Jurnal Agronomi Indonesia
(Indonesian Journal of Agronomy)

ISSN 2085-2916 | e-ISSN 2337-3652
August 2024, *52*(2), 176-186
DOI: https://dx.doi.org/10.24831/jai.v52i2.54078

Research Article

Optimizing cultivation system and pest management in different types of rice varieties

Ricky Andryan [1], Ahmad Junaedi [2,*], Purwono [2], Lilik Budi Prasetyo [3], and Arinal Haq Izzawati Nurrahma [4]

[1] Agronomy and Horticulture Study Program, Graduate School of IPB University, Jl Meranti Kampus IPB Dramaga, Bogor 16680, INDONESIA
[2] Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Jl Meranti Kampus IPB Dramaga, Bogor 16680, INDONESIA
[3] Department of Forest Resources Conservation and Ecotourism, Faculty of Forestry and Environment, IPB University, Jl Meranti Kampus IPB Dramaga, Bogor 16680, INDONESIA
[4] Research Center for Food Crops, National Research and Innovation Agency (BRIN), Jl Raya Bogor Km 46, Cibinong, Bogor 16911, INDONESIA
* Corresponding author (✉ junaedi_agr@apps.ipb.ac.id)

ABSTRACT

Improving rice productivity and efficiency is the main goal of cultivation techniques to meet the demand for rice production. The aim of this research was to evaluate the suitability of rice varieties in cultivation systems, namely: organic cultivation + biological pest management (BPM), inorganic cultivation + BPM, and conventional cultivation. Different types of rice varieties, namely New Superior Varieties (NSV: INPARI-30, INPARI-32), New Plant Type (NPT: IPB-3S), and Superior Varieties from West Sumatra (Batang Piaman, Anak Daro), may exhibit differences in agronomic performance across various cultivation systems. This research was conducted at the Sawah Baru Babakan Experimental Farm, IPB University, Dramaga Bogor, using a factorial nested design with 4 replications. The results based on yield per hill and plot showed that Batang Piaman and INPARI-30 varieties were suitable for all organic + BPM, inorganic + BPM, and conventional cultivational systems. The INPARI-32 and IPB-3S varieties were more suitable for conventional cultivation and inorganic + BPM; while the Anak Daro variety was better in organic cultivation + BPM. Utilizing varieties with different characteristics for better yield performance could be considered with obtaining the suitability of the cultivation system, whether organic + BPM, inorganic + BPM, or conventional.

Keywords: Chemical pest control; conventional cultivation; organic cultivation; integrated pest management

Edited by:
Maryati Sari
IPB University

Received:
25 February 2024
Accepted:
19 August 2024
Published online:
27 August 2024

Citation:
Andryan, R., Junaedi, A., Purwono, Prasetyo, L. B., & Nurrahma, A. H. I. (2024). Optimizing cultivation system and pest management in different rice type varieties. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*, *52*(2), 176-186

INTRODUCTION

Rice is considered one of the crop commodities serving as a priority and strategic food source, as it constitutes a staple in the Indonesian diet. Rice cultivation holds the highest rank among other food crops, such as corn and soybeans. Rice not only serves as the staple food for Indonesians but also acts as a source of employment and income for farmers, contributing significantly to the nation's economy (Abidin et al., 2019). Rice is consumed as a source of energy and nutrition, accounting for up to 95%, and contributes 32% to caloric needs. Therefore, the availability of rice must be continuously maintained and enhanced in tandem with the increasing population.

In 2020, Indonesia harvested rice from an area of 10.66 million hectares, but in 2021, there was a 2.30% decline, with the harvested area decreasing to 10.41 million hectares

(BPS, 2022). As a result, there was a slight decline of 0.45% in total rice production from 31.50 million tons in 2020 to 31.36 million tons in 2021 (BPS, 2022). To enhance rice yields, the use of new plant type varieties (NPT) and high-performing Superior Varieties from West Sumatra is encouraged. New rice varieties are genetically improved, and superior local varieties are known for their aromatic qualities, high economic value, and adaptability to various conditions (Wahyuti et al., 2013).

Crop management is the most crucial stage in rice cultivation, including activities such as fertilization and plant protection. In Indonesia, the majority of farmers practice conventional agriculture by using inorganic fertilizers and pesticides (chemical pest control). This is indicated by the relatively low total area of organic farming in Indonesia, amounting to only 0.6 percent (208,042 ha) in 2017 (FiBL & IFOAM, 2019). The use of chemicals in this system is intensive, involving the application of chemical fertilizers, pesticides, and herbicides to enhance rice production (Maulana & Ariningsih, 2018). This stands in contrast to the changing lifestyle of the population, which is increasingly inclined towards consuming healthy rice, driven by growing awareness of health, environmental, safety, and food quality issues (Estuningtyas et al., 2014). One of the cultivation systems that produce healthy rice is organic cultivation. This highlights the need for compatibility between organic and conventional cultivation systems of rice varieties. The objective of this study was to evaluate the suitability of various rice varieties in different cultivation systems, namely: organic cultivation, conventional cultivation with chemical pest control, and inorganic cultivation with integrated pest management.

MATERIALS AND METHODS

Research location

This research was conducted at the Sawah Baru Babakan Experimental Farm, Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University. The study was carried out from July to December 2022.

Research design

The experimental design used a factorial nested design. The main plot consisted of three cultivation systems, namely organic cultivation + Biological Pest Management (BPM), inorganic cultivation + BPM, and conventional cultivation (inorganic + chemical pest control). The subplots consisted of rice varieties, including New Superior Varieties (NSV: INPARI-30, INPARI-32), New Plant Type (NPT: IPB-3S), and Superior Varieties from West Sumatra (Batang Piaman, Anak Daro). The experimental units measured 10.5 m × 7 m. Replications in this experiment were nested within the main plot. The treatments were replicated four times, resulting in a total of 60 experimental units. The organic cultivation system + BPM and the inorganic cultivation system + BPM both use biological pesticides, while the difference between the two is the use of organic fertilizer for the organic cultivation system and inorganic fertilizer for the inorganic cultivation system. Conventional cultivation systems include the use of inorganic fertilizers and pesticides.

The soil preparation used a hand tractor for plowing, leveling, and furrowing. Basic fertilizer applications included cow manure at a dosage of 5 tons ha^{-1} and dolomite at a dosage of 500 kg ha^{-1}. The application of cow manure and dolomite was carried out simultaneously for all experimental units 7-14 days before planting (soil preparation). Seeds were soaked in water for 12 hours, and any floating seeds were discarded. Subsequently, the seeds undergo immersion in a mixture of plant growth promoting rhizobacteria (PGPR, *Rhizobium* sp., *Bacilllus polymixa*, *Pseudomonas flouurescens*) at a dosage of 10 g L^{-1} for 12 hours. The soaked seeds were then incubated for 1×24 hours until germination occurred (radicula emerged). The germinated seeds were planted in prepared seedbeds and covered with a net.

The planting distance of 30 cm × 15 cm was marked using *caplak*, a traditional tool for marking straight rows in rice planting (Sugandi et al., 2018) with a 6:1 "legowo row" planting system. In a planting hole, two seedlings were planted (per hill). Maintenance included: (1) Fertilizer application was conducted in two stages, at 1 and 5 weeks after transplanting (WAT). Stage 1 fertilization involved cow manure at a dosage of 5 tons ha^{-1} for organic cultivation + BPM, and inorganic fertilizer (N 150 kg ha^{-1}, P_2O_5 150 kg ha^{-1}, and K_2O 100 kg ha^{-1}) for inorganic + BPM, and conventional cultivations. Stage 2 fertilization included additional cow manure at a dosage of 5 tons ha^{-1} for organic cultivation + BPM and N fertilizer at a rate of 150 kg for inorganic + BPM and conventional cultivations; (2) Replanting for dead or less vigorous plants around 7-14 days after transplanting (DAT); (3) Weed control was carried out manually before second fertilizer application; (4) Pest and disease prevention involved the use of biological pesticides (macro and microelements, antagonistic bacteria and actinomycetes, dose 5 g L^{-1}, spray volume 200 L ha^{-1}, 3 sprayings) for organic and inorganic + BPM cultivation, while chemical pest control (deltamethrin, dose 2 mL L^{-1}, spray volume 200 L ha^{-1}, 3 sprayings) for conventional cultivation. Bird protection was implemented through transparent net installation. Harvesting was done when the plants had shown mature harvest criteria, characterized by 90% of the grains turning yellow, and the optimal age of the panicle was around 30 days from the day after flowering (DAF).

Observation variables included morphological characteristics such as plant height and the number of tillers. Physiological traits consisted of Photosynthetic rate was observed at 9 WAT, leaf greenness (measured using SPAD) was at 7 WAT, and Relative Growth Rate (g per week) with the formula:

$$LTR = \frac{\ln(W_2) - \ln(W_{1)}}{(T_2 - T_1)}$$

Note: ln W1 = lan from dry weight 7 WAT, ln W2 = lan of dry weight 9 WAT, T1 = observation time 7 WAT, T2 = observation time 9 WAT.

Generative and yield-related traits included the percentage of productive tillers, flowering time, number of panicles, weight of 1,000 grains, harvest index, number of filled grains, number of unfilled grains, percentage of filled grains, grain weight per panicle, and yield.

Data analysis

The obtained data were subjected to analysis of variance at a significance level of α 5%. If the analysis of variance showed a significant effect, further testing was conducted using the honestly significant difference (HSD) test at a significance level of α=5%. Data was prepared using Microsoft Excel 2013 (Microsoft Corporation, Redmond, WA, USA) and Statistical Tool for Agricultural Research (STAR IRRI version 2.0.1 International Rice Research Institute, Los Baños, Philippines).

RESULTS AND DISCUSSION

Morphological characters

Cultivation systems and varieties as a single factor showed a significant influence on morphological characteristics of plant height and tiller number, whereas the interaction was not significant on these variables. Among the examined varieties, IPB 3S demonstrated the tallest stature, while INPARI 30 exhibited the lowest plant height (Table 1). IPB 3S, despite its height advantage, showed a lower tiller number compared to the other four varieties, with Anak Daro being the variety with the highest tiller number (Table 1). Each variety generally exhibits distinct growth responses in both plant height and tiller number due to unique morphological descriptions and characteristics associated with each variety. Consistent with the findings of Herdiyanti et al. (2015), IPB 3S stands out for its tall stature but produces a lower tiller number. This trait aligns with the classification of IPB 3S as a New Plant Type (NPT), known for its relatively fewer tillers compared to NSV and Superior Varieties from West Sumatra.

Table 1. Plant height and number of tillers at 7 WAT of different rice varieties and cultivation systems.

Treatment	Plant height (cm)	Number of tillers per hill
Varieties		
Anak Daro	91.29b	22.2a
Batang Piaman	88.11b	21.7a
INPARI 30	81.92c	20.3a
INPARI 32	82.34c	19.6a
IPB 3S	105.36a	13.0b
Cultivation systems		
Conventional	93.80a	19.6b
Inorganic + BPM	89.55ab	21.3a
Organic + BPM	86.07b	17.2c

Note: Values followed by different letters within the same column and factor are significantly different based on the honestly significant difference (HSD) test at α=5%. WAT = weeks after transplanting.

Conventional cultivation systems showed the highest values for the plant height variable and are significantly different from organic cultivation (Table 1). The inorganic cultivation system had the most significant number of tillers, followed by conventional and organic cultivation systems (Table 1). Organic fertilizers could not completely replace the use of chemical fertilizers in both inorganic and conventional cultivation. Arianti et al. (2022) noted that organic fertilizer alone does not increase plant height and number of tillers significantly. Allamah et al. (2018) recommended integrating organic and chemical fertilizers to increase the number of tillers. Moreover, she stated that the increase in the number of seedlings as a result of this integration is due to the availability of sufficient nutrients that can be absorbed by plants, apart from that the influence of microelements from organic fertilizer helps the growth process optimally and effectively.

Physiological characters

The interaction between cultivation systems and varieties had a significant impact on physiological characteristics, specifically the Relative Growth Rate (RGR) (Table 2). In the condition of the inorganic cultivation system, there was no significant difference among varieties at both 7 to 9 WAT and 9 to 14 WAT, except for INPARI 30 which showed the lowest RGR at 9-14 WAT. In the conventional cultivation system, Batang Piaman exhibited as the best performance, showing the highest RGR at both 7 to 9 WAT and 9 to 14 WAT compared to other varieties. In the organic cultivation system, Anak Daro is the best variety at 7 to 9 WAT, while IPB 3S emerges as the best variety at 9 to 14 WAT (Table 2). A high RGR at the early growth stage indicates a relationship between source and sink related to the increased source capacity that can fulfill the sink's needs, thus influencing grain yield.

The variety treatment significantly influenced other physiological characteristics, namely photosynthetic rate and leaf greenness, while the cultivation system did not exhibit any significant effect on these physiological traits (Table 3). Table 3 shows that IPB 3S demonstrated the highest photosynthetic rate, whereas Anak Daro exhibits the lowest rate among the compared varieties. This is likely attributed to the upright leaf morphology of IPB 3S, which facilitates better light penetration and distribution evenly to the lower parts, supporting an optimized photosynthetic process (Herdiyanti et al., 2015).

The INPARI 32 variety had the highest leaf greenness, but it was not significantly different from the IPB 3S, INPARI 30 varieties while the Anak Daro variety had the lowest leaf greenness (Table 3). These differences could be due to variations in leaf characteristics among varieties, indicating differences in leaf greenness values. SPAD values are influenced by several factors, including consistent genetic (variety) traits, plant age, leaf thickness (Yang et al., 2014; Barutcular et al., 2015), and the adequacy of nitrogen nutrients (Singh et al., 2020). The SPAD meter readings can range from 25 to 44 (Singh et al., 2020). Imanishi et al. (2010) revealed that SPAD values are associated with the potential to initiate photosynthetic rates and plant biomass.

Table 2. Relative Growth Rate (RGR) in the interaction of cultivation systems and rice varieties.

Cultivation systems	Variety	RGR (g per week)	
		7-9 WAT	9-14 WAT
Conventional	Anak Daro	0.425ab	1.024b
	Batang Piaman	0.555a	1.047a
	INPARI 30	0.450 ab	1.023b
	INPARI 32	0.383b	1.034ab
	IPB 3S	0.375b	1.020b
Inorganic + BPM	Anak Daro	0.475a	1.049a
	Batang Piaman	0.502a	1.049a
	INPARI 30	0.445 ab	1.032b
	INPARI 32	0.530a	1.045a
	IPB 3S	0.403ab	1.043a
Organic + BPM	Anak Daro	0.535a	1.030b
	Batang Piaman	0.413ab	1.011c
	INPARI 30	0.495ab	1.017bc
	INPARI 32	0.418ab	1.020bc
	IPB 3S	0.365b	1.039a

Note: Values with different letters in the same column are significantly different based on the honestly significant difference (HSD) test at α=5%. WAT = weeks after transplanting.

Table 3. Photosynthetic rate and leaf greenness of each rice variety.

Variety	Photosynthetic rate at 9 WAT ($\mu mol\ CO_2 m^{-2} s^{-1}$)	Leaf greenness at 7 WAT (SPAD value)
Anak Daro	28.92c	35.12c
Batang Piaman	33.73ab	37.82b
INPARI 30	30.34bc	38.69ab
INPARI 32	31.46abc	40.11a
IPB 3S	34.30a	39.50ab

Note: Values with different letters in the same column are significantly different based on the honestly significant difference (HSD) test at α=5%. WAT = weeks after transplanting, SPAD = Soil Plant Analyses Development.

Generative and yield traits

The interaction between cultivation systems and varieties influenced generative traits, specifically the percentage of productive tillers and flowering time (data not shown). In the condition of the inorganic cultivation system, Batang Piaman and IPB 3S stood out as the best varieties, exhibiting the highest percentage of productive tillers (Table 4). In the conventional cultivation system, Anak Daro had the lowest percentage of productive tillers compared to the other four varieties, although the difference was not different statistically. In the organic cultivation system, Batang Piaman emerged as the best variety, demonstrating the highest percentage of productive tillers, surpassing INPARI 32 (Table 4).

Anak Daro exhibited the longest flowering time compared to other varieties across all three cultivation system conditions (Table 4). This suggests that the Anak Daro variety undergoes a more extended vegetative stage. Conversely, the IPB 3S consistently had the shortest flowering time across all three cultivation system conditions compared to other varieties. This indicates that, under all cultivation systems, IPB 3S was characterized by early flowering (Table 4). In the field, varieties with longer time to flower produce more tillers, but the most late tillering failed to produce seed. According to Wangiyana et al. (2009), rice tillers that produce late panicles potentially will not produce fully filled grains, meaning that they are potentially to produce unfilled grains. In addition, this phenomenon is related to the length of time for grain filling.

Table 4. Percentage of productive tillers and day of flowering in the interaction of cultivation system an rice varieties.

Cultivation system	Variety	Productive tillers (%)	Days to flowering (days)
Conventional	Anak Daro	78.87b	79.0a
	Batang Piaman	95.16a	71.5b
	INPARI 30	91.14a	72.3b
	INPARI 32	92.55a	67.0c
	IPB 3S	90.39a	65.8d
Inorganic + BPM	Anak Daro	84.81b	77.8a
	Batang Piaman	92.53a	71.5b
	INPARI 30	86.21ab	71.3b
	INPARI 32	88.64ab	68.3c
	IPB 3S	91.63a	65.8d
Organic + BPM	Anak Daro	87.63ab	77.3a
	Batang Piaman	93.76a	69.8c
	INPARI 30	88.71ab	72.3b
	INPARI 32	83.45b	63.5d
	IPB 3S	89.83ab	62.8d

Note: Different letters in the same column indicate a significant difference based on the honestly significant difference (HSD) test at α=5%.

Varietal treatments significantly influence yield-related traits, including the number of panicles and the weight of 1,000 grains (Data not shown), but the cultivation system did not significantly affect these variables. Among the varieties, Batang Piaman had the highest number of panicles (22.77), while the IPB 3S (11.48) had fewer panicles compared to other varieties. Batang Piaman also had the highest weight of 1,000 grains 28.75 g), while Anak Daro (22.83 g) had the lowest weight of 1,000 grains compared to other varieties. The weight of 1,000 grains was influenced not only by genetic factors and the description of each variety but also by other variables, including grain weight per panicle and the percentage of productive tillers. Consistent with previous research (Satria et al., 2017; Marliani et al., 2019) it is stated that the weight of 1,000 grains of a variety is significantly influenced by the percentage of productive tillers, grain weight per panicle, and plant height.

The interaction between the cultivation system and varieties significantly influences yield characteristics, including the number of filled grains, the number of unfilled grains, and the harvest index (Table 5). However, this interaction did not have a significant impact on the percentage of filled grains. Across the three cultivation system conditions, the variety Anak Daro consistently exhibited the highest average number of filled grains, while the variety IPB 3S consistently had the lowest, compared to other varieties (Table 5). This indicates that the increase in the number of filled grains is due to the formation of the number of tillers and a high percentage of productive tillers. The number of grains per panicle is a variable with moderate heritability, indicating that genetic influence is moderately significant compared to environmental factors (Pasaribu et al., 2013).

In the conventional cultivation system, the Anak Daro and INPARI 30 varieties had the highest number of unfilled grains (Table 5). Anak Daro, IPB 3S, and INPARI 32 varieties had the highest number of unfilled grains in the inorganic cultivation system. In the organic cultivation system, the Anak Daro variety had the highest number of unfilled grains. It is probable that Anak Daro had a limited nutrient supply, which resulted in high unfilled grains in the organic cultivation system. Grain filling is determined by the balance between source and sink in rice plants (Okamura et al., 2018). Consistent with the results of the study by Maisura et al. (2015), it was revealed that several limiting factors, such as narrow, thin, flat, fast-aging leaves, and short-lived, cause low assimilate production, resulting in a high potential for unfilled grains.

Table 5. Number of filled grains, number of unfilled grains, percentage of filled grains, and harvest index in the interaction of cultivation system and rice varieties.

Cultivation system	Variety	Number of filled grains per hill	Number of unfilled grains per hill	Filled grains (%) per hill	Harvest index
Conventional	Anak Daro	2,164.2a	857.9a	71.39	0.30b
	Batang Piaman	1,650.4b	537.4b	75.48	0.49a
	INPARI 30	1,561.8b	617.6ab	72.12	0.45ab
	INPARI 32	1,300.3bc	414.6b	75.74	0.46ab
	IPB 3S	1,131.2c	504.8b	69.81	0.43ab
Inorganic + BPM	Anak Daro	2,419.5a	887.4a	73.75	0.25b
	Batang Piaman	1,830.6b	544.3b	77.18	0.52a
	INPARI 30	1,824.6b	553.2b	76.97	0.50a
	INPARI 32	1,891.4b	645.5ab	74.46	0.45ab
	IPB 3S	1,531.0b	660.6ab	69.49	0.50a
Organic + BPM	Anak Daro	2,778.0a	1,057.4a	72.28	0.49a
	B. Piaman	1,838.0b	448.5b	80.39	0.58a
	INPARI 30	1,694.4b	484.5b	77.84	0.56a
	INPARI 32	1,317.1c	360.1c	78.61	0.49a
	IPB 3S	1,322.4c	625.6b	68.07	0.45ab

Note: Numbers followed by different letters in the column are considered significantly different based on the honestly significant difference (HSD) test at α=5%.

In the present study, Batang Piaman variety under three cultivation system conditions, is the best variety with the highest average harvest index, while the Anak Daro variety has the lowest harvest index value, except for IPB 3S which showed the lowest harvest index in the organic cultivation system (Table 5). The increase in the harvest index is influenced by the balance of assimilated yield between the weight of the grains produced and the dry weight of the canopy and roots.

The interaction between cultivation system and variety significantly affected grain weight per hill (Table 6). Under the conventional cultivation system, Batang Piaman variety was found to be the best variety with the highest grain weight per hill. In the condition of the inorganic cultivation system, the best variety was Batang Piaman although it was not significantly different grain weight per hill to INPARI 32, INPARI 30, and IPB 3S. While in the condition of organic cultivation system, Batang Piaman variety is obtained as the best variety with the highest grain weight per hill, but not significantly different from Anak Daro variety (Table 6).

Table 6. Grain weight (g) per hill in the interaction of cultivation systems and rice varieties.

Variety	Grain weight per hill (g)		
	Conventional	Inorganic + BPM	Organic + BPM
Anak Daro	43.35c	48.85b	53.20ab
Batang Piaman	57.15a	64.75a	61.00a
INPARI 30	50.65b	54.00ab	50.20b
INPARI 32	45.55b	55.35ab	42.30c
IPB 3S	44.85b	53.30ab	43.50c

Note: Different letters indicate significant differences based on the honestly significant difference (HSD) test at a 5% significance level.

Based on the yield estimation of grain weight per hill, it shows that under the conventional cultivation system, the best variety was Batang Piaman variety with the highest yield of milled grain (Figure 1A). Under the inorganic cultivation system + BPM, the Batang Piaman was also the best variety with the highest yield of milled grain, but it was not significantly different from INPARI 30, INPARI 32, and IPB 3S varieties. Under the organic + BPM cultivation system, the Batang Piaman also as the best variety with the highest yield of milled grain, but it was not significantly different to Anak Daro.

Based on the yield estimation results from tile sampling (called *ubinan*), Batang Piaman had a similar position among varieties in different cultivation systems (Figure 1B). It means that Batang Piaman become suitable varieties in different cultivation technology.

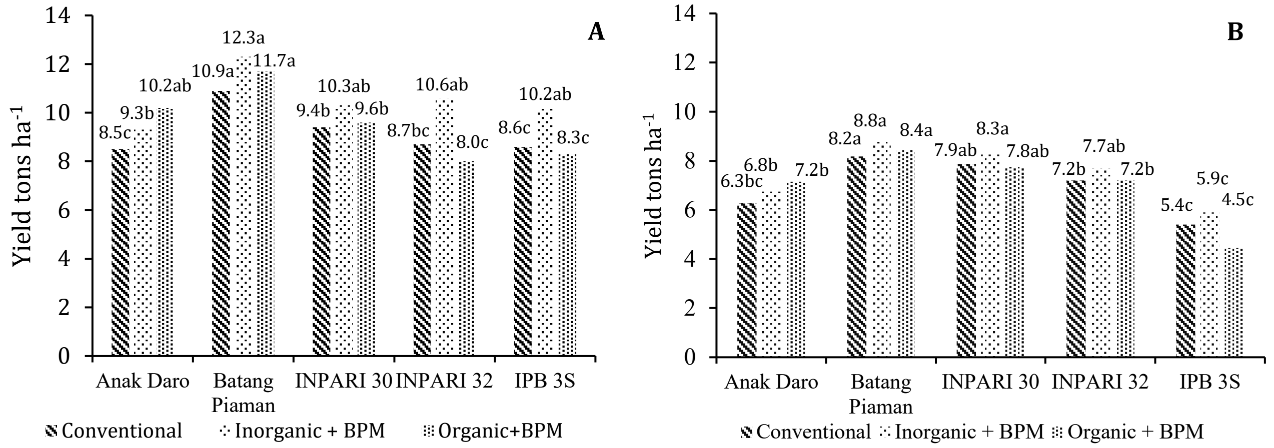

Figure 1. Yield estimation of different rice varieties in different cultivation systems. A) Yield estimation based on grain weight per hill; B) Yield estimation based on tile sampling (ubinan).

The lower yield of the IPB 3S variety is suspected to be due to the low number of tillers and panicles (Table 4). Varieties IPB 3S and INPARI 32 belong to the New plant Type variety and New Superior Variety (NSV), which is highly responsive to fertilization, resulting in high yields in the inorganic + BPM cultivation system. Local varieties, including Batang Piaman, Anak Daro, and NSV: INPARI 30, exhibit adaptive characteristics to various cultivation systems, whether conventional, inorganic + BPM, or organic + BPM. However, in this study, the Anak Daro variety is more suitable for the organic + BPM cultivation system. Local varieties are generally not responsive to fertilization application and already adaptive to local agrosystems. In line with the study by Mulyawati et al. (2021), local varieties are chosen for their ability to adapt well to various ecosystems and biotic and abiotic stresses in the local area.

Each variety showed different responses in the three cultivation systems based on the observed variables. This indicated the importance of genetic factors in rice cultivation. In rice, environmental conditions also influence plant growth (Efendi et al., 2012). This is in line with Safrida et al. (2019), who revealed that environmental conditions vary from one place to another, and plants' need for special environmental conditions can result in diversity in plant growth. In the present study, different varieties show variations in response to different cultivation systems. The main characteristics of the influence of variety, growing location, and season affect growth, yield, and yield components including plant height, leaf length, number of shoots per plant, number of tubers, average tuber weight, total yield, and marketable yield per hectares recorded from shallots (Yeshiwas et al., 2023).

It is important to note that, in terms of rice yield, conventional farming still has a greater yield than organic farming in most varieties except Anak Daro as presented in Figure 1. Organic farming is a kind of regenerative farming, that is believed as best model for climate-smart agriculture. It is interesting to study in the future why Anak Daro performed better rice yield under organic farming than conventional farming. Organic matter is a viable long-term option for improving soil quality (Leskovar & Othman 2018). Furthermore, Reganold and Wachter (2016) revealed that organic farming outperforms conventional farming in many ecological, social, and economic dimensions, although according to de Ponti et al. (2012), the harvest yield is lower compared to conventional farming. In line with the research results of Seufert et al. (2012), organic farming yields are lower than conventional farming, ranging from 5% to 35%, depending on the crop type and agroecological conditions. There is a need for the integration of organic and conventional fertilizers to support plant growth and productivity. Optimal integration of organic and inorganic fertilizer levels can enhance sustainable plant growth and productivity (Mahmood et al., 2017). Sugiyanta et al. (2008), revealed that the use of 7.5 tons of straw fertilizer ha^{-1} was able to reduce the use of inorganic fertilizers by up to 50% (125 kg urea ha^{-1}, 50 kg SP-36 ha^{-1}, 50 kg KCl ha^{-1}).

CONCLUSIONS

Batang Piaman and INPARI-30 varieties were suitable for organic + BPM, inorganic + BPM, and conventional cultivational systems. The INPARI-32 and IPB-3S varieties were more suitable for conventional cultivational and inorganic + BPM; while the Anak Daro variety was better suited for organic cultivation+ BPM. Utilizing varieties with different characteristics for better yield performance could be considered by obtaining the suitability of the cultivation system, whether organic + BPM, inorganic + BPM, or conventional.

ACKNOWLEDGEMENTS

The authors express gratitude to the Ministry of Finance of the Republic of Indonesia for the LPDP Scholarship for the first author, and "Digital Food Ecosystem" PT Telkomsel for the research funding support.

REFERENCES

Abidin, Z., Leksono, A. S., Yanuwiadi, B., & Purnomo, M. (2019). The model of organic paddy farming practices by revitalization of the values of local wisdom in Malang Regency. *IOP Conference Series: Earth and Environmental Science*, *239*, 012040. https://doi.org/10.1088/1755-1315/239/1/012040

Allamah, A., Hapsoh, H., Wawan, W., & Dini, I. R. (2018). The growth and yield of rice (*Oryza sativa* L.) with organic and inorganic fertilizer application by cellulolytic microbes in peat. *Indonesian Journal Agricultural Research*, *1*(3), 295-306. https://doi.org/10.32734/injar.v1i3.472

Arianti, F. D., Pertiwi, M. D., Triastono, J., Purwaningsih, H., Minarsih, S., Kristamtini, Hindarwati, Y., Jauhari, S., Sahara, D., & Nurwahyuni, E. (2022). Study of organic fertilizers and rice varieties on rice production and methane emissions in nutrient-poor irrigated rice fields. *Sustainability*, *14*(10), 5919. https://doi.org/10.3390/su14105919

Barutcular, C., Toptas, I., Turkten, H., Yildirim, M., & Koc, M. (2015). SPAD greenness to estimate genotypic variation in flag leaf chlorophyll in spring wheat under mediterranean conditions. *Turkish Journal Field Crops*, *20*(1), 1-8.

BPS. (2022). *Paddy Harvested Area and Production in Indonesia 2021*. BPS-Statistics Indonesia. https://www.bps.go.id/en/publication/2022/04/19/5f540b7c91aa100a775f397c/executive-summary-of-paddy-harvested-area-and-production-in-indonesia-2021.html

de Ponti, T., Rijk, B., & van Ittersum, M. K. (2012). The crop yield gap between organic and conventional agriculture. *Agricultural Systems*, *108*, 1-9. https://doi.org/10.1016/j.agsy.2011.12.004

Efendi, Halimursyadah, & Simajuntak H. R. (2012). The response of local acehnese germplasm of rice to growth and production in aerobic conditions. (In Indonesian.). *Jurnal Agrista*, *16*(3), 114-121.

Estuningtyas, D. E., Izzati, M., & Purnaweni, H. (2014). Program analysis and implementation of rice organic farming system in Semarang Regency. *Waste Technology*, *1*(2), 1-5.

FiBL, & IFOAM. (2019). *The World of Organic Agriculture on Public Support.* FiBL (Forschungsinstitut für Biologischen Landbau); IFOAM (International Organic Agriculture Movement).

Herdiyanti, T., Sugiyanta, & Aswidinnoor, H. (2015). Response of three rice varieties to combination of fertilizers with straw incoporation system. (In Indonesian.). *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*, *43*(3), 179. https://doi.org/10.24831/jai.v43i3.11242

Imanishi, J., Nakayama, A., Suzuki, Y., Imanishi, A., Ueda, N., Morimoto, Y., & Yoneda, M. (2010). Nondestructive determination of leaf chlorophyll content in two flowering cherries using reflectance and absorptance spectra. *Landscape and Ecological Engineering*, *6*, 219-234. https://doi.org/10.1007/s11355-009-0101-8

Leskovar, D., & Othman, Y. A. (2018). Organic and conventional farming differentially influenced soil respiration, physiology, growth, and head quality of artichoke cultivars. *Journal of Soil Science Plant Nutrition*, *18*(3), 865-880. https://doi.org/10.4067/S0718-95162018005002502

Mahmood, F., Khan, I., Ashraf, U., Shahzad, T., Hussain, S., Shahid, M., Abis, M., & Ullah, S. (2017). Effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties. *Journal of soil Science plant Nutrition*, *17*(1), 22-32. https://doi.org/10.4067/S0718-95162017005000002

Maisura, Chozin, A. M, Lubis, I., Junaedi, A., & Ehara, H. (2015). Rate of assimilation total and relative growth of drought tolerant rice on paddy system. (In Indonesian.). *Jurnal Agrium*, *12*(1), 10-15.

Marliani, L., Sumadi, & Nurmala, T. (2019). Growth, yield, and lodging intensity responses of rice cv IPB 3S on biofertilizer and nano-silica application. (In Indonesian.). *Jurnal Kultivasi*, *18*(2), 845-850.

Maulana, M., & Ariningsih, E. (2018). Comparing social costs of the conventional rice production system and system of rice intensification: a case study of Indonesia. *International Journal of Environment and Sustainable*, *7*(1), 10-29.

Mulyawati, R., Parjanto, & Yunus, A. (2021). Yield of the mutant (M6) short stem of mentik wangi rice varieties resulting from gamma-ray irradiation 300 gray. *Journal of Biodiversity and Biotechnology*, *1*(2), 72-79.

Okamura, M., Arai-Sanoh, Y., Yoshida, H., Mukouyama, T., Adachi, S., Yabe, S., Nakagawa, H., Tsutsumi, K., Taniguchi, Y., Kobayashi, N., & Kondo, M. (2018). Characterization of high-yielding rice cultivars with different grain-filling properties to clarify limiting factors for improving grain yield. *Field Crops Research*, 219, 139-147. https://doi.org/10.1016/j.fcr.2018.01.035

Pasaribu, A., Kardhinata, E. H., & Bangun, M. K. (2013). Test of several varieties of irrigated lowland rice (*Oryza sativa* L.) and application of potassium fertilizer (KCl) to increase production and lodging resistance. (In Indonesian.). *Jurnal Online Agroekoteknologi*, *1*(2), 45-57.

Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. *Nature Plants*, *2*(15221). https://doi.org/10.1038/NPLANTS.2015.221

Safrida, Ariska, N., & Yusrizal. (2019). Response of several local rice varieties (*Oryza sativa* L.) to palm oil ash amelioration on peatlands. (In Indonesian.). *Jurnal Agrotek Lestari*, *5*(1), 28-38. https://doi.org/10.35308/jal.v5i1.1964

Satria, B., Harahap, E. M., & Jamilah. (2017). The increased productivity of paddy (*Oryza sativa* L.) by application of some distance planting and cropping system. (In Indonesian.). *Jurnal Agroekoteknologi Fakultas Pertanian USU*, *5*(3), 629-637.

Seufert, V., Ramankutty, N., & Foley, J. A. (2012). Comparing the yields of organic and conventional agriculture. *Nature*, *485*, 229-232. https://doi.org/10.1038/nature11069

Singh, S., Mohanty, D. S., Sahu, M., Bhaskar, N., & Verma, B. (2020). Evaluation of SPAD meter values for estimating rice nitrogen status. *International Journal of Chemical Studies*, *8*(4), 1-5. https://doi.org/10.22271/chemi.2020.v8.i4a.9947

Sugandi, W. K., Maulida, D., & Zaida. (2018). Application of appropriate technology (Ttg) for rice planting line-making tools in Cipunagara District, Subang Regency. (In Indonesian.). *Jurnal Pengabdian Kepada Masyarakat*, *2*(2), 154-159.

Sugiyanta, Rumawas, F., Chozin. M. A., Mugnisyah, W. Q., & Ghulamahdi, M. (2008). Absorption of N, P and K, and yield of five lowland rice cultivars (*Oryza sativa* L.) under inorganic and organic fertilization. (In Indonesian.). *Jurnal Agronomy Indonesia (Indonesian Journal of Agronomy)*, *36*(3), 196-203.

Wahyuti, T. B., Purwoko, B. S., Junaedi, A., Sugiyanta, & Abdullah, B. (2013)Correlation of leaf characteristics and yield of various types of rice cultivars. (In Indonesian.). *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)*, *41*(3), 181-187.

Wangiyana, Laiwan, Z., & Sanisah. (2009). Growth and yield of rice under "SRI (system of rice intensification)" technique at various ages and numbers of seedlings per hill. (In Indonesian.). *Crop Agronomy, Scientific Journal of Agronomy*, *2*(1), 70-78.

Yang, H., Yang, J., Lv, Y., & He, J. (2014). SPAD values and nitrogen nutrition index for the evaluation of rice nitrogen status. *Plant Production Science*, *17*(1), 81-92. https://doi.org/10.1626/pps.17.81

Yeshiwas, Y., Temsegen, Z., Wubie, M., & Wagnew, T. (2023). Effects of varieties and different environments on growth and yield performance of shallot (*Allium cepa* var. *aggregatum*). *International Journal of Agronomy*, *2023,* 1-12. https://doi.org/10.1155/2023/3276547