Vol. 14, No. 3, pp. 651-662, August 2026 DOI: https://doi.org/10.23960/jat.v14i3.11588

Jurnal Agrotek Tropika

P-ISSN: 2337-4993
E-ISSN: 2620-3138

Journal homepage: https://jurnal.fp.unila.ac.id/index.php/JA

GROWTH AND YIELD RESPONSE OF THREE VARIETIES OF RICE (Oryza sativa L.) TO SUPERBOKASHI MA-11 ORGANIC FERTILIZATION

RESPON PERTUMBUHAN DAN HASIL TIGA VARIETAS PADI (*Oryza sativa* L.) AKIBAT PEMUPUKAN ORGANIK SUPERBOKASHI MA-11

Ajang Maruapey[1]*, Selvia Tarukliling[2], and Hanny Hidayati Nafi'ah[3]

[1]Faculty of Agriculture, Muhammadiyah University of Sorong (UNAMIN), Indonesia
[2]St. Thomas Aquinas College of Agricultural Sciences, Jayapura, Indonesia
[3]Faculty of Agriculture, Garut University, Indonesia
* Corresponding Author. E-mail address: ajangmarpy@gmail.com

ARTICLE HISTORY:

Received: 30 August 2025
Peer Review: 26 January 2026
Accepted: 24 July 2026

KEYWORDS:

Organic fertilizer, rice varieties, superbokashi MA-11, Sorong

ABSTRACT

This study was designed to examine the growth responses and yield performance of three rice varieties under different dosage levels of the organic fertilizer Superbokashi MA-11. The experiment utilized a two-factor factorial Randomized Block Design (RBD). The first factor consisted of rice varieties, namely Ciherang (V1), Situ Bagendit (V2), and Inpari 13 (V3), while the second factor was the level of organic fertilizer dosage Superbokashi MA-11, including 0 tons ha^{-1} (P0), 8 tons ha^{-1} (P1), and 16 tons ha^{-1} (P2). A significant interaction between variety and fertilizer dosage was observed only for the number of productive tillers, with Inpari 13 reaching its optimum at 8 tons ha^{-1}, averaging 22.67 tillers. In contrast, no significant interaction was observed in plant height, number of filled grains, 1000-grain weight, or harvested grain yield. Individually, Inpari 13 demonstrated the best performance with a production yield of 5.87 tons ha^{-1}, which was statistically comparable to Situ Bagendit (5.53 tons ha^{-1}), but significantly higher than Ciherang (4.86 tons ha^{-1}). Increasing the fertilizer dosage up to 16 tons ha^{-1} was proven to enhance the 1000-grain weight to 27.44 g and produce the highest grain yield of 6.11 tons ha^{-1}. This study concludes that integrating the Inpari 13 or Situ Bagendit varieties with the application of Superbokashi MA-11 at a dosage of 16 tons ha^{-1} is a strategic approach to improve rice productivity.

KATA KUNCI:

Pupuk organik, superbokashi MA-11, Sorong, varietas padi

ABSTRAK

Penelitian ini dirancang untuk mengkaji respons pertumbuhan serta capaian hasil dari tiga varietas padi terhadap berbagai level dosis pupuk organik Superbokashi MA-11. Eksperimen ini menggunakan dua faktor perlakuan dalam Rancangan Acak Kelompok (RAK). Faktor pertama mencakup pemilihan varietas padi, yakni Ciherang (V1), Situ Bagendit (V2), dan Inpari 13 (V3), sementara faktor kedua adalah level dosis pupuk organik Superbokashi MA-11 yang meliputi 0 ton ha^{-1} (P0), 8 ton ha^{-1} (P1), serta 16 ton ha^{-1} (P2). Temuan riset mengungkapkan adanya interaksi signifikan antara jenis varietas dan dosis pupuk hanya pada parameter jumlah anakan produktif, di mana Inpari 13 menunjukkan titik optimal pada dosis 8 ton ha^{-1} dengan rerata 22,67 anakan. Sebaliknya, tidak terdeteksi interaksi nyata pada variabel tinggi tanaman, jumlah gabah berisi, bobot 1000 butir, maupun produktivitas gabah panen. Secara individu, Inpari 13 mencatatkan performa paling unggul dengan hasil produksi 5,87 ton ha^{-1}, angka yang secara statistik setara dengan Situ Bagendit (5,53 ton ha^{-1}), namun mengungguli Ciherang (4,86 ton ha^{-1}) secara nyata. Eskalasi dosis pupuk hingga 16 ton ha^{-1} terbukti mampu mendongkrak bobot 1000 butir menjadi 27,44 g dan menghasilkan produksi gabah tertinggi sebesar 6,11 ton ha^{-1}. Studi ini menyimpulkan bahwa integrasi varietas Inpari 13 atau Situ Bagendit dengan aplikasi Superbokashi MA-11 pada dosis 16 ton ha^{-1} menjadi langkah strategis dalam meningkatkan produktivitas padi.

1. INTRODUCTION

As a strategic commodity, rice (Oryza sativa L.) plays a central role in maintaining food security stability in Indonesia. The availability and affordability of rice for the public are crucial indicators of national food sovereignty (Dama *et al*. 2025; Mamun *et al*. 2024). The Central Statistics Agency (2026) reported that in 2025, national rice production reached 60.21 million tons of dry milled rice, obtained from a total harvest area of 11.32 million hectares. Although this figure indicates a 13.29% increase in production compared to the previous period (Ministry of Agriculture, 2026),Maintaining the momentum of sustainable production remains a major challenge in agricultural development today.

Ideally, accelerating rice productivity should be in line with the implementation of environmentally friendly cultivation systems. Amiroh *et al*. (2021) emphasize that the success of environmentally friendly rice cultivation depends heavily on two main factors: a cultivation strategy that includes precise plant nutrient management and the use of superior varieties that adapt to land dynamics.However, the reality in Sorong Regency shows that there is a serious problem related to the degradation of soil fertility due to massive dependence on subsidized chemical fertilizers (Maruapey *et al*. 2025). The practice of intensive inorganic fertilization without being balanced with organic input causes a decline in soil quality, both in terms of physical, chemical, and biological aspects (Marbun *et al*. 2024), which in turn threatens the sustainability of future harvests (Kambu *et al*. 2024). Therefore, the integration of organic materials is an urgent solution to restore land health while building farmer independence in procuring independent production facilities.

Current land restoration strategies are shifting toward utilizing local biomass, particularly livestock waste (Guo, 2022). Despite its potential, traditional composting methods are often hampered by slow decomposition processes, making them inefficient (Ningsih & Yanuarita, 2022). The innovative Super Bokashi technology, incorporating Microbacter Alfafa-11 (MA-11) activator, offers a solution that accelerates the fermentation phase, taking just seven days (BPP Grogol, 2022). The presence of functional microorganisms in MA-11 optimizes the availability of N and P elements and stimulates the activity of Rhizobium sp., which plays a vital role in nitrogen fixation and the secretion of plant growth regulators (Ahmadi *et al*. 2022; Herlika *et al*. 2020). However, the effectiveness of nutrient absorption from this rapid decomposition process is greatly influenced by differences in the morphophysiological characteristics and root systems of each rice variety.

Although the effectiveness of MA-11 has been reported on certain varieties such as Mekongga and Inpari10 (Wardana *et al*. 2024; Maruapey & Asbur, 2025), However, in Sorong Regency, Southwest Papua, rice productivity is still fluctuating and inconsistent (BPTP West Papua, 2019). The phenomenon of fluctuations in rice yields in Sorong Regency reflects the limited information regarding the extent to which the Ciherang variety Situ Bagendit, and Inpari 13 are able to respond to nutrient mineralization from organic fertilizer on marginal land. To date, comprehensive studies on genotype-environment interactions in response to MA-11 technology in Southwest Papua are still very limited. Yet, identifying synergies between genetic potential and organic fertilizer dosage is crucial for the successful formulation of efficient and site-specific technology packages.

The urgency of this research lies in providing alternative cultivation technologies for farmers amidst the uncertainty of subsidized fertilizer distribution. The primary focus of this research is to analyze the growth response and yield components of the Ciherang, Situ Bagendit, and Inpari 13 varieties treated with Super Bokashi MA-11. Through this approach, it is hoped that recommendations can be formulated regarding the optimal dosage of organic fertilizer and the selection of the most adaptive varieties to ensure stable rice production, especially for farmers in Klaru Village, Mariat District.

2. MATERIALS AND METHODS

2.1 Time and Place

This research was conducted in Klaru Village, Mariat District, Sorong Regency, Southwest Papua, in the period August–November 2024. The research location is located at an altitude of ±31 m above sea level with geographical coordinates of 1°01'45.8"S and 131°18'47.2"E.

2.2 Materials and Tools

The materials used are rice seeds from the National Innovation Research Agency (BRIN) of the Ciherang, Situ Bagendit, and Inpari 13 varieties. The organic fertilizer used is Superokashi MA-11 which is produced independently with raw materials: cow dung (carbon source), rice bran (energy source), rice husk charcoal (microbial media), and molasses as a catalyst. The fermentation process uses the bio-activator Microbacter Alfaafa-11 (MA-11). The tools used include a hand tractor, hoe, tarpaulin, scales, handsprayer, and a documentation camera.

2.3 Research Design

This study was designed using a 3 × 3 factorial RAK with three replications. The rice variety factors consisted of Ciherang, Situ Bagendit, and Inpari 13, while the Superbokashi MA-11 organic fertilizer dose factor included 0 ton ha^{-1} (control), 8 ton ha^{-1} (5 kg/plot), and 16 ton ha^{-1} (10 kg/plot). There were 9 treatment combinations, repeated three times, resulting in a total of 27 experimental units with a plot size of 2.5 × 2.5 m.

2.4 Research Implementation

This series of research activities began with the production of Super Bokashi MA-11 organic fertilizer through anaerobic fermentation. The raw materials used included 50 kg of mature cow dung, 1 kg of rice bran, and 5 pieces of charcoal husk, all mixed homogeneously. The mixture was then inoculated with an activator solution consisting of 3 bottle caps of MA-11, 3 tablespoons of sugar, and 3 liters of water until the humidity level reached 30–40%, then fermented for seven days. (BPP Grogol, 2022).Simultaneously with the fertilizer decomposition process, the research area was prepared by tilling the soil to create an optimal mud structure. The research area was then divided into several 2.5 m x 2.5 m plots, with a 50 cm spacing between plots to facilitate drainage and ease mobility during field observations. Meanwhile, the rice seeds were pre-selected using a salt solution before being sown in trays for 21 days until they reached the planting stage.

The Super Bokashi MA-11 organic fertilizer was applied one week before the seedling transfer to the field. The fertilizer was spread evenly and incorporated into the topsoil layer according to the target doses of 0, 8, and 16 tons ha^{-1}. This strategy aims to allow time for the functional microbes in MA-11 to initiate optimal nutrient mineralization before being absorbed by the plant. Seedlings that had reached 21 days after sowing were planted using a tile system with a spacing of 25 cm × 25 cm between plants, with 2–3 seedlings per planting hole. Plant maintenance management was carried out intensively, including replanting activities limited to 7 days after planting (DAP), manual weeding, and water management through an intermittent irrigation system. Control of plant pests was carried out based on Integrated Pest Management (IPM) principles to maintain growth integrity. The research activity concluded with harvesting when the plants reached physiological maturity, which was visually indicated by 90–95% of the panicles having turned yellow. In order to maintain the validity of the data from the influence of the border effect, plant sampling was only carried out in the tiled area in the middle of each experimental plot.

2.5 Observation Variable

Plant growth characteristics were evaluated at 60 days after planting (DAP). Measured parameters included plant height (cm), recorded from the stem base to the tip of the highest panicle, and the number of productive tillers per clump, determined by counting the functional panicles. Data on yield components and production variables were collected at physiological maturity, defined as the stage when 90–95% of the panicles had turned yellow. These components included the number of grains per panicle, calculated by summing the filled and unfilled grains in each sample. Additionally, the 1000-grain weight (g) was determined at 95 DAP using a precision analytical balance. Final crop productivity was calculated based on the harvested dry grain (GKP) weight in tons ha^{-1}, extrapolated from the sampling plot yields. To standardize the data for post-harvest analysis, final grain weights were recorded after the grains were dried to a constant moisture content of 14%.

2.6 Data Analysis

Field observation data is first tabulated systematically using Microsoft Excel..To test the significance of the influence of variety factors, organic fertilizer dosage, and the interaction between the two, the data were then processed through a two-way analysis of variance (ANOVA). If the results of the statistical test indicate a significant influence on the observed parameters, further testing was carried out using the Least Significant Difference (LSD) method. This mean comparison procedure was applied at a 95% confidence level (= 0.05) to identify significant differences between the tested treatments.

3. RESULTS AND DISCUSSION

3.1 Variation Analysis

A two-way analysis of variance (ANOVA) revealed that both rice variety (V) and the dose of Superbokashi MA-11 organic fertilizer (P) significantly affected (P < 0.05) all measured growth parameters and yield components (Table 1). This indicates that the genetic characteristics of the varieties and the nutrient availability from the organic inputs acted as independent, primary determinants of rice performance on marginal lands in Sorong Regency. The consistent positive response observed across variables, ranging from plant height to per-hectare productivity, underscores the crucial role of microbially derived nutrients in supporting optimal plant metabolism.

However, a significant interaction between variety and fertilizer dose (V × P) was observed exclusively for the number of productive tillers. In contrast, no significant interaction (*ns*) was detected for plant height, number of filled grains, 1000-grain weight, or total production. This implies that the response of each genotype to increasing organic fertilizer doses was uniform across the majority of yield components. The exception observed for productive tillers suggests that a plant's capacity to produce functional panicles relies heavily on the synergy between its specific genetic potential and the nutrients released through MA-11 mineralization during the active vegetative phase.

3.2 Growth Variables

3.2.1 Plant Height (cm)

The two-way analysis of variance showed that both variety and the dose of Superbokashi MA-11 organic fertilizer significantly influenced plant height, although there was no significant interaction between the two factors (Table 2). This indicates a consistent response across varieties to increasing fertilizer doses, demonstrating that stem elongation is determined independently by intrinsic genetic factors and nutrient availability. Physiologically, this vegetative expression is governed by the genetic constitution regulating cell division in the apical meristem in response to external conditions (Fukai & Mitchell, 2025). Consequently, fertilizer application stimulated growth across all genotypes without altering their relative height hierarchy.

As shown in Table 2, the Inpari 13 (118.74 cm) and Situ Bagendit (114.94 cm) varieties did not differ significantly in plant height. However, both were significantly taller than the Ciherang variety, which reached only 97.60 cm. These performance variations reflect inherent genetic differences in the regulation of cell division and elongation during the vegetative phase. A genotype's genetic constitution plays a central role in determining its environmental adaptation capacity and nutrient absorption efficiency (Sakran *et al*. 2025). Varieties with stronger vertical growth potential tend to exhibit dominant vegetative performance, functioning as a physiological strategy to compete for sunlight.

In addition to the genotype factor, the application of Superbokashi MA-11 organic fertilizer significantly increased rice plant height. A significant increase was observed at a dose of 8 tons ha^{-1} (113.39 cm) compared to the control. However, increasing the dose further to 16 tons ha^{-1} (116.99 cm) did not yield a statistically significant difference from the 8 tons ha^{-1} treatment. This indicates that the 8 tons ha^{-1} dose is the optimum rate for improving the physical, chemical, and biological properties of the soil to support vertical plant growth. The incorporation of organic matter increases the soil's cation exchange capacity (CEC) and stimulates microbial activity, which in turn accelerates the mineralization of essential nutrients (Brady & Weil, 2016). Furthermore, the functional microbial consortium in MA-11 is crucial for decomposing organic material, facilitating a slow and sustained release of nutrients over an extended period. This stable nutrient availability supports key physiological processes, particularly protein synthesis and endogenous hormone activity, which trigger stem elongation (Adzigbe *et al*. 2025). Thus, applying Superbokashi MA-11 is an effective strategy for enhancing vegetative growth by improving soil ecosystem health and nutrient utilization efficiency.

Table 1.Summary of the results of the analysis of variance regarding the effect of varieties and levels of organic fertilizer doses on the growth performance and productivity of rice plants.

Sources of Diversity	Plant Height (cm)	Productive Tillers (tillers/clump)	Full Grain (Grain/Panicle)	Weight of 1000 Grains (g)	Production (ton ha^{-1})
Variety (V)	*	*	*	*	*
Fertilizer Dosage (P)	*	*	*	*	*
V × P	ns	*	ns	ns	ns

Note: ns (non-significant) indicates no real effect; * indicates a real effect at the 5% test level (P < 0.05).

Table 2. Independent Effect of Variety and Fertilizer Dose on Plant Height (Cm)

Treatment Factors	Plant Height (Cm)	LSD 5%
Variety (V)		
V1 = Ciherang	97.60	b
V2 = Situ Bagendit	114.94	a
V3 = Inpari 13	118.74	a
Fertilizer Dosage (P)		
P0 = 0 tons ha^{-1}	100.90	b
P1 = 8 tons ha^{-1}	113.39	a
P2 = 16 tons ha^{-1}	116.99	a
LSD 5%	5.48	

Note: Numbers with the same letters in the column indicate no significant difference according to the 5% LSD test.

Table 3. Interaction of Variety x Fertilizer Dose on the Number of Productive Tillers per Clump

Variety (V)	Number of Productive Tillers per Clump		
	Fertilizer Dosage (P)		
	P1 = 0 tons ha^{-1}	P1= 8 tons ha^{-1}	P2 = 16 tons ha^{-1}
V1 = Ciherang	12.45 ax	14.60 bx	16.67 cx
V2 = Situ Bagendit	14.33 ay	17.67 by	19.67 cy
V3 = Sister 13	15.00 az	22.67bz	22.29 bz
LSD 5%	2.38		

Note: Numbers followed by the same letter in the same row (a, b, c) or the same column (x, y, z) indicate no significant difference based on the 5% BNT test.

3.2.2 Number of Productive Tillers per Clump

The analysis of variance revealed a significant interaction between rice variety and the dose of Superbokashi MA-11 organic fertilizer on the number of productive tillers (Table 3). This indicates that functional tiller formation is not solely governed by independent genetic or nutritional factors, but rather by their synergy. Specifically, the highest number of productive tillers was observed in the Inpari 13 variety treated with 8 tons ha^{-1} (22.67 tillers), which was statistically equivalent to the 16 tons ha^{-1} treatment for the same variety (22.29 tillers). This suggests that 8 tons ha^{-1} is the optimal dose for Inpari 13 to stimulate functional tiller formation. Conversely, the lowest number of productive tillers was recorded in the unfertilized Ciherang control (12.45 tillers). These differential responses reflect variations in metabolic efficiency among varieties in utilizing nutrients derived from MA-11 decomposition to initiate lateral shoots. Inpari 13 reached nutrient saturation at a lower dose compared to Situ Bagendit and Ciherang, which exhibited a linear increase up to the maximum dose. This confirms that Inpari 13 possesses genetic traits that are highly responsive to improved soil fertility. Such variation is closely linked to the plant's internal mechanisms for triggering new shoots from the basal meristem (Zhang *et al*., 2025).

Agronomically, tiller number is a vital yield component because each tiller has the potential to develop into a productive panicle. During the early vegetative phase, plants are highly sensitive to nutrient availability particularly nitrogen, which plays a crucial role in stimulating cell division in meristematic tissues (Yoshida, 1981). The application of Superbokashi MA-11 has been shown to effectively improve the cation exchange capacity (CEC) and stimulate soil microbial activity, thereby increasing the availability of macronutrients (N, P, K) for vegetative growth (Brady & Weil, 2016). Furthermore, the improved soil structure resulting from the incorporation of organic matter supports root system expansion (Arianti *et al*. 2022). An extensive and healthy root system allows for enhanced nutrient absorption to meet the metabolic demands of shoot formation (Adzigbe *et al*. 2025). This interaction emphasizes that yield optimization is highly dependent on the synchronization between a variety's genetic potential and the environmental nutrient supply. Utilizing responsive genotypes, such as Inpari 13, combined with an appropriate dose of organic fertilizer, is a key strategy for maximizing the vegetative performance of rice plants.

3.3. Outcome Variables

3.3.1 Number of Filled Grains (Grains/panicles)

The analysis of variance revealed that both variety and the dose of Superbokashi MA-11 organic fertilizer significantly influenced the number of filled grains per panicle. However, no significant interaction was found between the two factors (Table 4). This indicates that a plant's capacity to produce filled grains is independently controlled by its intrinsic genetic potential and the availability of soil nutrients derived from the organic fertilizer. Consequently, the interpretation of this parameter focuses on the main effect of each factor separately.

Table 4. Independent Effect of Variety and Dose on the Number of Filled Grains (Grains/panicle)

Treatment Factors	Number of grains (grains/panicle)	LSD 5%
Variety (V)		
V1 = Ciherang	170.54	b
V2 = Situ Bagendit	192.13	a
V3 = Inpari 13	198.88	a
Fertilizer Dosage (P)		
P0 = 0 tons ha^{-1}	172.41	b
P1 = 8 tons ha^{-1}	193.57	a
P2 = 16 tons ha^{-1}	195.57	a
LSD 5%	9.50	

Note: Numbers with the same letters in the column indicate no significant difference according to the 5% LSD test.

As shown in Table 4, the Inpari 13 (198.88 grains/panicle) and Situ Bagendit (192.13 grains/panicle) varieties did not differ significantly in their number of filled grains, but both produced significantly more filled grains than the Ciherang variety (170.54 grains/panicle). This performance reflects genetic variation among varieties in spikelet formation capacity and grain-filling efficiency during the generative phase. Varieties with stronger genetic potential are generally supported by a larger flag leaf area and a higher photosynthetic rate, enabling the optimal translocation of assimilates to the reproductive organs (Sakran *et al.*, 2025).

In addition to the genotype effect, the application of Superbokashi MA-11 organic fertilizer significantly increased the number of filled grains. A significant increase was observed at a dose of 8 tons ha^{-1} compared to the control. However, increasing the dose further to 16 tons ha^{-1} did not yield a statistically significant difference from the 8 tons ha^{-1} treatment. This indicates that a dose of 8 tons ha^{-1} is highly effective at improving soil fertility and supplying essential nutrients during the critical phases of panicle formation and grain filling.

The incorporation of organic matter from Superbokashi MA-11 plays a crucial role in increasing the cation exchange capacity (CEC) and stimulating soil microbial activity, which ultimately supports nutrient mineralization (Chang *et al.*, 2026). A stable supply of macronutrients, particularly nitrogen, phosphorus, and potassium, is a primary determinant of grain-filling quality. Nitrogen is vital for maintaining persistent photosynthetic rates, while phosphorus and potassium contribute to energy (ATP) metabolism and the efficient translocation of assimilates from the source to the panicle (sink) (Putra *et al.*, 2024). The absence of significant interaction in this parameter indicates that all tested varieties responded uniformly positively to soil improvement through organic intervention. This confirms that the increase in full grain yield is the result of the combination of the varieties' genetic potential and the optimization of the growing environment. Therefore, integrating the use of superior varieties such as Inpari 13 with an organic fertilizer dose of 8 tons ha^{-1} is a highly promising strategy for increasing rice yield components.

3.3.2 Weight of 1000 Grains (g)

The genotype of the variety and the application of Superbokashi MA-11 organic fertilizer significantly influenced the 1,000-grain weight parameter. However, no significant interaction was found between the two treatment factors (Table 5). This finding indicates that grain weight is independently controlled by the intrinsic genetic capacity of each variety and the availability of nutrients from organic fertilizer in the soil. Therefore, interpretation of the 1,000-grain weight parameter will focus on the main effect of each factor separately.

The data in Table 5 shows that the Inpari 13 variety recorded the highest 1,000-grain weight (26.68 g), statistically outperforming Ciherang (25.18 g), but yielding results equivalent to Situ Bagendit (25.88 g). Variation in grain weight between varieties is closely related to genetic characteristics that regulate grain dimension, morphology, and density. Genotypes with genetic advantages tend to have a stronger physiological capacity to accumulate photosynthetic products into reproductive organs during the crucial phase of grain filling (Sakran *et al*. 2025).

1000-grain weight is a yield component parameter that reflects grain size and density, where its value is highly dependent on the efficiency of photosynthate translocation from the flag leaf. During the generative phase, assimilates are massively transported to form starch reserves in the endosperm. Varieties with better photosynthetic efficiency and assimilates mobilization ability will produce fuller and heavier grains (Peng *et al*. 2021). In addition to genetic factors, the application of Superbokashi MA-11 organic fertilizer has been shown to significantly increase 1000-grain weight. Unlike the previous growth parameters, for this variable, the application of a dose of 16 tons ha^{-1} resulted in a significant increase (27.44 g) compared to the dose of 8 tons ha^{-1} and the control. This indicates that the grain filling process requires more intensive nutritional support than the vegetative phase. The role of organic matter through MA-11 in improving the physical, chemical, and biological structure of the soil is crucial in maintaining the stability of the availability of macro and micro nutrients until the end of the plant life cycle (Zhang *et al*. 2024; Liu *et al*. 2026).

Nutrient availability, particularly nitrogen, phosphorus, and potassium, plays a vital role in grain filling metabolism. Nitrogen maintains leaf chlorophyll levels to keep them green longer (stay-green), phosphorus is involved in ATP energy transfer, while potassium plays a role in regulating cell turgor and facilitating sugar transport from the stem to the panicle (Putra *et al*. 2024). The absence of significant interactions indicates that all varieties responded uniformly positively to organic interventions to increase grain weight. Integrating the use of potential varieties with organic fertilizer support up to a dose of 16 tons ha-1 has proven effective in optimizing grain filling quality and rice yield components.

Table 5. Independent Effect of Variety and Fertilizer Dose on the Weight of 1000 Grains of Grain (g)

Treatment Factors	Weight of 1000 Grains of Paddy (g)	LSD 5%
Variety (V)		
V1 = Ciherang	25.18	b
V2 = Situ Bagendit	25.88	ab
V3 = Inpari 13	26.68	a
Fertilizer Dosage (P)		
P0 = 0 tons ha^{-1}	25.46	c
P1 = 8 tons ha^{-1}	25.65	b
P2 = 16 tons ha^{-1}	27.44	a
LSD 5%	0.86	

Note: Numbers with the same letters in the column indicate no significant difference according to the 5% LSD test.

Table 6. Independent Effect of Variety and Fertilizer Dose on Dry Grain Yield (ton ha^{-1})

Treatment Factors	Harvested Grain Yield (ton ha^{-1})	LSD 5%
Variety (V)		
V1 = Ciherang	4.86	b
V2 = Situ Bagendit	5.53	a
V3 = Inpari 13	5.87	a
Fertilizer Dosage (P)		
P0 = 0 tons ha^{-1}	4.77	b
P1 = 8 tons ha^{-1}	5.38	a
P2 = 16 tons ha^{-1}	6.11	a
LSD 5%	0.63	

Note: Numbers with the same letters in the column indicate no significant difference according to the 5% LSD test.

3.3.3 Harvested Dry Grain Production (ton ha^{-1})

The analysis of variance revealed that both variety and the application of Superbokashi MA-11 organic fertilizer significantly influenced harvested grain productivity (tons ha^{-1}). However, no significant interaction was observed between the two factors (Table 6). This indicates that grain yield is independently controlled by a variety's intrinsic genetic capacity and the availability of nutrients from organic inputs. Consequently, the interpretation of these production parameters focuses on the main effects of each factor separately.

As shown in Table 6, variety selection is a crucial factor in optimizing the effectiveness of organic inputs in the field. The Inpari 13 (5.87 tons ha^{-1}) and Situ Bagendit (5.53 tons ha^{-1}) varieties exhibited statistically equivalent yield potentials, and both produced significantly higher yields than the Ciherang variety (4.86 tons ha^{-1}). This difference in productivity stems from the specific characteristics of each genotype: Inpari 13 possesses an early-maturing trait that is highly responsive to nutrient uptake, whereas Situ Bagendit demonstrates robust adaptability to dynamic field conditions. This phenomenon aligns with the findings of Sakran *et al*. (2025), who noted that genetically superior varieties exhibit higher physiological efficiency in exploiting environmental resources, enabling them to produce greater biomass and grain yields in organic farming systems.

Agronomically, grain production is the cumulative result of various interacting yield components, including the productive tiller population, the density of filled grains per panicle, and 1000-grain weight. This productivity depends heavily on the plant's capacity to optimize photosynthesis and assimilate translocation from source organs (leaves) to sink organs (grains) during the grain-filling phase (Peng *et al*., 2021).

In addition to the varietal effect, the application of Superbokashi MA-11 organic fertilizer significantly increased production. In this study, increasing the dose to 16 tons ha^{-1} resulted in the highest productivity (6.11 tons ha^{-1}), significantly exceeding both the 8 tons ha^{-1} dose and the control. This indicates that achieving maximum yields on a large scale requires adequate organic nutrient support to improve soil structure and stimulate microbial activity (Zhang *et al*. 2024). The yield of 5.87 tons ha^{-1} achieved by Inpari 13 demonstrates the consistent effectiveness of MA-11, although variations exist when compared to previous reports, such as that by Wardana *et al*. (2024), who recorded 6.94 tons ha^{-1} for the Mekongga variety. This difference is likely driven by the interaction between the specific genetic potential of each variety and the microclimatic conditions of the research site.

The application of organic fertilizer increases the utilization efficiency of essential nutrients (N, P, and K), which are vital for both the vegetative and generative phases (Putra *et al*., 2024). Organic-based cultivation has been proven to boost rice productivity through sustainable soil fertility restoration (Wihardjaka *et al*., 2020) while improving long-term soil quality in Indonesian rice fields (Kasno *et al*., 2022). The absence of a significant interaction for this parameter indicates that the response to increased grain yield was relatively uniform across all tested varieties. Therefore, integrating responsive varieties such as Inpari 13 with an application of 16 tons ha^{-1} of Superbokashi MA-11 organic fertilizer is an effective strategy for increasing rice productivity in a sustainable and environmentally friendly manner.

4. CONCLUSION

This study concludes that the Inpari 13 variety demonstrated superior agronomic performance, yielding 5.87 tons ha^{-1}. This yield was statistically equivalent to that of Situ Bagendit but significantly higher than that of Ciherang. The application of Superbokashi MA-11 organic fertilizer was crucial for stimulating growth and yield. While a dose of 8 tons ha^{-1} was sufficient to optimize plant height and the number of filled grains, achieving the maximum productivity of 6.11

tons ha^{-1} required increasing the dose to 16 tons ha^{-1}. A significant interaction between genotype and fertilizer dose was observed exclusively for the number of productive tillers. Notably, Inpari 13 reached a nutrient saturation point earlier at a dose of 8 tons ha^{-1}, whereas the other parameters exhibited a uniform, linear response across all three varieties. To enhance food security in Sorong Regency, we recommend cultivating the Inpari 13 variety combined with an application of 16 tons ha^{-1} of Superbokashi MA-11 organic fertilizer. Furthermore, farmers should be encouraged to independently produce organic fertilizers utilizing local biomass.

5. ACKNOWLEDGMENT

The authors express their sincere gratitude to the Faculty of Agriculture, Muhammadiyah University of Sorong, for the research facilities provided, and to their colleagues in the Agrotechnology Study Program for the scientific discussions. We extend our deepest appreciation to the National Research and Innovation Agency (BRIN) for providing seeds of the Inpari 13, Situ Bagendit, and Ciherang varieties. We also extend our appreciation to the Sidodadi Farmers Group and the extension workers in Mariat District for their technical assistance in the field. We sincerely hope that this study on the effectiveness of Super Bokashi MA-11 will encourage the advancement of organic farming in Southwest Papua.

6. REFFERENCES

Adzigbe, J., Frimpong, F., Danquah, A., Danquah, E. Y., Asante, I. K., Abebrese, S. O., Asante, M. D. (2025). The responses and adaptations of rice (*Oryza sativa* L.) to drought stress: A review. *Climate Smart Agriculture*, *1*, Article 100080.

Ahmadi, R., Nashruddin, M., & Parmi, H. J. (2022). Pemanfaatan kotoran sapi dengan dekomposer Microbacter Alfaafa-11 sebagai bahan pupuk organik [Utilization of cow dung with Microbacter Alfaafa-11 decomposer as organic fertilizer]. *Jurnal Masyarakat Mandiri (JMM)*, *6*(6), 4506–4514.

Amiroh, A., Azis, M. A., & Istiqomah, I. (2021). Pengaruh kombinasi macam varietas dan pupuk kimia majemuk terhadap pertumbuhan dan hasil padi (*Oryza sativa* L.) pada penanaman sistem jajar legowo [The effect of a combination of varieties and compound chemical fertilizers on the growth and yield of rice (*Oryza sativa* L.) in the legowo row planting system]. *AGRORADIX: Jurnal Ilmu Pertanian*, *5*(1), 11–18.

Arianti, F. D., Pertiwi, M. D., Triastono, J., Purwaningsih, H., Minarsih, S., Kristamtini, ... 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), Article 5919.

Badan Pusat Statistik. (2026, February 2). *Luas panen padi pada tahun 2025 mencapai sekitar 11,32 juta hektare dengan produksi padi sebanyak 60,21 juta ton gabah kering giling (GKG) (Berita Resmi Statistik No. 16/02/Th. XXIX)* [The rice harvest area in 2025 reached approximately 11.32 million hectares with rice production of 60.21 million tons of dry milled grain (GKG) (Official Statistics News No. 16/02/Th. XXIX)]. https://www.bps.go.id/id/pressrelease/2026/02/02/2545/luas-panen-padi-pada-tahun-2025-mencapai-sekitar-11-32-juta-hektare-dengan-produksi-padi-sebanyak-60-21-juta-ton-gabah-kering-giling--gkg-.html

BPP Grogol. (2022, October 16). *Tutorial pembuatan pupuk super bokashi menggunakan MA-11* [Tutorial on making super bokashi fertilizer using MA-11] [Video]. YouTube. https://www.youtube.com/watch?v=t_ULgCl5uMY

BPTP Papua Barat. (2019). Adaptasi varietas unggul baru dan umur semai terhadap produktivitas padi sawah tadah hujan bukaan baru [Adaptation of new superior varieties and seedling age to the productivity of newly opened rainfed lowland rice fields]. *Jurnal Pertanian Agros*, *21*(2), 243–254.

Brady, N. C., & Weil, R. R. (2016). *The nature and properties of soils* (15th ed.). Pearson.

Chang, Y., Zhang, X., Shu, Q., Sun, Z., Yang, M., Liu, X., Wang, T. (2026). Effects of fertilization measures on soil fertility and crop yields in drylands of the North China Plain: A meta-analysis. *Frontiers in Plant Science*, *17*, Article 1768991.

Dama, T. B. P., Olilingo, F. Z., & Akib, F. H. Y. (2025). Pengaruh produksi lokal dan non lokal terhadap ketersediaan beras di Provinsi Gorontalo [The influence of local and non-local production on rice availability in Gorontalo Province]. *Jurnal Akuntansi, Manajemen dan Ilmu Ekonomi (Jasmien)*, *5*(3), 111–122.

Fukai, S., & Mitchell, J. (2025). Genotypic adaptation to soil water deficit in rice: A comparison of desirable traits for aerobic production and lowland drought resistance. *Crop and Environment, 4*(1), 23–37.

Guo, Z., Lv, L., Liu, D., He, X., Wang, W., Feng, Y., Islam, M., Wang, Q., Chen, W., Liu, Z., Wu, S., & Abied, A. (2022). A global meta-analysis of animal manure application and soil microbial ecology based on random control treatments. *PLoS ONE, 17*, Article e0262139.

Herlika, S. R., & Mual, C. D. (2020). Pengaruh formula pupuk organik padat berbasis *Microbacter Alfaafa*-11 (MA-11) terhadap pertumbuhan tanaman padi (*Oryza sativa* L.) di Kampung Prafi Mulya Distrik Prafi Kabupaten Manokwari [The effect of solid organic fertilizer formula based on *Microbacter Alfaafa*-11 (MA-11) on the growth of rice plants (*Oryza sativa* L.) in Prafi Mulya Village, Prafi District, Manokwari Regency]. *Prosiding Seminar Nasional Pembangunan dan Pendidikan Vokasi Pertanian, 1*(1), 204–213.

Kambu, D., Soekamto, M. H., Ohorella, Z., & Maruapey, A. (2024). Kajian inovasi teknologi pengelolaan tanaman terpadu (PTT) padi sawah di Kelurahan Klaru, Distrik Mariat-Kabupaten Sorong-PBD [Study of integrated crop management (ICM) technology innovation for lowland rice in Klaru Village, Mariat District, Sorong Regency, Southwest Papua]. *AGROSCIENCE, 14*(1), 35–48.

Kasno, A., Setyorini, D., & Suastika, I. W. (2020). Pengelolaan hara terpadu pada lahan sawah tadah hujan sebagai upaya peningkatan produksi beras nasional [Integrated nutrient management in rainfed rice fields as an effort to increase national rice production]. *Jurnal Sumberdaya Lahan, 14*(1), 15–24.

Kementerian Pertanian Republik Indonesia. (2026, February 4). *BPS rilis angka tetap produksi beras 2025 capai 34,69 juta ton, naik 13,29 persen* [BPS releases final figures for 2025 rice production, reaching 34.69 million tons, an increase of 13.29 percent]. https://pertanian.go.id/?show=news&act=view&id=7517

Liu, Q., Yang, L., Ma, L., Zhai, Y., & Wang, D. (2026). Effects of organic fertilizers on soil properties in arid zones and their mechanism of action. *Frontiers in Environmental Science, 14*, Article 1681958.

Mamun, M., Nihad, S., Sarker, M., Sarkar, M., Hossain, M., & Kabir, M. (2024). Spatial and temporal mapping of rice area growth and productivity in Bangladesh. *PLoS ONE, 19*, Article e0300648.

Marbun, S. N. S. (2024). Studi tentang evaluasi dampak penggunaan pupuk kimia terhadap kualitas hasil pertanian [Study on evaluating the impact of chemical fertilizer use on the quality of agricultural products]. *Tugas Mahasiswa Fakultas Pertanian, 1*(2).

Maruapey, A., & Asbur, Y. (2025). Pemanfaatan Super Bookashi MA-11 dan Biosaka terhadap pertumbuhan dan hasil padi (*Oryza sativa* L.) varietas Inpari 10 [Utilization of Super Bookashi MA-11 and Biosaka on the growth and yield of rice (*Oryza sativa* L.) variety Inpari 10]. *Agrosains: Jurnal Penelitian Agronomi, 27*(2), 111–119.

Maruapey, A., Badaruddin, M. I., Refra, M. S., Nurlela, N., & Macpal, S. (2025). Edukasi progresif: Pengembangan potensi pertanian organik Superbokashi MA-11 di Kelompok Tani Mekarsari, Majener Kabupaten Sorong Papua Barat Daya [Progressive education: Development of the potential of Superbokashi MA-11 organic farming in the Mekarsari Farmers Group, Majener, Sorong Regency, Southwest Papua]. *Jurnal Abdimas Indonesia, 5*(4), 3254–3267.

Ningsih, H., & Yanuarita, H. T. (2022). Inovasi pemanfaatan limbah kotoran sapi sebagai pupuk organik (bokashi) di Desa Jungke, Karanganyar [Innovation in utilizing cow dung waste as organic fertilizer (bokashi) in Jungke Village, Karanganyar]. *E-Jurnal Spirit Pro Patria, 8*(2), 150–156.

Peng, S., Huang, J., Zhong, X., Yang, J., Wang, G., Zou, Y., ... Li, Y. (2021). Research strategies in improving rice yield potential. *Field Crops Research, 266*, Article 108144.

Putra, R. E., Rayes, M. L., Kurniawan, S., & Ustiatik, R. (2024). Pengaruh kombinasi pupuk organik dan anorganik terhadap sifat tanah dan produksi padi [The effect of a combination of organic and inorganic fertilizers on soil properties and rice production]. *Jurnal Agrikultura, 35*(1), 136–150.

Sakran, R. M., Ghazy, M. I., Gaballah, M. M., Hussein, F. A., Aamer, S. M., Ghazy, H. A., & Abdelghany, A. M. (2025). Genetic variability in physiological and agronomic traits of newly developed rice lines under well-watered and water-deficit conditions. *BMC Plant Biology, 25*(1), Article 1291.

Sulaiman, L., Maruapey, A., & Riskawati, R. (2025). Peran pupuk organik Super Bokashi MA-11 terhadap pertumbuhan dan hasil panen ubi jalar (*Ipomoea batatas* L.) [The role of Super Bokashi MA-11 organic fertilizer on the growth and yield of sweet potatoes (*Ipomoea batatas* L.)]. *Agriland: Jurnal Ilmu Pertanian, 13*(1), 1–11.

Wardana, M. A., Maruapey, A., & Rosalina, F. (2024). Application of Super Bokashi MA-11 organic fertilizer on the growth and yield of rice (*Oryza sativa* L.) Mekongga variety. *Agrikan: Jurnal Agribisnis Perikanan, 17*(1), 209–218.

Wihardjaka, A., Pramono, A., & Sutriadi, M. T. (2020). Peningkatan produktivitas padi sawah tadah hujan melalui penerapan teknologi adaptif dampak perubahan iklim [Increasing rainfed rice productivity through the application of adaptive technology to the impacts of climate change]. *Jurnal Sumberdaya Lahan, 14*(1), 25–36.

Yoshida, S. (1981). *Fundamentals of rice crop science*. International Rice Research Institute.

Zhang, L., Wang, F., Luo, B., Chen, N., Wang, Y., & Zhang, X. (2025). Mechanism and application of developmental factors in plant genetic transformation. *International Journal of Molecular Sciences, 26*(20), Article 10135.

Zhang, Y., Liu, J., Wang, Z., & Chen, X. (2024). Effects of organic and chemical fertilizer combinations on rice yield and soil properties. *Frontiers in Agronomy, 6*, Article 1354691.