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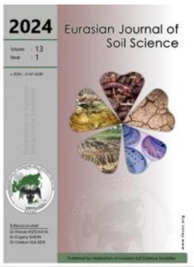

Comparative analysis of lowland rice (*Oryza sativa* L. var. PSB Rc18) performance across different farming systems

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Abstract

Organic farming is gaining recognition as a viable alternative to conventional methods, promising soil health preservation and sustained crop productivity with economic benefits. This study evaluated the physiological, growth, and yield responses of the PSB Rc18 rice variety and appraised its economic feasibility under different production systems. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications and three treatments: T1-best bet organic production system, T2-farmers' organic production system in Leyte, and T3-farmers' conventional production system in Leyte. The crop growth rate (CGR) of PSB Rc18 remained consistent across the different systems. However, the Net Assimilation Rate (NAR) peaked significantly between 42-56 days after transplanting (DAT) in the T2. Additionally, the Leaf Area Index (LAI) in T1 was comparable to that of T3. Rice grown under T1 reached heading and maturation earlier than T3. Although T3 produced the highest fresh straw, most productive tillers, and heaviest total biomass, the grain yield was similar across all production systems. Economically, T2 outperformed with a superior benefit-cost ratio of $0.55 and $0.94 per USD invested, considering both regular and premium prices for organic palay. These findings highlight organic farming practices' economic and agronomic viability, suggesting that promoting organic farming can be a beneficial alternative to conventional methods in Leyte. This study underscores the potential for integrating organic practices to enhance sustainability and economic outcomes in rice production, making both T1 and T2 significant options for farmers in Eastern Visayas.

Keywords: Organic production systems, physiological response, profitability analysis.

Introduction

Rice (*Oryza sativa* L.) is a critical staple food for 2.7 billion people, predominantly cultivated by several global farmers. Its production exhibits remarkable sustainability and productivity. In comparative terms, irrigated rice boasts significantly higher productivity levels—approximately 100 times more than upland rice, over 12 times more than deep-water rice, and five times more than rainfed rice (Fairhurst and Dobermann, 2002; Mamiit et al., 2021).

In the Philippines, rice serves as the primary food for most Filipinos, yet the total lowland rice cultivation area inadequately caters to the escalating national demands. Eastern Visayas, for instance, allocates only 34% of its land to rice production, yielding an average of 3.44 t ha^{-1}, lower than the national average of 4 t ha^{-1} (PhilRice, 2022). This lower yield is mainly due to the area's susceptibility to tropical storms and ineffective soil and environmental management techniques. Xu et al. (2016) emphasize that enhancing crop management practices to achieve higher productivity, profitability, and environmental sustainability hinges on integrating appropriate nutrient management strategies with agronomic practices.

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However, significant reliance on chemical fertilizers for nutrient management often leads to lower grain yields in intensified rice cropping (Cassman and Pingali, 1995; Patra et al., 2016; Gaurana and Ratilla, 2020). The continual use of chemical fertilizers harms soil health, water sources, and air quality, impacting the soil's physical, chemical, and biological properties (Savci, 2012; Chandini et al., 2019). Surekha et al. (2012) further highlight that conventional fertilizer usage in rice production could lead to long-term soil degradation, adversely impacting productivity.

Organic farming is recognized as a more sustainable option for maintaining soil health and productivity (Surekha and Satishkumar, 2014). Organic production, supported by organic nutrient sources, promotes balanced nutrient release to plants, fostering soil fertility over time (Surekha et al., 2012). While organic farming typically yields less grain than conventional methods (Röös et al., 2018), it proves more resilient to extreme weather conditions such as drought, flooding, or waterlogging (Wani et al., 2013; Heckelman et al., 2018). While historical data may suggest that organic cropping systems are less profitable than conventional systems (Dobbs and Smolik, 1977), recent findings assert that organic farming can be more profitable (Crowder and Reganold, 2015; Reganold and Wachter, 2016; Gaurana and Ratilla, 2020).

Despite the potential benefits, the specific effects of organic farming on the physiological, growth, and yield responses of rice varieties in Eastern Visayas are not well-documented. Additionally, there is limited information on the economic feasibility of organic farming practices in this region. Understanding physiological parameters such as leaf area index (LAI), net assimilation rate (NAR), and crop growth rate (CGR) associated with different production systems is imperative to identify the factors limiting the yield of lowland rice. Elevated yield directly correlates with increased dry matter production (Peng et al., 1999; Hasegawa, 2003). Nevertheless, dry matter production varies based on genotype, environmental conditions, and cultivation practices (Quang Duy et al., 2004).

This study aims to fill this gap by evaluating the physiological, growth, and yield responses of the PSB Rc18 rice variety under different production systems. Specifically, it investigates how organic and conventional farming practices affect these parameters and their economic feasibility. By addressing these aspects, the study seeks to provide insights into the viability of organic farming as an alternative to conventional methods in the Philippines, particularly in regions like Eastern Visayas. This research aims to assess the impact of different production systems on the CGR, NAR, LAI, and growth and yield performance of PSB Rc18 and to analyze the economic benefits of organic and conventional farming practices.

Material and Methods

The research took place at the experimental area of the Department of Agronomy, Visayas State University, Visca, Baybay City, Leyte, Philippines (10º44’45’’N 124º47’33’’E) from August to December 2017. Before planting, a comprehensive soil analysis was undertaken, considering the preceding cropping. Soil samples per treatment per replication were collected from the experimental area before land preparation at a 0-20 cm depth.

These samples were air-dried, pulverized, and sieved using 2.0 mm wire mesh and were submitted for the analysis of soil pH (1:2.5 soil water ratio; ISRIC 1995), organic matter content (%) (Modified Walkley Black Method, PCARR 1980), total N (%) (Modified Kjeldahl Method, Nelson and Sommers, 1982), available P (mg kg^{-1}) (Modified Olsen Method, Olsen et al., 1954) and exchangeable K (meq/100 g) (Ammonium Acetate Method, ISRIC 1995) at the Central Analytical Services Laboratory (CASL), PhilRootCrops, VSU, Visca, Baybay City, Leyte, Philippines. Specifically, the soil displayed a range of pH levels from strongly acidic to very strongly acidic, deficient %OM and %OC, and low available P. However, the total N content and exchangeable K exhibited a medium amount based on Landon (1991) indices.

For the final soil analysis, three soil samples were collected after harvesting from each treatment plot in every replication. These were processed and analyzed for the same aforementioned soil parameters.

Experimental Design and Treatments

The experiment was laid out in RCBD with four replications. Each block was subdivided into three plots measuring 5 m x 6 m with 2 m alleyways between replications and treatment plots. Treatments are as follows:

T1 : best bet organic production system (green leaf manuring + vermicast [37.26–508.25–13.07 kg N, P_2O_5, K_2O ha^{-1}] + vermitea [0.06–4.87–0.32 L N, P_2O_5, K_2O ha^{-1}] + fermented plant juice [0.94–23.70–7.02 L N, P_2O_5, K_2O ha^{-1}] + fermented fruit juice [0.67–3.42–39.06 L N, P_2O_5, K_2O ha^{-1}])

T2 : organic farmers' practice in Leyte (vermicast [10.35–141.18–3.63 kg N, P_2O_5, K_2O ha^{-1}] + vermitea [0.04–3.13–0.21 L N, P_2O_5, K_2O ha^{-1}] + fermented plant juice [0.35–8.88–2.63 L N, P_2O_5, K_2O ha^{-1}] + fermented fruit juice [0.67–3.42–39.60 L N, P_2O_5, K_2O ha^{-1}]

T3 : conventional farmers' practice in Leyte (109.04–17.5–17.5 kg N, P_2O_5, K_2O ha^{-1})

The organic fertilizers employed in this research underwent nutrient analysis at the Central Analytical Services Laboratory (CASL), PhilRootCrops, VSU, Visca, Baybay City, Leyte, Philippines, to determine the pH, total N, P, K, and moisture content (MC). The pH, total N (%), and MC (%) were analyzed using the same methods for soil analysis. The total P (%) was determined using the Vanadomolybdate Method, and the total K (%) was measured using Flame Atomic Emission Spectroscopy (FAES) following the protocols outlined by the Bureau of Soils and Water Management (BSWM, 2014). The nutrient analysis results (Table 1) unveiled distinctive characteristics among the different organic fertilizers. Vermicast had a near-neutral pH of 6.83, while Fermented Plant Juice (FPJ) was the most acidic (pH 4.20). Furthermore, vermicast demonstrated the highest levels of total nitrogen (0.69%) and phosphorus (4.11%), while Fermented Fruit Juice (FFJ) recorded the highest potassium content at 18.18%. Among the utilized nutrient sources, vermicast underscores the potential for supplying nutrients beneficial for rice crops.

Table 1. pH, organic matter, total N, P, K, and % MC of nutrient sources

Fertilizers	pH (1:2.5)	OM (%)	Total N (%)	Total P (%)	Total K (%)	MC (%)
Vermicast	6.83	10.34	0.69	4.11	0.20	69.16
Vermitea	4.53		0.02	0.73	0.09	
Fermented Fruit Juice (FFJ)	4.60		0.37	0.83	18.18	
Fermented Plant Juice (FPJ)	4.20		0.19	2.07	1.16	

Source: Central Analytical Services Laboratory, PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte, Philippines

Before the commencement of the experiment, plots identified under T1 received an application of kakawate *(Gliricidia sepium)* as green leaf manure, applied at a rate of 2 kg m^{-2} and incorporated into the soil before final land preparation. This was allowed to decompose for two weeks before transplanting. In contrast, T3 was administered with inorganic fertilizers at a rate of 109.04-17.5-17.5 kg N, P_2O_5, K_2O ha^{-1}. This involved a basal application comprising a mixture of 125 kg ha^{-1} complete fertilizer combined with 79 kg ha^{-1} urea, split into two applications—one given a week after transplanting and the other 15 days later. Following this, urea was top-dressed at a rate of 120 kg ha^{-1} during panicle initiation, which was identified through a visual examination of the furry tip at the center of the stem. The fertilizers applied were incorporated into the soil after application.

On the other hand, plots assigned to T1 and T2 received vermicast applications at rates of 5 t ha^{-1} and 1.5 t ha^{-1}, respectively, before the transplanting. Fermented Plant Juice (FPJ), FFJ, and vermitea were employed in T1 and T2 treatments for foliar spray applications. Treatment 1 received weekly applications of vermitea and alternated with a 10% FPJ solution starting from one week after transplanting and continuing up to the flowering stage, administered at a rate of 291.66 L ha^{-1} vermitea and 500 L ha^{-1} for FPJ. Conversely, T2 was sprayed weekly with a combination of FPJ and vermitea, with a total volume of 375 L ha^{-1}, starting two weeks after the transplanting until the heading stage. At the panicle initiation phase, FFJ was sprayed in T1 and T2 two weeks before harvest. The foliar fertilizers were applied late afternoon, between 4:00-5:00 pm.

Rice Establishment and Maintenance

Lowland rice seedlings were raised using the wet bed method wherein PSB Rc18 seeds weighing 480 g per treatment were soaked in tap water for 24 hours and incubated for 36 hours. Pre-germinated seeds for T1 were sown in a prepared seedbed enriched with 1 kg m^{-2} of vermicast. After 21 days, these seedlings were transplanted at a distance of 20 cm x 20 cm. A day after transplanting (DAT), myko plus was drenched in T1 at 100 g 16 L^{-1} of water. Replanting was performed five days after transplanting to replace missing hills and maintain the desired population of 750 hills per plot.

At 5 DAT, the experimental area was irrigated with water to a depth of 2.5 cm. However, during rainy periods, the water source for irrigation was temporarily closed to prevent excessive flooding. The field was drained with water two weeks before harvest to promote maturity and facilitate harvesting. Rotary weeding was performed at 14 DAT, and hand weeding was carried out five days later to manage weeds around the hills. Subsequently, weeds in dikes were controlled by under-brushing using a sharp sickle. Pests and disease incidence in the T1 and T2 treatments were addressed by applying panyawan (*Tinospora rumphii*) extracts.

In the case of T3, karate (lambda-cyhalothrin) was sprayed at a rate of 30 mL 16 L^{-1} of water to control rice stink bugs (*Oebalus pugnax*) during the vegetative and flowering stages at intervals of 10 days. During the heading stage, lannate (methomyl insecticide) was sprayed at a rate of 30 mL 16 L^{-1} of water to manage rice bugs (*Leptocorisa oratorius*). During the spraying process, a plastic enclosure was employed around the conventional treatment plots to prevent contamination of spray mists with other treatments. Harvesting was done when 85% of the grains within the panicles had ripened. The harvested grains were threshed, cleaned, and sun-dried to 14% MC before weighing.

Data gathered

Three soil samples were gathered from each treatment plot within each replication upon harvest to assess potential changes in soil properties following the application of specified treatments. These samples were analyzed for parameters such as soil pH, % OM, total N, available P, and exchangeable K. For the lowland rice crops, the collected data encompassed both physiological parameters, including Net Assimilation Rate (NAR), Crop Growth Rate (CGR), and Leaf Area Index (LAI), and agronomic characteristics, which is the number of days from sowing to heading and maturity, plant height (cm) and fresh straw yield (t ha^{-1}). The yield and yield components were the numbers of productive tillers per hill, filled and unfilled grains per panicle, percentage of filled spikelets per panicle, weight of 1000 grains (g), panicle length (cm), grain yield (t ha^{-1}) and total biomass (t ha^{-1}). The Harvest Index, a measure of plant productivity, was computed by dividing the economic yield (grains) by the biological yield. To ensure accuracy, both grains and the herbage from three sample plants in each treatment were subjected to oven-drying at 70°C for 72 h before weighing.

A profitability analysis aggregated all expenses incurred during the study, from land preparation to harvesting. These costs were then subtracted from the gross income. Additionally, net return and the benefit-cost ratio were calculated as part of the analysis.

Meteorological data, including total weekly rainfall, minimum and maximum temperatures, and relative humidity throughout the study, were sourced from the Philippine Atmospheric Geophysical and Astronomical Services Station, Visayas State University, Visca, Baybay City, Leyte.

Statistical analysis

The consolidated data were analyzed using Statistical Analysis Software (SAS) Version 9.2 developed by SAS Institute. Significant means were compared using Tukey's Honestly Significant Difference (HSD) test.

Results and Discussion

Soil characteristics

The findings from the final soil analysis indicated that most soil parameters were similar across various production systems, except exchangeable K. Notably, at a depth of 20 cm, the exchangeable K levels in T1 and T2 were significantly higher compared to T3. This increase could be linked to the higher turnover of rice straw and residues from previous crop cycles (Table 2). Rice straw contains a substantial amount of potassium (Dobermann and Fairhurst, 2002), and for this potassium to become available, soil microorganisms need to decompose the residues. In contrast to the inorganic plots (T3), the organic plots (T1 and T2) received organic fertilizers like vermicast, vermitea, FFJ, and FPJ, potentially enhancing the soil's microbial population. This suggests that the organic plots (T1 and T2) retained more available nutrients from the added crop residues.

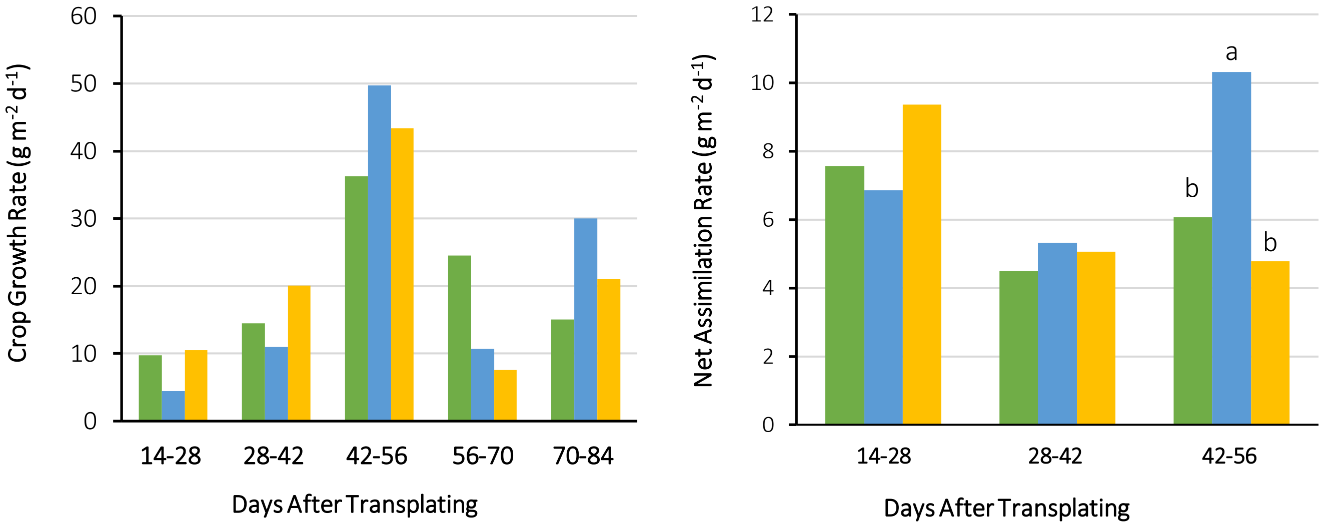
Table 2. Soil analysis of the experimental area before and after the conduct of the study

Treatment	pH (1:2.5)	SOM (%)	SOC (%)	Total N (%)	Avail. P (mg/kg)	Exch. K (meq/100g)
Before Planting						
T1 = Best bet organic production system	5.08	2.97	1.73	0.34	6.51	0.50
T2 = Organic farmers' practice in Leyte	5.05	2.82	1.64	0.28	8.63	0.39
T3 = Conventional farmers' practice in Leyte	4.91	2.81	1.64	0.27	7.43	0.35
CV (%)	4.77	5.03	5.03	27.97	29.11	33.01
After Planting						
T1 = Best bet organic production system	5.13	2.66	1.55	0.21	7.10	0.36^{a}
T2 = Organic farmers' practice in Leyte	5.15	2.56	1.49	0.16	5.21	0.34^{ab}
T3 = Conventional farmers' practice in Leyte	5.09	2.43	1.41	0.16	4.93	0.19^{b}
CV (%)	1.07	11.34	11.34	20.42	25.88	24.58

Treatment means within a column without a letter or followed by a common letter(s) are not significantly different at a 5% level of significance using HSD

Physiological Response

Figure 1 reveals that the various production methods influenced the NAR of rice, specifically between 42-56 DAT, whereas the CGR did not differ significantly. Nevertheless, numerical data showed increased CGR from 14-56 DAT, followed by a decline as the crop matured due to some senescence. This trend parallels the findings of Itang (2014) and Abit (2016), indicating that the increase in CGR during the vegetative stage of rice was associated with an increased leaf area, allowing for more effective light interception, thereby augmenting photosynthetic rates and the production of dry matter. As leaves aged and were shed, there was a noticeable decline in CGR at 60-90 DAT (Mehta et al., 2013). The highest NAR value recorded between 42-56 DAT in rice grown under T2 may be linked to its upright leaf canopy. Conversely, vigorous growth in T1 and T3 led to mutual shading among rice plants, potentially contributing to their lower NAR values. Consequently, the reduced shading in T2 likely facilitated more efficient photosynthetic activity.



Legend:
🟩 T_1 = Best bet organic production system
🟦 T_2 = Organic farmers' practice in Leyte
🟨 T_3 = Conventional farmers' practice in Leyte

Figure 1. Physiological characteristics of lowland rice (PSB Rc18) under different production systems

Agronomic Response

The study results indicated significant differences in the days to heading and maturity, leaf area index (LAI), fresh straw yield, and total biomass (Table 3). Notably, rice plants in T1 exhibited an earlier heading and maturation than those in T3. This result aligns with research by Gaurana and Ratilla (2020), which found that organic fertilizer application led to earlier heading and maturity compared to inorganic fertilizers. Treatments 1 and 3 recorded higher LAI values than T2, likely due to more significant N application in the former two production systems. The nutrient analysis (Table 1) reveals that T1 and T3 received relatively higher N inputs than T2. The higher LAI in T1 may have been influenced by the incorporation of kakawate (*G. sepium*) as green leaf manure, the addition of vermicast, and weekly foliar spraying of fermented plant juice (FPJ), which supplied substantial N, resulting in larger and broader leaves. Similarly, the application of 109.04 kg ha^{-1} of nitrogen in T3 contributed to the elevated LAI values, consistent with the findings of Vaesen et al. (2001) that increased nitrogen application positively impacted the LAI of lowland rice.

Table 3. Days from sowing to heading and maturity, plant height, leaf area index, fresh straw yield and total biomass of lowland rice (PSB Rc18) under different production systems

Treatments	Days from sowing to		Plant Height (cm)	Leaf Area Index	Fresh Straw Yield (t/ha)	Total biomass (t/ha)
	Heading	Maturity				
T_1 = Best bet organic production system	83.00^{c}	126.00^{b}	110.58	5.66^{ab}	22.02^{b}	24.95^{b}
T_2 = Organic farmers' practice in Leyte	88.00^{b}	126.00^{b}	102.53	3.64^{b}	19.40^{b}	21.84^{c}
T_3 = Conventional farmers' practice in Leyte	89.00^{a}	133.00^{a}	114.13	8.50^{a}	29.20^{a}	31.29^{a}
CV (%)	0.00	0.00	7.40	23.80	5.86	4.38

Treatment means within a column without a letter or followed by a common letter(s) are not significantly different at a 5% level of significance using HSD

In contrast, T3 exhibited a notably higher fresh straw yield and total biomass among the different production systems, likely due to the rapid conversion of urea into readily available N for rice plants. This differs from organic amendments, where a significant portion of the N is released after mineralization (Dash et al., 2011). Treatments 1 and 2, which rely on organic fertilizers, contained lower N amounts, approximately 37.26 kg and 10.35 kg ha^{-1}, along with 1.67 L ha^{-1} and 1.06 L ha^{-1} from foliar supplements, respectively, in comparison to T3, which received 109.04 kg N ha^{-1}. Similar findings have been reported by Mannan et al. (2010) and Cagasan and Tamayo (2016), emphasizing that higher N rates significantly increase the fresh straw yield of lowland rice. This increased fresh straw yield in T3 also translated into higher total biomass, in line with the results obtained by Gaurana and Ratilla (2020) and Dela Peña (2017). Among the parameters related to yield and yield components assessed, the number of productive tillers and panicle length significantly varied among the production systems (Table 4 and 5). Treatment 3 yielded the highest number of productive tillers, followed by T1. This result is consistent with the findings of Cagasan and Tamayo (2016), demonstrating that inorganic fertilizer application resulted in increased tiller production. Additionally, longer panicles were observed in both T1 and T3, likely due to the higher N supply. Nitrogen was found to substantially influence panicle formation and elongation, consistent with Pramanik and Bera (2013) and Gaurana and Ratilla (2020).

Table 4. Number of productive tillers, filled and unfilled grains, and percent filled grains per panicle of lowland rice (PSB Rc18) under different production systems

Treatments	No. of productive tillers	No. of grains per panicle		Percent filled spikelet per panicle
		Filled	Unfilled	
T_1 = Best bet organic production system	15.50^b	100.75	63.00	61.45
T_2 = Organic farmers' practice in Leyte	11.50^c	93.50	48.73	65.58
T_3 = Conventional farmers' practice in Leyte	18.00^a	80.75	60.05	57.51
CV (%)	5.88	11.25	19.31	9.19

Treatment means within a column without a letter or followed by a common letter(s) are not significantly different at a 5% level of significance using HSD

Table 5. Panicle length, weight of 1000 grains, grain yield, and harvest index of lowland rice (PSB Rc18) under different production systems

Treatments	Panicle length (cm)	Weight of 1000 grains (g)	Grain yield (t/ha)	Harvest index
T_1 = Best bet organic production system	25.42^a	23.22	2.93	0.35
T_2 = Organic farmers' practice in Leyte	23.48^b	23.91	2.44	0.36
T_3 = Conventional farmers' practice in Leyte	25.45^a	22.55	2.09	0.27
CV (%)	2.63	3.89	18.91	16.09

Treatment means within a column without a letter or followed by a common letter(s) are not significantly different at a 5% level of significance using HSD

Despite T1 and T3 displaying longer panicles, there were no significant differences in grain yield across the various production systems. This may be due to the compensatory effects of comparable 1000-grain weight, number of filled grains, percentage of filled spikelets per panicle, and harvest index, among other factors. Despite T1 and T3 receiving relatively higher nutrient inputs, T2 utilized its available nutrients more efficiently. However, it is imperative to acknowledge the external factors contributing to the observed reduction in grain yield. Notably, the influence of three tropical storms during the heading and grain-filling stages underscores the susceptibility of rice crops to adverse weather conditions (Yoshida, 1981). Moreover, the residual crop from the previous cultivation could have depleted soil nutrients, given that no amendments were added to the prior crop. Residual cropping can consume available nutrients in the soil through nutrient mining (Syers, 1997). However, continuous application of organic amendments may increase grain yield in lowland rice production.

Profitability analysis

In this study, the net income recorded lower values than the preceding five croppings (Table 6 and 7). This decline might be attributed to the impact of tropical storms occurring during critical growth stages heading and grain-filling stages. However, despite this, all production systems remained profitable, recovering their production costs. Considering the current market price of \$0.34 kg^{-1} of ordinary palay in the locality, T2 achieved the highest net return of \$296 ha^{-1}, with the most favorable benefit-cost ratio of USD 0.55. Following T2, T3 acquired a net return of \$217 ha^{-1}, with a benefit-cost ratio of USD 0.44. Even though T1 obtained the highest grain yield, it incurred more significant production costs due to expensive vermicast, resulting in a lower net return of \$20 ha^{-1} and a benefit-cost ratio of USD 0.02.

Table 6. Cost and return analysis of lowland rice (PSB Rc18) under different production systems following the price of ordinary rice

Treatments	Grain yield (t/ha)	Gross Income** (USD/ha)	Production Cost (USD/ha)	Net Income (USD/ha)	Benefit Cost Ratio (USD)	Break Even Yield (kg/ha)
T_1 = Best bet organic production system	2.93	996	976	20	0.02	2,870.55
T_2 = Organic farmers' practice in Leyte	2.44	830	534	296	0.55	1,570.55
T_3 = Conventional farmers' practice in Leyte	2.09	711	494	217	0.44	1,451.85
Mean	2.49	845	668	178	0.34	1,964.32

**Based on the price of unmilled rice at farm gate price at $0.34/kg

Table 7. Cost and return analysis of lowland rice (PSB Rc18) under different production systems following the premium price for organic rice

Treatments	Grain Yield (t/ha)	Gross Income** (USD/ha)	Production Cost (USD/ha)	Net Income (USD/ha)	Benefit Cost Ratio (USD)	Break Even Yield (kg/ha)
T1 = Best bet organic production system	2.93	1,245	976	269	0.28	2,296.44
T2 = Organic farmers' practice in Leyte	2.44	1037	534	503	0.94	1,256.44
T3 = Conventional farmers' practice in Leyte	2.09	711	494	217	0.44	1,451.85
Mean	2.49	998	668	330	0.55	1,668.24

**Based on the price of unmilled organic rice at $0.43/kg (T1 and T2)

However, considering the potential sale of organic rice at a premium price of \$0.43 kg^{-1}, T2 continued to exhibit the highest net return of \$503 ha^{-1} and a cost-benefit ratio of USD 0.94. T1 also generated a net return of \$269 ha^{-1} with a cost-benefit ratio of USD 0.28, surpassing the net return of T3. Through assessments based on break-even yield, net income, and benefit-cost ratios, all three production systems exhibited the capability to recover their production costs under adverse climatic conditions. Nevertheless, when exposed to adverse conditions, T2 demonstrated relative practicality, profitability, and resilience advantages. Despite T1 achieving a relatively high grain yield in unfavorable conditions, its higher production costs did not equate to increased net returns. Consequently, these results suggest that T2 represents a potential option capable of competing with T3, albeit highlighting the need to optimize its nutrient application further. Furthermore, multiple researchers have highlighted the benefits of organic rice farming, including energy efficiency (Mendoza, 2004), improvements in soil physical, fertility, and biological properties (Ramesh et al., 2010), enhanced adaptive capacity, mitigation potential, reduced vulnerability (Heckelman et al., 2018), and assurance of food safety for consumers and producers (Sirieix, 2011; EFIC, 2013).

Meteorological data

Figure 2 illustrates the total rainfall accumulation throughout the experimental period, amounting to 2,255.50 mm. The highest recorded rainfall was documented during week 17, reaching 556.60 mm, followed by week 9 with 441.30 mm, while the lowest rainfall occurred during week 2, with 25.40 mm. The substantial increase in rainfall during weeks 9 and 17 can be attributed to the influence of tropical storms "Lan," "Kai-tak," and "Tembin." As per established standards, the total water requirement for rice typically stands at approximately 1,200 mm (Yoshida, 1981). Week 9, identified as the early vegetative stage in this study, experienced continuous rainfall. Yu et al. (2016) highlighted that prolonged rainy periods during this stage adversely impact the tillering stage, ultimately resulting in reduced grain yields. Conversely, week 17 marked the milking and dough stages, in which strong winds accompanying tropical storms "Kai-tak" and "Tembin" led to lodging and grain shattering.

An interesting observation among the production systems was that 50% of the rice plants in T3 experienced lodging at an angle of 60^0. In contrast, all rice plants in the organic treatments (T1 and T2) remained upright. This finding suggests that rice plants cultivated under organic production systems exhibit greater resilience to adverse weather conditions, such as tropical storms. This aligns with the findings of Heckelman et al. (2018), emphasizing that paddy rice grown under organic systems demonstrates enhanced climate resilience compared to conventional methods.

On the other hand, the recorded minimum and maximum air temperatures fluctuated between 21-27.50^{0}C and 27.50-35.80^{0}C, respectively. These temperatures conformed to the optimum requirement of growing paddy rice for average growth and development, which ranges from 25-35^{0}C (Shimono et al., 2002). Additionally, the relative humidity levels throughout the study period ranged from 78.50% to 92.42%, consistently within the required range for paddy rice cultivation.

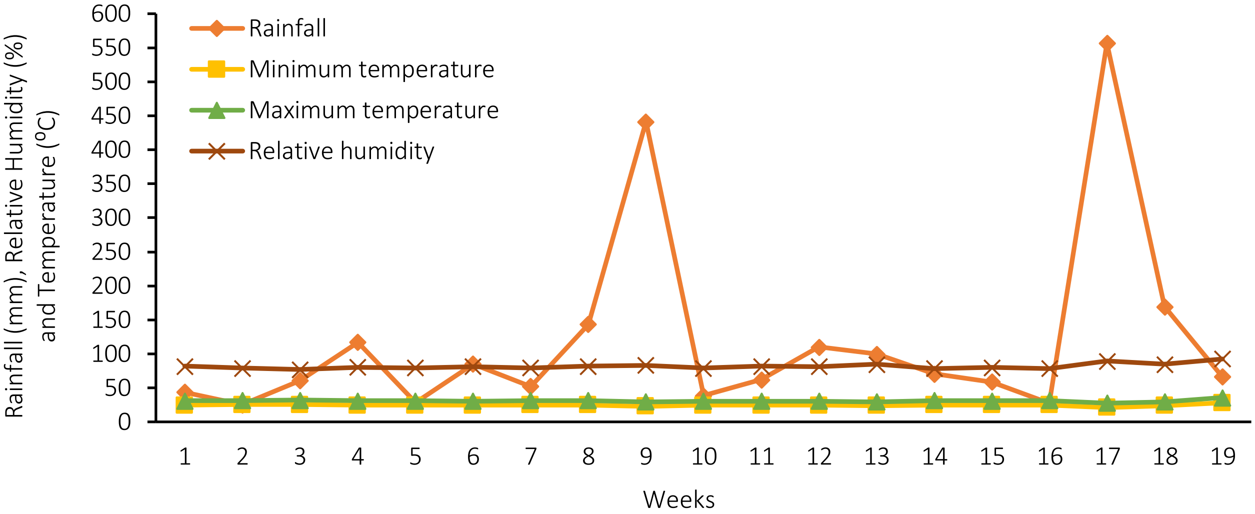


Figure 2. Total weekly rainfall, average weekly minimum and maximum temperature and relative humidity during the conduct of the study (August 21 - December 30, 2017)

Conclusion

The crop growth rate (CGR) remained consistent across all systems, while the organic system in Leyte (T2) demonstrated the highest net assimilation rate (NAR) between 45-56 days after transplanting (DAT). The leaf area index (LAI) in the optimal organic system (T1) was comparable to that of the conventional system (T3), which, despite having more productive tillers and higher total biomass, produced a grain yield similar to that of other systems. Economically, all systems were profitable, but T2 achieved a superior benefit-cost ratio, with $0.55 and $0.94 per USD invested at regular and premium organic palay prices, respectively. These results align with existing literature suggesting that organic farming can yield comparable results to conventional methods while enhancing economic returns and sustainability. However, the study's focus on a single rice variety and specific regions may limit generalizability, highlighting the need for further research on different varieties and regions. Despite these limitations, the study underscores the potential of organic farming practices to provide significant economic and environmental benefits, promoting their broader adoption in agricultural practices.

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