WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Summarising the Technical and Economic Achievements of the Organic Rice Production Model in the Intensive Farming Area of an Giang Province, Vietnam

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A B S T R A C T

From 2019 to 2021, farmers in Tri Ton district, An Giang province, were sponsored by the Department of Science and Technology of An Giang Province in the framework of the “4 H” project, turning the area into an organic rice specialising region. The organic rice production model was implemented by the Asian Organic and Agricultural Research Institute (AOI) to guarantee the product’s quality to international standards such as USDA (USA), EU (European Union), and JAS (Japan). After 3 years, the implemented model got a significant success. The number of chemicals prohibited from being used in organic production and heavy metals in the soil, water, and final products decreased steadily during the implemented period. There was no sign of them in the final products. Although inorganic rice yielded slightly more than organic rice, the net profit was 20% higher because the total investment in organic rice was 8.4% lower. The selling price was higher than inorganic production. In An Giang province's intensive farming area, the organic production model is sustainable and economically efficient. Therefore, organic rice production can help to increase profit for farmers and contributes to sustainable farming practice.

Keywords: Organic Rice Production Model, Farming, Giang Province

1. Introduction

India is one of the leading countries producing organic products. According to Singh and George (2012), farmers in India have utilised organic farming since the time memorial, with a gradual shift to inorganic agriculture since the 1950s. The heavy use of chemicals during the Green Revolution led to health and environmental hazards. In addition, this also leads to a decrease in soil fertility with stalled productivity and reduced efficiency. The growing demand for healthy food and a clean environment has encouraged the return of organic farming.

Marmefelt (1998) stated that Laos’s farmers rely heavily on subsistence farming like farmers from many developing countries. One of the fundamental factors in increasing the livelihood of the rural population, especially for small farmers, is to increase their income from farming. One of the feasible plans is to switch from typical subsistence farming to export-oriented organic agriculture, as the international market for organic products is growing, and consumers are willing to spend more on them. Laos also has good conditions for growing organic rice. Organic rice in Laos has risen over the last decade as a large amount of organic rice is produced and exported. Most organic rice is produced by small farmers in support programs or farmers who sign contracts with agricultural firms.

Kennvidy (2011) emphasised in his research that organic farming is an essential system of agriculture and general food production. It is a sustainable method and can generate positive impacts in a rural community. The development of organic agriculture in Cambodia had just begun. Thus, this research aimed to gauge the perception of farmers toward organic rice and the system’s efficiency. Data gathering was done by interviews, both directly and

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indirectly, and the analysis was done with analytical programs for social science. The results show that most farmers switched to organic farming because the selling price was higher, and their income was boosted by 15% compared to when they used the traditional method. Areas suited for rice farming can increase rice yield by 5%, from 2.46 to 2.59 tons per ha, with the total rice production rising by 21%. Moreover, organic farming can be more financially stable due to higher economic profit.

Thomas Marfelt (2011) also analysed the reasons behind these structural changes by using evolutionary economics theory pioneered by economists like Schumpeter (2003) and Marmefelt (1998), which focuses on transforming firms and banks as a foundation for changes in the economy. The research emphasised the importance of contract farming in this process. Analysis showed that two types of pressure cause farmers to switch to organic rice farming. The first reason was that the price is higher for organic rice (42%). As the demand rose in the international market, this pressure came from the market, pushing the price higher. This led to increased production with higher prices and more profit for organic rice growers. The switch to organic rice cultivation can be seen as a demand-pushed transformation. In the paper, the author did not make sure if the change would happen without the participation of agricultural companies. The farmers had no capital to grow organic rice and no channel to sell their organic rice in the international market. The author concluded that the ability to enter contracts with firms to provide the market information, channels for new markets, initial investment, and technological support enable farmers to switch to organic rice farming.

Since 2015, scientists at the Institute of Agricultural Sciences for Southern Vietnam (IAS) and AOI have developed the rice-shrimp model in Vietnam. It has since brought improvements in the economic, social, and environmental aspects in 6 provinces with the rice-shrimp model in the Mekong Delta (Nguyen and Van, 2021). However, spreading this model to specialising rice areas capable of two to three crops a year in An Giang province specifically and the Mekong Delta, in general, is not easy.

To construct an organic rice model in specialising rice areas in Tri Ton district, An Giang province, Viet Nam, we have organised farmers into cooperatives and invited firms to enter contracts with the cooperatives and farmers to cultivate and consume organic rice. This study aims to report the achievements of production techniques and economic efficiency of the organic model built in the intensive farming area of An Giang province. The initial implementation faced many problems, but the project has brought positive results (Fig. 1). The project has been sponsored by the Science and Technology Department of An Giang province and Oxfam in Vietnam.

Fig. 1 - Model of organic rice in the rice-intensive farming area of An Giang province.

2. Materials and Methods

2.1. Materials

Hong Ngoc Oc Eo variety (i.e., belongs to the Oryza sativa species), having a growing duration of 95 days, was chosen to cultivate in the project area. Organic fertilisers were imported from Italy with OMRI certification and other products allowed for use in organic farming.

2.2. Study site

The model was built from March 2019 to July 2021 in Luong An Tra commune, Tri Ton district, An Giang province, Vietnam (Fig. 2).

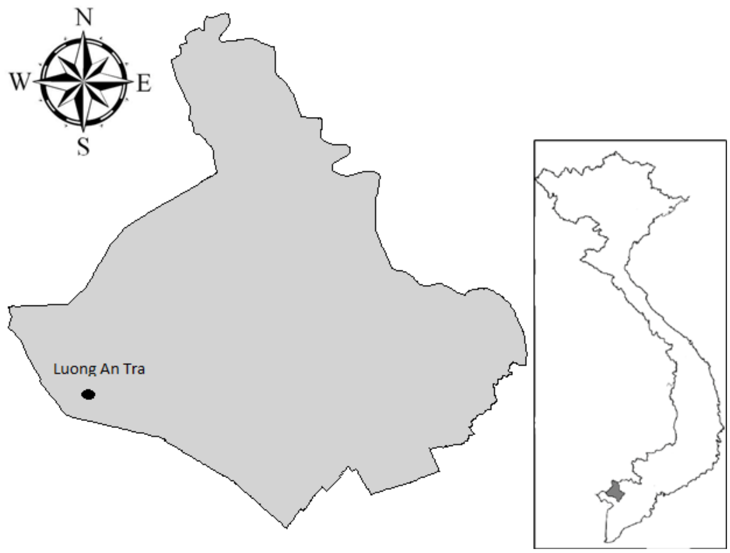

Fig. 2–Location of the organic rice model

2.3. Methodology

The organic rice model in Tri Ton district, An Giang province, was registered to be certified 100% organic by international standards such as USDA (US Department of Agriculture), EU (European Union), and JAS (Japan). The cultivation procedure was audited and certified by a third party for every crop. It can be summarised as follows: soil and water were analysed and must pass safety standards. The farms should be assembled and adjacent to each other with secured water sources. They should be far from industrial zones and have a buffer zone separated from the inorganic production area. Organic compost could be used. However, organic fertilisers needed to be certified by authorisedorganisations. Crops were protected using natural enemies, pestilence-resistance varieties, and biological traps. It eliminated weeds by rotating crops, preparing the soil using mechanical methods, and picking out the weeds by hand if needed. Non-GMO (genetically modified organism) crops were used. The organic farming process was controlled internally by the ICS (internal control system). The harvesting, processing, packaging, and transportation of the final product were checked by ICS to prevent the mixing of inorganic materials. They were branding the products with organic-certifying logos according to international standards.

Farmers who participated in this model were selected according to their self-motivation to follow the procedure. Farmers were trained in production techniques thoroughly to know how to record input and output data from the fields, and they were organised into groups belonging to a cooperative linked with firms. The firms provided farmers capital and contracted to consume the final products.

Before project implementation, irrigation water, soil, and plants were sampled to check for heavy metals and pesticide residues for choosing the appropriate area to deploy the project. Plant samples were collected during and after project implementation to contain the contaminated pesticides according to the organic standards. Heavy metals were tested based on the ISO/IEC 17025 standard of the National Institute for Food Control (2022). Plant samples were extracted and analysed using GC-MS/MS, described by Braun et al. (2018) and LC-MS/MS, characterised by Shah et al. (2015). The input and output data were gathered and analysed by the Excel program.

3. Results and Discussion

3.1. Assessment of soil, water quality before project implementation

Before the project implementation, the soil, water, and plant samples were collected to evaluate the environmental status of the production areas according to standard organic criteria. The data was gathered and represented in Table 1.

Table 1 - Result of heavy metal analysis in soil, water, and plant samples before project implementation.

No.	Parameters	Methods	LOD	Detected concentration (mg kg^{-1})		
			(mg kg^{-1})	In soil	In water	In rice
1	Cadmium (Cd)	AAS	0.003	4.10	N. D	<0.025
2	Lead (Pb)	AAS	0.003	0.25	N. D	<0.06
3	Arsen (As)	AAS	0.003	21.6	N. D	0.24
4	Mercury (Hg)	DMA-80	0.003	N. D	N. D	N. D

(N.D: Not detected; LOD: limit of detection). AAS: Atomic absorption spectroscopy, DMA-80: Direct Mercury Analysis System.

The soil samples collected in the project area detected heavy metals, including arsenic (As), cadmium (Cd), and lead (Pb), with concentrations of 4.1, 0.25, and 21.6 mg kg^{-1}, respectively. However, mercury (Hg) was not detected. Because arsenic (As) naturally occurs in the soil and elsewhere in the environment, the New South Wales Department of Primary Industries suggests that agricultural soil should have less than 20 mg of arsenic per kg of soil. Different guidelines may depend on other areas, but this is a good general guide. At the same time, cadmium (Cd) is a non-essential trace element that is widely distributed in the environment. Both geogenic and anthropogenic sources can elevate cadmium (Cd) concentrations in soils and groundwater. In soils, cadmium (Cd) occurs at 0.01 to 1 mg kg^{-1} with a worldwide mean of 0.36 mg kg^{-1} (Kubier et al., 2019). According to WHO (2000), renal effects in areas contaminated by past cadmium emissions indicate that the general population's cadmium body burden in some parts of Europe cannot be further increased without endangering renal function. To prevent any further increase of cadmium in agricultural soils likely to increase the dietary intake of future generations, a guideline of 5 ng m-3 is established. In the case of lead (Pb), Pb-contaminated soil can pose a risk through direct ingestion, uptake in vegetable gardens, or tracking into homes (Lanphear et al., 2005). The standard for lead (Pb) level in the soil is less than 50 parts per million (ppm), but soil lead levels in many urban areas exceed 200 ppm (U.S. Department of Health & Human Services, 2022). Eventually, The acceptable limit for mercury in the soil suggested by Revis et al. (1990) was 722 ppm. Comparing the literature data to the test result, we see that the present concentration of heavy metals in the examined area is acceptable for rice cultivation.

The water sample did not contain heavy metals like arsenic (As), cadmium Cd, lead (Pb), and mercury (Hg). So, the water in the project area was considered satisfactory for organic rice production.

The plant samples were contaminated with three kinds of heavy metals, including arsenic (As), cadmium Cd, and lead (Pb), with concentrations of <0.025, <0.06, and 0.24, respectively. According to the upper limit of heavy metals (ULHM) in food by the Ministry of Health(2011), the acceptable levels of heavy metals in nutrition are as follows: Arsenic (0.5 – 1.0 mg kg^{-1}), cadmium (1.0 – 2.0 mg kg^{-1}), and lead (0.02 – 0.5 mg kg^{-1}). So, with low contamination with heavy metals, rice plants grown in the project area would be fine to meet the requirements of organic standards. Moreover, when grown under the organic procedure, the risk of heavy metal contamination will be reduced because the inputs would be strictly managed.

Table 2 - Result of pesticide analysis in plant samples before project implementation.

No.	Parameters	Methods	LOD (mg/kg)	Concentration (mg/kg)
6	Tebuconazole	GC-MS/MS	0.005	<0.01
7	Isoprothiolane	LC-MS/MS	0.003	<0.01
8	Tricyclazole	LC-MS/MS	0.005	0.71
9	Hexaconazole	GC-MS/MS	0.007	<0.01
10	Propiconazole	GC-MS/MS	0.007	N. D
11	Spinosad A	LC-MS/MS	0.003	N. D
12	Spincaed D	LC-MS/MS	0.003	N. D
13	Acetamiprid	LC-MS/MS	0.003	N. D

(N.D: Not detected; LOD: limit of detection)

According to the rice exporters, 8 residual pesticides should not be existed in rice for exporting to the European market, including tebuconazole, isoprothiolane, tricyclazole, hexaconazole, propiconazole, spinosad A, spinosad D, acetamiprid (self-interview, 2019). On the other hand, farmers usually use these pesticides to control pests and diseases on their farms. These chemicals need to be tested before the project is implemented to prevent farmers from using them in the following seasons. According to Table 2, spinosad A, spinosad D, and acetamiprid were not detected, while tebuconazole, isoprothiolane, and hexaconazole were not detected,tricyclazole, and propiconazole was detected in the rice samples. Among them, tricyclazole and propiconazole may be used widely by farmers since their heavy contamination with 0.71 and 0.6 mg kg^{-1}, respectively.

3.2. Chemical residues assessment of the built organic rice model

After 3 years of farmers joining cooperatives and participating in the project, the organic rice model was 100% organic certified by Control Union (CU). According to the CU's organic audit program, the rice samples were tested for 854 different chemicals (Duong et al., 2022). The result showed no toxic chemicals inhibited from being used in organic production like herbicide, fungicide, insecticide, growth booster, etc., in the rice sample.

3.3. Economic efficiency assessment of the built organic rice model

The project's area spans 40 ha of the summer-autumn and winter-spring harvests in Luong An Tra commune were observed and analysed to see the difference between the inorganic rice model and the organic rice model with similar external circumstances.

Table 3 - Invested costs of organic and inorganic rice production in Luong An Tra commune during 2019 – 2021.

No.	Invested costs	Summer-autumn (1000 VND ha^{-1})		Winter-spring (1000 VND ha^{-1})	
		Organic	Inorganic	Organic	Inorganic
1	Seeds	1.000	1.728	1.000	1.728
2	Fertilisers	5.810	5.300	200	200
3	Herbicide/ weeding by hands	3.000	6.400	5.530	5.200
4	Pesticides/ natural products	320	3.800	2.800	320
5	Soil preparation works	1.800	1.800	320	3.500
6	Seed treatment works	200	200	1.600	1.600
7	Irrigation works	1.500	1.500	1.500	1.500
8	Spraying works	1.200	2.000	1.200	1.800
9	Fertilising works	1.200	800	1.200	800
10	Sowing works	500	500	500	500
11	Harvest works	2.000	2.000	1.800	1.800
Total costs		**18.530**	**20.268**	**17.650**	**18.948**

Source: monitoring 40 ha of which 50% organic production, 50% inorganic production

Table 3 shows the cost comparison between rice and inorganic rice production. The production cost for the organic model was 18.530 million VND ha^{-1}, and that of the inorganic model was 20.268 million VND ha^{-1}. Despite the cost of weeding by hands being higher in the organic model, the organic model used lime instead of pesticides. Few seeds were used in the organic model, thus saving around 2 million VND ha^{-1}. The production cost for the organic model for the winter-spring harvest 2019-2020 was 17.650 million VND ha^{-1}, and that of the inorganic model was 18.948 million VND ha^{-1}. Thus, the production cost of the organic model was lower by 1 million VND ha^{-1}.

Data on organic and inorganic production models were gathered to compare their economic performance. Fig. 1 shows the models' total income, expenses, and net profit. The results show that the entire income in organic rice production was higher in both the winter-spring and summer-autumn crops than in inorganic rice production. Hence, the total revenue in organic production for the entire year (including two crops) was 6% higher than inorganic production. Meanwhile, total investment in organic rice production was 8.4% lower than inorganic rice production in both crops. As a result, organic production has a net profit of 20% higher than inorganic production, which is impressive. Although inorganic production yields are high, organic production yields are slightly higher, but net profit is higher due to lower production costs and a higher selling price. This finding indicates that the organic rice production model's economic efficiency is very promising.

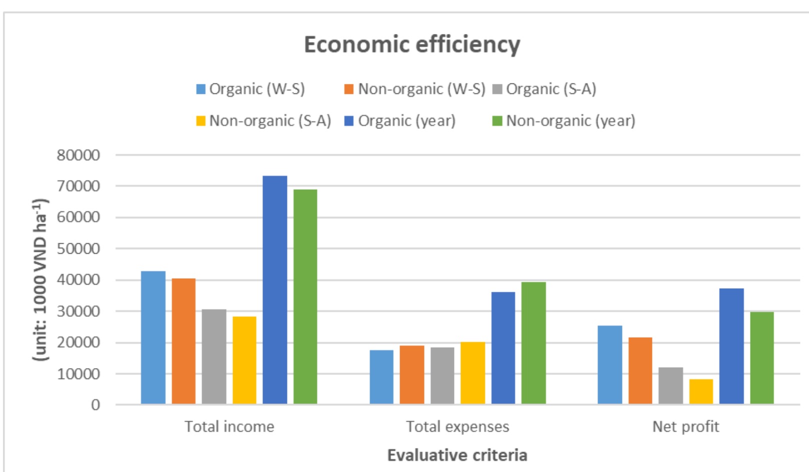

Fig. 3 - Economic efficiency of organic versus inorganic rice production during 2019-2021 in Luong An Tra commune. Organic (W-S): organic rice produced in the winter-spring crop; Organic (S-A): organic rice grown in the summer-autumn crop; Non-organic (W-S): non-organic rice produced in the winter-spring yield; Non-organic (S-A): non-organic rice produced in the summer-autumn crop; Organic (year): organic rice produced in a year, including winter-spring crop and summer-autumn crop; Non-organic (year): non-organic rice produced in a year, including winter-spring crop and summer-autumn crop.

4. Conclusion

Rice in the organic model was cultivated and processed according to organic standards. At the beginning of project implementation, soil, water, and rice plant samples were collected to test for the presence of toxic chemicals and heavy metals. Rice plant samples were also orderedto evaluate the presence of pesticide residues at the end of project implementation. The substances prohibited from being used in organic production were not detected in the final products after three years of project implementation. Data were also monitored for evaluation of economic efficiency. Although inorganic rice yielded slightly more than organic rice, the net profit was 20% higher because the total investment in organic rice was 8.4% lower. The selling price was higher than inorganic production. In An Giang province's intensive farming area, the organic production model is sustainable and economically efficient. As a result, this model must be expanded to assist producers in increasing economic efficiency, ensuring consumer health, and contributing to long-term environmental protection.

Acknowledgements

Special thanks to Oxfam in Vietnam for financial support and assistance to conduct the project on building an organic rice model and linking the value chain. We are also very grateful to the esteemed reviewers for their time and expert opinion.

Conflicts of interest

The authors declare that they have no conflict of interest.

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