of breeding early maturing varieties as part of the government's climate-change mitigation efforts. NSIC Rc418 had the highest actual days to maturity at 111 days, showing significant differences from the other test varieties for rainfed lowland. This finding was consistent with Lalican et al. (2017), who reported that NSIC Rc418 is a medium-maturing variety that matures in 113 days after sowing (DAS). Similarly, during the 2019 wet season, NSIC Rc418 also had the longest days to mature among the varieties, although there were no significant differences.

Regarding plant height, the data from 2019 showed that NSIC Rc418 had the tallest height at 107 cm, with a significant difference from the other test varieties. However, no significant differences were observed in plant height during the 2020 wet cropping season. NSIC Rc416 had the highest mean tiller counts, with 15 counts for both 2019 and 2020, though statistically, there were no significant differences among the test varieties. Overall, NSIC Rc418 exhibited the longest maturity and tallest plant height, which were characteristics that farmers disliked during the preferential analysis.

Conversely, NSIC Rc27 and NSIC Rc416, which had the shortest duration of maturity and highest tiller counts, were preferred by farmers when selecting a variety.Grain yield is a major criterion in recommending an adaptable variety. The yield of the newly released rainfed rice varieties was generally higher than the check varieties, with at least a 0.5 to 1.0 ton per hectare difference, although there were no significant differences among the varieties in either cropping season.

Among the varieties tested, NSIC Rc416 and NSIC Rc480 (commonly known as GSR 8) had the highest grain mean yields, with 5,031.86 kg/ha and 5,012.45 kg/ha, respectively. They consistently out-yielded the two check varieties in both cropping seasons, with NSIC Rc27 and IR64 having the lowest grain yields among the test varieties.

In general, NSIC Rc416 and NSIC Rc418 had a yield advantage of 1.47 and 1.21 times over the check varieties NSIC Rc27 and IR64, respectively. This yield advantage, along with the preferred agronomic traits such as early maturity and higher tiller counts, made NSIC Rc416 a particularly favorable choice for farmers.

These results underscore the importance of integrating farmer preferences into the selection and recommendation of new rice varieties to enhance adoption and improve productivity in rainfed lowland areas.

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Table 3: Agronomic Traits and Yield Performance of Newly Released Rainfed Rice Varieties

Varieties	*2019 wet season*				*2020 wet season*				*Grain Mean Yield (kg/ha^{-1})*
	Maturity (DAS)	**Plant Height (cm)**	**Tiller Counts (hill^{-1})**	**Grain Yield (kg ha^{-1})**	**Maturity (DAS)**	**Plant Height (cm)**	**Tiller Counts (hill^{-1})**	**Grain Yield (kg ha^{-1})**	
NSIC Rc346	97	98.66^{ab}	13	4,026.05	104^{cd}	95.54	14	4,145.58	4,085.81
NSIC Rc416	101	92.19^{b}	15	4,775.75	109^{abc}	97.21	14	5,287.98	5,031.86
NSIC Rc418	102	106.89^{a}	14	4,271.30	111^{a}	98.33	11	4,787.65	4,529.47
NSIC Rc478	99	98.31^{ab}	14	4,052.41	110^{ab}	89.02	10	3,856.16	3,954.28
NSIC Rc480	98	96.73^{ab}	13	4,508.71	106^{bcd}	96.17	12	5,516.20	5,012.45
NSIC Rc27 (chk)	99	103.38^{ab}	12	4,228.22	103^{d}	81.90	13	4,061.19	4,144.70
IR 64 (chk)	97	93.14^{b}	13	3,434.03	104^{cd}	93.62	12	3,521.68	3,477.85
Cv (%)	*4.4*	*5.14*	*12.61*	*13.81*	*3.32*	*13.98*	*20.69*	*26.68*	-

Means with different letter superscript per column are significantly different at 0.01 level of significance.

The table presented agronomic traits and yield performance data for several newly released rainfed rice varieties, including two check varieties (NSIC Rc27 and IR 64), spanning two wet seasons (2019 and 2020). In the 2019 Wet Season, the maturity of the varieties ranged from 97 to 102 DAS. NSIC Rc416 had the longest maturity period (101 DAS), while NSIC Rc346 and IR 64 had the shortest (97 DAS). Significant differences were observed in plant height, with NSIC Rc418 being the tallest (106.89 cm), and NSIC Rc416 being the shortest (92.19 cm). Tiller counts per hill varied from 12 to 15, with NSIC Rc416 having the highest tiller count (15) and NSIC Rc27 the lowest (12). NSIC Rc416 also had the highest grain yield (4,775.75 kg ha-1), followed by NSIC Rc480 (4,508.71 kg ha-1), while the lowest yield was observed in IR 64 (3,434.03 kg ha-1).

In the 2020 Wet Season, maturity ranged from 103 to 111 DAS, with NSIC Rc418 maturing the latest (111 DAS) and NSIC Rc27 the shortest (103 DAS). Plant height varied significantly, with NSIC Rc418 remaining the tallest (98.33 cm) and NSIC Rc478 the shortest (89.02 cm). Tiller counts ranged from 10 to 14, with NSIC Rc416 again showing high tiller counts (14) and NSIC Rc478 the lowest (10). The highest grain yield was recorded for NSIC Rc480 (5,516.20 kg ha-1), followed closely by NSIC Rc416 (5,287.98 kg ha-1), while NSIC Rc478 had the lowest (3,856.16 kg ha-1).

Across both seasons, NSIC Rc416 exhibited the highest mean grain yield (5,031.86 kg ha-1), indicating consistent high performance. NSIC Rc480 also performed well, with a mean yield of 5,012.45 kg ha-1, while IR 64 had the lowest mean yield (3,477.85 kg ha-1). Statistical analysis showed significant differences among the varieties for traits like plant height, tiller counts, and grain yield.

In summary, NSIC Rc416 and NSIC Rc480 demonstrated the highest grain yields across both seasons, making them promising choices for rainfed rice cultivation. NSIC Rc418, while not the highest yielder, had the tallest plants and longest maturity periods, potentially advantageous in certain contexts. The check varieties, NSIC Rc27 and IR 64, had lower yields compared to

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the newly released varieties, highlighting potential improvements. This data analysis provides valuable insights for farmers and agronomists in selecting rice varieties based on specific agronomic traits and yield performance under rainfed conditions.

5. CONCLUSION

The study aimed to evaluate the performance and farmer preferences of various rainfed rice varieties over two wet cropping seasons (2019 and 2020). The results showed a clear preference among farmers for the variety NSIC Rc416 due to its favorable agronomic traits, including early maturation, high tillering capacity, resistance to lodging and pests, and high yield. NSIC Rc416 consistently ranked highest in both seasons, indicating its robustness and reliability under rainfed conditions. Other varieties like NSIC Rc480 also showed good performance, particularly in terms of grain yield.

In contrast, varieties such as NSIC Rc27 and IR64 were less favored due to their lower tillering ability, longer maturation periods, and susceptibility to pests and diseases. These varieties consistently ranked lower in farmer preference scores and demonstrated lower grain yields compared to the newly released varieties.

The agronomic data supported these preferences, with NSIC Rc416 showing the highest tiller counts and grain yields across both seasons. NSIC Rc418, although exhibiting the longest maturity and tallest plants, was less favored due to these traits. The study highlights the importance of integrating farmer preferences into the selection process for new rice varieties to ensure their successful adoption and improved productivity in rainfed lowland areas.

6. RECOMMENDATIONS

Promotion of NSIC Rc416: Given its consistent high performance and farmer preference, efforts should be made to promote the cultivation of NSIC Rc416 in rainfed lowland areas. Extension services and agricultural programs should focus on providing farmers with access to seeds and training on the best practices for growing this variety.

Further Evaluation of NSIC Rc480: While NSIC Rc480 performed well in terms of grain yield, it showed variable preference scores between the two seasons. Further evaluation and field trials should be conducted to better understand its performance under different conditions and to address any concerns that may have led to its lower preference in 2019.

Development of Early-Maturing Varieties: The study underscores the importance of early maturation as a key trait for rainfed rice varieties. Breeding programs should continue to focus on developing early-maturing varieties that can adapt to changing climatic conditions and mitigate the risks associated with delayed planting and shorter growing seasons.

Addressing Issues with Low-Performing Varieties: Varieties like NSIC Rc27 and IR64 should either be improved through breeding programs to address their weaknesses (e.g., low tillering ability, pest susceptibility) or gradually phased out in favor of more robust and preferred varieties like NSIC Rc416 and NSIC Rc480.

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Participatory Approach in Variety Selection: The study's participatory approach, involving farmers in the evaluation and selection process, proved effective in identifying varieties that meet practical needs and preferences. This approach should be continued and expanded to other regions and crop types to ensure that agricultural research and development are closely aligned with farmer requirements.

Continued Monitoring and Support: Continuous monitoring and support should be provided to farmers adopting these new varieties. This includes providing technical assistance, monitoring crop performance, and making adjustments as necessary to ensure the successful adoption and sustainability of the new varieties.

By following these recommendations, agricultural stakeholders can enhance the productivity and resilience of rainfed rice farming systems, ultimately improving food security and livelihoods for farmers in these areas.

Declaration of Interest Statement

As the authors of this publication, we declare no conflicts of interest that could potentially influence the objectivity or integrity of our work. Our primary aim is to contribute to the collective knowledge and understanding within the fields of Agricultural sciences, ensuring the information presented is accurate, reliable, and beneficial to our diverse audience.

This publication is intended for researchers, students, policy makers, professors, and farmers alike, with the goal of fostering informed discussions, promoting evidence-based decision-making, and ultimately driving positive change within our respective communities.

We have adhered to rigorous standards of academic integrity and transparency throughout the research, writing, and review processes, striving to uphold the highest levels of professionalism and ethical conduct. Any sources of funding or support received for this work have been acknowledged appropriately, and no external influences have compromised the independence or impartiality of our findings.

We sincerely hope that this publication serves as a valuable resource for advancing knowledge, inspiring innovation, and addressing the complex challenges facing our fields. Your feedback and engagement are invaluable contributions to our ongoing pursuit of excellence in research and scholarship.

Thank you for your interest in our work.

Sincerely,

Dr. Irene M. Adion,

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