Agricultural Practice Assessment to Accelerate Organic Rice Farming Adoption: A Case Study in West Java, Indonesia

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Abstract. Rice is a crucial carbohydrate source for the world population's food and global food security. The Indonesian government has tried to increase domestic production through the green revolution policy. The government has initiated concerns about enhancing rice quality through organic rice production. Organic rice has been emerging as an alternative to sustainable farming. Unfortunately, the acreage ratio to conventional farming is still relatively low, and productivity declined during the conversion period.This research aimed to explore deeply the agricultural practices between organic and conventional farming for fostering the adoption. That is why it is essential to be assessed comprehensively. This research focused on the organic rice farming production center in Subang and Tasikmalaya Regency, West Java Province. The total respondents were 203, consisting of 100 organic and 103 conventional smallholder farmers, respectively. Agricultural practice data of organic and conventional rice farming systemswere compared descriptively. Statistical analysis used Chi-square and t-test to test the significance of agricultural practices differences between the organic and conventional characteristics. The finding shows that organic rice farming had certain agricultural practices, such as farmers' preferences to use variety, seedling, transplanting time, watering system, pest control, and fertilization approach. Organic farmers use a premium price-oriented variety, aromatic and red-rice types. Organic rice farmers produced their self-owned seed production. While in the cultivation technique, organic rice farming is considered to have more transplanting days, adopting alternate wetting and drying (AWD), using wide spacing at a minimum of 20x20 cm, and using an Integrated Pest Management (IPM) system.
Keywords: Rice, Organic farming, Conventional farming, Agricultural practices, Indonesia.

1 Introduction

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Rice, an essential carbohydrate source and the staple food for most of the world's population is crucial in ensuring global food security and sustaining the livelihoods of Millions. With its remarkable production capabilities and versatility, rice is crucial in addressing hunger, poverty, and malnutrition worldwide[1]. Its efficient cultivation and high yield potential make it a reliable source of sustenance, particularly in regions where resources are scarce. The cultivation of rice is deeply intertwined with cultural traditions and economic systems, providing employment opportunities and supporting rural communities. Furthermore, rice production contributes to environmental sustainability, as it serves as a carbon sink and plays a critical role in water management. Through its substantial nutritional value and socioeconomic significance, rice remains an indispensable component of the world's food system, promoting stability, resilience, and nourishment for a growing global population[2]. The production of rice sustains rural livelihoods and fosters economic growth and stability in many regions[3].

Rice has undoubtedly played a pivotal role in ensuring global food security; however, it is vital to acknowledge the adverse effects of the Green Revolution and its impact on rice production[4, 5]. The Green Revolution introduced high-yielding cultivars, pesticides,and chemical fertilizers, expanded rice output dramatically, and relieved famine in many world regions. However, it also brought unintended consequences. Over-limit chemical usage resulted in environmental damage, soil erosion, contaminated water, and biodiversity loss.[6]. Moreover, the focus on high-yielding varieties often resulted in a decline in traditional rice varieties, reducing genetic diversity and leaving crops vulnerable to disease outbreaks. The heavy reliance on irrigation for rice cultivation strained water resources, contributing to water scarcity in some regions[7]. These negative consequences emphasize the need for a more sustainable and ecologically balanced approach to rice production, considering the long-term environmental and social impacts while ensuring food security for future generations. By learning from the shortcomings of the Green Revolution, we can strive for more holistic and sustainable practices in rice production, striking a balance between productivity, environmental stewardship, and social well-being.

In 2021, Indonesian rice production was about 54.42 million tons of dry unhusked paddy produced from 10,41 million ha. Rice farming has become a livelihood for 14.1 million farmer households[8]. Most farmers rely on rice growing as their primary source of income.Generally, rice farmers in Indonesia belong to the smallholder farmer category due to their small landholding tenure, i.e., less than 2 ha. The average amount of lowland and highland land owned by Indonesian rice farmers was just 0.67 ha and 0.50 ha, respectively. The average farmer household was predicted to earn $855.17 annually from agriculture, which equals 42.92% of the national per capita income, or $1,992.5 annually. Moreover, rice farmer households decreased by 0.41% (58.4 thousand) in one decade[9]. Hence, farmers should find an alternative innovative farming system to earn more from their limited land. Farmers expected that organic farming could create more outstanding money with the same land size and be supported by customers' willingness to pay higher prices for organic products.

In the quest to address the adverse impacts of the Green Revolution on rice production, organic farming emerges as a promising alternative that promotes sustainability, biodiversity, and environmental stewardship[10]. Organic rice farming promotesusingchemical-free and organic inputs, such as compost, cover crops, and biological pest control methods, while minimizing the reliance on synthetic chemicals and fertilizers. Farmers can mitigate the harmful effects of excessive pesticide and fertilizer use by adopting organic practices, reducing environmental pollution, and safeguarding ecosystems. Organic rice farming also fosters the preservation and resurgence of traditional rice varieties, which are often more resilient to pests, diseases, and environmental stressors

[11]. This approach promotes genetic diversity, ensuring the long-term sustainability and adaptability of rice crops. Moreover, organic farming methods prioritize soil health and fertility through crop rotation and organic matter, enhancing soil structure, water-holding capacity, and nutrient cycling. This, in turn, reduces soil erosion and promotes long-term soil sustainability[11].Furthermore, organic rice farming promotes water conservation by employing efficient irrigation techniques, such as the Rice Intensification program, which reduces water usage while maintaining or increasing yields. By implementing water management strategies and leveraging the natural benefits of organic farming, organic rice production can contribute to water resource preservation and alleviate water scarcity concerns[12].Beyond the environmental benefits, organic rice farming also offers economic opportunities[13]. Organic rice commands premium prices in global markets, providing farmers better financial returns and improving their livelihoods. Additionally, organic farming practices often promote local and small-scale agriculture, fostering rural development and community empowerment. In contrast, implementing organic farming still has challenges, such as declining production in the initial stage, selecting highly productive cultivars, difficulties handling pests, and preventing contamination from other farmsregarding water management systems[14].

For several reasons, understanding and implementing good agricultural practices (GAP) in organic rice farming is crucial. The GAP provides guidelines and standards that ensure the production of safe, high-quality organic rice[15, 16]. By adhering to GAP, farmers can minimize potential risks associated with contamination, pesticide residues, and other harmful substances, safeguarding consumer health and enhancing food safety. The knowledge of GAP in organic rice farming promotes efficient resource management[17]. It encompasses sustainable water usage, responsible nutrient management, and effective pest and disease control methods. Implementing GAP helps optimize resource utilization, reduce waste, and increase productivity. By employing proper irrigation techniques, efficient fertilizer application, and integrated pest management strategies, farmers can maximize yields while minimizing environmental impact. The GAP is pivotal in maintaining soil health and fertility[18]. Organic rice farming builds and nurtures healthy soils through organic matter incorporation, crop rotation, and cover crops. Understanding GAP enables farmers to enhance soil structure, nutrient availability, and microbial activity, contributing to long-term soil sustainability, erosion prevention, and improved soil health. Additionally, knowledge of GAP empowers farmers with the skills needed to adapt to climate change and other environmental challenges. Organic rice farming, guided by GAP, encourages resilient and diverse agroecosystems, which are better equipped to withstand extreme weather events, pests, and diseases. Organic rice farmers can prevent climate change's effects and build more resilient farming systems by implementing climate-smart practices, such as water conservation, agroforestry, and biodiversity conservation. Finally, knowing and implementing GAP in organic rice farming fosters organic adoption, transparency, accountability, and certification. Compliance with recognized organic standards and certifications ensures that farmers meet the requirements of organic farming practices and gain access to premium markets. Understanding and implementing good agricultural practices in organic rice farming are essential for accelerating its adoption, ensuring food safety, efficient resource management, soil health, climate resilience, and market access. By embracing GAP, farmers can contribute to sustainable agricultural systems that prioritize environmental stewardship, social well-being, and the production of safe, nutritious, and environmentally friendly organic rice.

This research aims to evaluate the differencesin the current status of GAP of Organic Farming compared to conventional farming. The study aims to gather comprehensive data and insights to understand the extent to which organic rice farmers adhere to GAP guidelines and standards, identify potential gaps in implementation, and explore factors that influence the acceleration of organic adoption. We hope this new insight into GAP's organic rice farming can teach all parties who want to encourage sustainable organic rice development.

2 Methodology

2.1 Research location

The survey was conducted in West Java Province, which is geographically located between 104°8'E and 108°41'E and between 5°50°S and 7°50'S. The research focused on the two largest organic rice center districts in West Java, Tasikmalaya and Subang. Locations of the study were chosen purposively due to several primary reasons. First, the province has several districts where organic rice farming is well developed. Secondly, from the market and consumer point of view, organic rice is produced and marketed not only for the domestic market but also for the global market. Third, thosetwo regions were appropriate for cultivating organic rice due to land suitability and climatology.

2.2 Datasources

The primary data were collected from interviews with organic and conventional farmers using a structured questionnaire related to demographic farmers' characteristicsand agricultural practices implemented by farmers. The depth interview was also conducted with the farmers' group chief and the agricultural extension officer. Secondary data were explored from the literature. The selected farmer groups were determined randomly based on data from the certification body. The data collected is the agricultural practices parameters from seedling to harvesting such as seed, variety, planting model, spacing, fertilization, irrigation system, and pest control, both organic and conventional. The respondents weredecided based on the determination of the estimated population data from the Ministry of Agriculture in those locations. The total number of organic farmer respondents is 100 families, while the total number of conventional farmer respondents is 103 families. So, the total number of respondents is 203 farmer householdsRespondents of organic farmers were divided by district and referred to the total of organic farmers in that area, i.e., 60 households in Tasikmalaya district and 40 households in Subang district. Conventional farmer respondents were randomly selected in locations close to organic respondents, namely 63 households in Tasikmalaya and 40 in Subang.

2.3 Data Analysis

Agricultural practice data of both organic and conventional farming were compared descriptively. Statistical analysis (the t-test and Chi-square test) was utilized to analyze the difference between the organic and conventional rice farming mean value on some essentialagricultural practices'characteristics. From depth interview, data were transcribed into the script, extracted, and categorized to the main point and essential note using qualitative assisted software analysis, Nvivo-12. Qualitative data was used for elaborating the pictorial finding and reason.

3 Results and discussion

3.1 Characteristics ofrespondents

Farmer demographic characteristics wereessential in the technologicalintroduction of agricultural systems. Farmers' household and demographic characteristics, including land tenure status, formal and informal education, and supporting resources for adopting organic rice farming, were equated.The results show no significant differences in age, household size, farm size, extension service, and farmers' experience between organic and conventional farmers. However, the two types of rice farming significantly differ in the number of participating household members, extension services per season, formal and informal education, rice farming, and total household income at various significance levels.

The analysis reveals that there wasnot any significant contrast between organic versus conventional farming farmers' characteristicsin terms of age, household size, farm size, and years of experience. These variables showed similar means and standard deviations for both groups. Similarly, formal education and age showed no significant differences. ORF and CRF farmers showed similarities in age, household size, farm size, and experience. There were notable differences in variables such as participating household members, extension services received, informal training education, income from rice farming, and other household incomes. These differences highlight potential distinctions between the two farming systems' practices, knowledge, and economic outcomes.

The formal education variable shows that most farmers' formal education attainment was junior high school. However, ORF farmers had higher formal and informal educational attainment than CRF farmers. ORF farmers had more junior high school education frequency than CRF farmers. In contrast, CRF farmers had more elementary school frequency than organic farmers, meaning that ORF farmers were more educated than conventional farmers. Furthermore, farmerswho implemented the organic system visited the extension officer more frequently to ask for consultation than conventional farmers, i.e., at least twice per season. They also preferred participating in informal education like seminars, coaching programs, and workshops to improve their farming and market. The number of family members participating in organic farming was higher than in conventional farming. In addition, organic ricefarmers had higher incomes than conventional rice farmers from rice farming and total income.

Other important farmers'socioeconomic variables include land tenure, farmer group membership, extension services, access to credit, and infrastructure support. The percentage of land tenure is quite different between organic and conventional rice farming. In the organic rice system, most farmers had a private ownership right of rice fields (70%), but in the conventional rice system, most fields were land-sharing (44%)and owned by other people. Farmers with private land have control over adopting organic or conventional rice farming. In contrast, land-sharing farmers need permission from the land owner, primarily because shifting to organic farming needs a conversion time. Farmers' membership in the organic farmer group was higher than in conventional farming. Most organic farmers were members of a farmer association (99%), while conventional farmers who joined the group were only 72%. Commonly, the main occupations were similar, namely working as farmers, but the percentage of farmers'households who had additional main occupations as merchants were higher in the organic system (8%) than in conventional rice farming (3%). This characteristic of farmers could be related to the additional cost requirement if farmers shift from conventional farming. Converting to organic farming needsan investment budget and additional financing [14].

3.2 Agricultural Practices

After adopting ORF, the inputs and agricultural practices changed. The critical practices selected in this study focused on the rice varieties used in both systems, farmers' reasons for using those cultivars, seedling methods, irrigation systems, water management, fertilization, and pest control. The essential finding attributed to organic practices was adopting the early transplanting method (less than 15 planting days), alternate wetting and drying (AWD) system, and wide spacing (minimum 20x20 cm). However, farmers did not adopt the single seedling planting method due to the susceptibility to golden snail attacks. The differences in agricultural practices implemented between organic and conventional rice farming systemsare described as follows.

3.2.1 Rice cultivar

In West Java Province, most rice farmers adopted the high-yield varieties (HYVs) promotedsince the green revolution program by the government and other organizations, which are used widely in some of Indonesia's regions, such as IR 64. Most also used the national varieties, such as Ciherang and Mekongga. The difference in rice varieties used in ORF and CRF is presented in Figure 1.

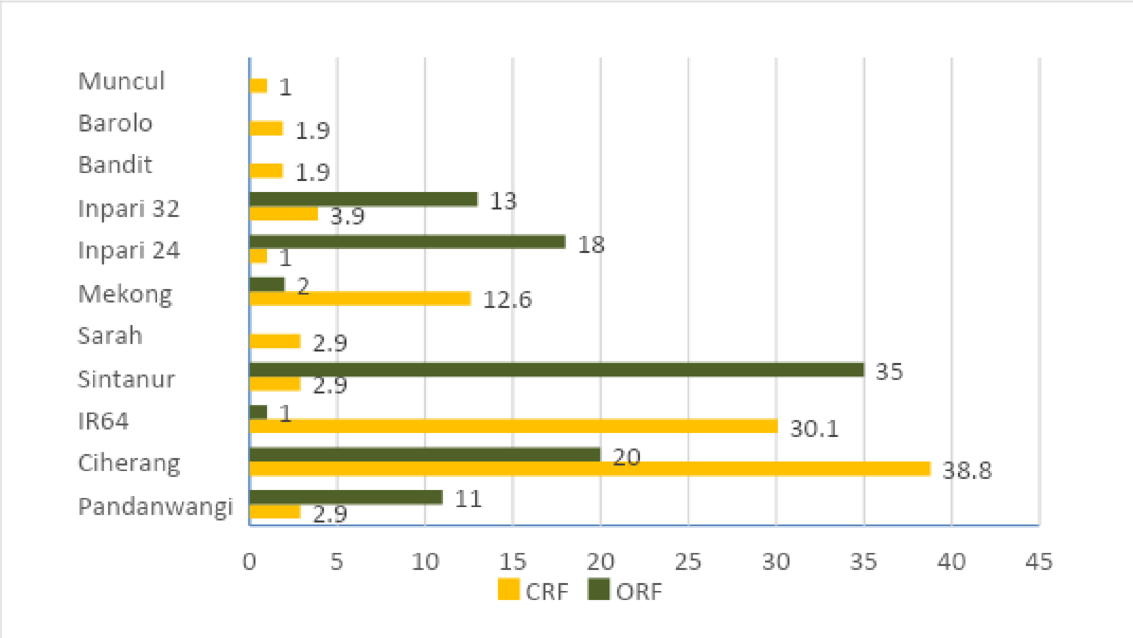

Fig 1. Rice varieties are used in organic and conventional rice farming.

Most rice varieties used in organic rice systems are aromatic high-quality cultivars with a premium price. Most organic farmers preferred to adopt Sintanur, an aromatic variety, while the cultivar used in conventional farming was Ciherang. Organic farmers also used Pandanwangi, an aromatic rice cultivar. The aroma and flavor of Pandanwangi wereparticular and demanded by consumers. Secondly, a popular cultivar of rice variety used by farmers for organic farming was Ciherang. Meanwhile,IR64 and other cultivars were promoted by the government and IRRI in conventional rice farming.The other preferred cultivar adopted by organic farmers wasInpari-24, which isthe red or brown rice cultivar invented by the Ministry of Agriculture, especially the Indonesian Center for Rice Research Institute (ICRRI). This farmers' likelihoodcultivar was based on the consumers'demand for rice quality attributes such as nutrition, appearance, flavor, and taste. Besides that, some farmers producing organic farming depended on contracts with buyers from other regions to be marketed in urban areas. This crucial finding explained that farmerswho adopted the organic system changed their preference to adopt a particular cultivar that has better quality, price, and market by adopting an organic system.

Organic farmers' primary rationale for utilizing particular rice cultivars were climatic endowment factors, land suitability, productivity, rice quality, premium price, and consumer demand (Figure 2). Most farmers were determined to plant one specific rice variety depending on produced quality, climatic endowment factors, and cultivar productivity, with 96%, 95%, and 91%, respectively. Furthermore, the organic farmers' insight also thought about price and consumer market demand, indicated by the higher proportion of farmers who revealed market demand (84%) and price (86%) than conventional farmers, market demand (62%), and price (47%). Meanwhile, conventional farmers had ordered primary reasons based on climate suitability, productivity, standard quality, market demand, price, and culture accordance. These findings show that organic and conventional farmers are motivated to utilize a specific variety. Fromthe implication perspective, if we are going to accelerate organic development, those reasons are beneficial for understanding farmers' motives so that organic farming can be supported and developed well.

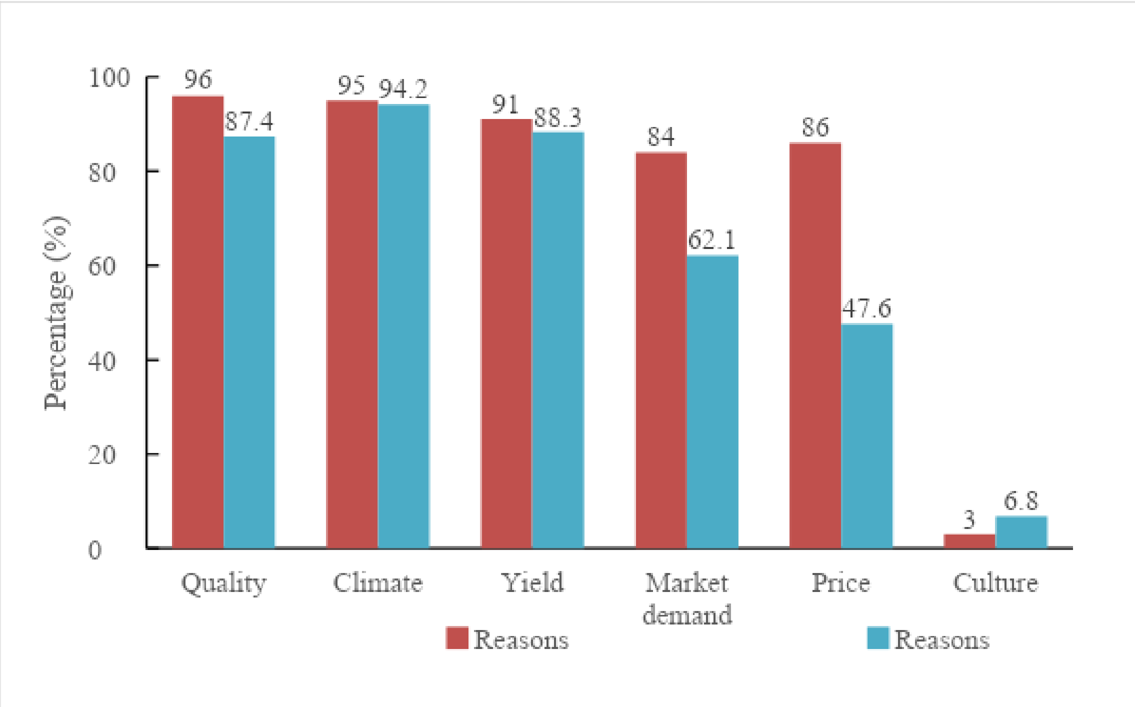

Fig 2.Farmers' reasons for using the varieties.

3.3 Cultivation technique

Table 1 presents the cultivation technique applied by ORF and CRF farmers. The transplanting method is the most planting technique used by farmers in Indonesia. Before transplanting the seed to the rice field, farmers sow the seed on the seedbed and take care of the seed growing until mature condition. Farmers use media of seedbeds made from fertile soil ameliorated with organic manure, husk ash, and compost. Both organic and conventional farmers conducted this treatment, and there was no significant difference in practices between them. The cultivar paddy seed was selected rigorously based on the seed quality and soaked one night. The seeds were wrapped inwet cotton or cloth until the seedsgrew buds. If the budding seed grew, the seed was ready to sow on the seedbed.Rarely do farmers use promoting microbe or bacteria, such as plant growth-promoting rhizobacteria (PGPR),*Pseudomonas,*and *Bacillus*, to boost growth and prevent pestdisease [19, 20]. The difference in cultivation technique between organic and conventional rice farming was in the transplanting date. Farmers tended to transplant their seed more quickly in the organic rice system than in conventional farming, with the average transplanting date in organic and conventional 16 + 3.9 and 19 + 2.4 days after sowing seed, respectively.In contrast, conventional rice farmers transplanted seeds longer than organic farmers. One similarity of cultivation practices was that they implemented spacing of planting mostly similar, 30 × 30 cm wide, and practicing seed planting 3–5 seeds per hole.

Table 1. The Frequency of implemented agricultural practices farmers practice in organic and conventional rice systems.

Farmers' activity related to rice farming practices	Organic farmers (n=100)				Conventional farmers (n=103)	
		Farmers' freq.	(%)		Farmers' freq	(%)
Planting system		Transplanting			Transplanting	
Time of planting (the day after seedling)		16 ± 3.9			19 ± 2.4***	
Planting space						
Indo jarwo		2	2.0		3	2.9
20 × 20 cm		1	1.0		15	14.6
25 × 25 cm		39	39.0		27	26.2
30 × 30 cm		58	58.0		58	56.3
Irrigation type						
Water pipe gravity	93	93.0		102	99.0	
Well pumping		7	7.0		0	0.0
Water from collecting from rain		0	0.0		1	1.0
Alternate Wet and Dry Systems		82	82.0		51	49.5
Farmers control water system depth from superficial.						
<50mm		74	74.0		23	22.3
>50mm		11	11.0		20	19.4
Famers did not control it		15	15.0		60	58.3

*** Statistic significance at 99% level.

Most irrigation systems in the study area generally come from river and secondary irrigation. Some farmers also irrigated their rice fields using gravitational pipes from water spring mountain. Few farmers irrigate their rice fields with water from the pump well (7%). The significant watering system was that the organic farmers preferred to use the Alternate Wetting and Drying system to water theirpaddy farm and control the water depthof less than 50mm. In local terminology, they called it *macak-macak* (in Bahasa).They claim that this model irrigation system is more efficient for water use and saving [21, 22].In contrast, conventional farmers did not control water, notably conceding the excess water passing through their fields. It shows that the water was utilized efficiently in ORF due to the plant water requirement.Farmers knew paddy was categorized as a plant needing water for biological growth.

3.4 Pest control management and fertilization

After adopting the organic rice farming system, farmers implemented the integrated pest control management system. Farmers used the IPM system because pest control was a crucial factor in the cultivation success. If they failed to manage the pest control, the economic loss they got would be high. The yield could decline drastically. The critical deference practice between organic and conventional is that organic rice farming is forbidden to use chemicals to control the pest.They must avoid using harmful and chemical pesticides. Instead, organic farmers use the manual barehand method of removing weeds and pests, biological predators, herbs, and leaves containing organic compounds as pesticides. No chemical herbicide was employedto remove weeds by organic farmers. All contrast is shown in Table 2. Therefore, organic farmers tried to shift pest control management from conventional farming to organic farming. Organic farmers used biopesticides from herbs and leaves of plants that were locally available but had pesticide and repellent effectson the pest. The herb such as soursop, neem, and citronella oil formulated the green biopesticide. Most of them made the biopesticide based on knowledge and information from the agricultural extensional officer and combined with their intuition and experience.

The farmers testified that they had implemented the Integrated Pest Managementsystem (82%) to suppress the pests under the economic loss level.However, afew conventional farmers claimed to adopt the IPM system to reduce pest cost expenditure.Organic farmers frequently conducted weed-cleaning of the rice field in the weeding agricultural practices. Organic farmers prefer to use bare hand-weeding systems. Some of them used modified mechanical weeders. That practices were done by women labor due to the workforce availability and lower incentive wage. In contrast with conventional farming, farmers used chemical pesticidesto control the weed.

Table 2.Control management practices of pests and diseases implemented by organic and conventional farmers.

	Organic farmers (n=100)			Conventional farmers (n=103)	
	Total freq.	(%)		Total freq.	(%)
Implementation of Integrated Pest Management	82	82.0		50	48.5
Controlling weed system					
▪ Manual by hand	96	96.0		60	58.3
▪ Machine	4	4.0		3	2.9
▪ Herbicides	0	0.0		40	38.8
Frequency of weeding	2.5±0.07	-		1.4±0.10	*** -
Suppressing weed by water control	92	92.0		84	81.6
Pest control					
▪ Utilizing organic repellent compoundandattractantcompound	28	28.0		11	10.7
▪ Biopesticide	90	90.0		18	17.5
▪ Utilizing predatoragainst pest	48	48.0		9	8.7
▪ PGPR	48	48.0		7	6.8
▪ Trapping cage for rats and pest	49	49.0		71	68.9
▪ Mechanical technique by bare hand	73	73.0		80	77.7

Notation of*** indicated the significance level due to independent t-test analysis at 99%.

Most controlling pest techniques in organic farming had a higher frequency than in conventional farmers' practices. Conventional farmers more commonly applied those two last methods. In organic farming practices related to controlling pests, farmers used herbs and essential oil as repellent agentsand attractantsdespitea very low level of adoption. These practices need the socialization of further techniques and knowledge from extensional officers. The neem, essential oil, white onion, soursop leaves, and other plants were frequently used as biopesticides.From giving questionnaires, they claim they never use nicotine from extracted tobacco as a pesticide. Some of them prefer to buy ready-to-use biopesticides from nearbyagricultural shops.Commercial biopesticidewas simple, efficient, and farmer-friendly in rice farming [23][22]. Nearly half of the farmers admitted using predators like owls or snakes to keep pests away from their properties. Organic farmers were concerned about the environment while they conducted their agricultural methods. Compared to traditional farming, they employed agricultural methods that are more environmentally friendly.Therefore, adopting organic farming, directly and indirectly, affects environmental aspects. Moreover, Anrunrat stated that organic rice farming had less carbon footprint and was environmentally sound[24].

3.5 Harvest and post-harvest practice

Agricultural practices in the post-harvest system were similar, and no difference between organic and conventional farming. Farmers harvest the paddy if the grains have reached the maturity indicated by age, color, and compactness of the whole seed. They harvested paddy rice with a power thresher harvesting machine and milled it with the milling machine. The harvested paddy was dried under solar light for 2-3 days. Harvesting should be separated from conventional rice farming in organic farming to preventproduct mixing. The organic rice was selected and purified from the rice bran. After those processes, organic rice was packaged in a vacuum-branded plastic bag and ready to deliver to consumers.

4 Conclusions

Organic farming has a differ agricultural practices than conventional farming systems in terms of variety, seed procurement, transplanting age, water management system, fertilization technique, and pest control management. Organic farmers prefer to use particular varieties with climatic land suitability, which have a high yield, good quality, and premium price due to expected high profit and fulfilling market demand. On the transplanting date, ORF had less seedling age than the CRFsystem and less number of provided seeds for planting. Organic farmers-controlled rice planting using the AWD irrigation system is efficient to water usability. They managed the water depth from the surface regularly. For pest control management, organic farmers have more awareness to adopt Integrated Pest Management (IPM) systems than conventional farmers, including suppressingweeds through water control. This practice has economic benefits using potential local herb plants. However, they still conducted hand-weeding practice manually. Farmers in organic systems used more variation pest control systems than conventional farming, such asrepellents and attractants, biopesticides, predator insects, biocontrol, and manual techniques.

Future research is focused on developing a superior variety that is highly productive and under the consumers' preferences and market demand. Despite this, research on providing low-cost and applicable integrated pest management is essential to overcome pest attacks. Farmers must increase their knowledge of good organic rice farming practices. By doing so, farmers can prevent declining production in the conversion period. Government and other actors should continuously promote field schools and training in organic rice farming practices.

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