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Comparative study on agrochemical residue on rice cultivation in Tasikmalaya, Indonesia: organic versus conventional

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This study was designed to examine the agrochemical residue and farmer characteristic strategy in two methods of rice cultivation, organic and conventional. Two groups of farmers were examined, each group (n = 18) with five hectares of land for rice cultivation. This study conducted rapid rural appraisal (RRA) and focus group discussion (FGD), and determined agrochemical residue in water, soil and paddy. The results show that organic rice cultivation has a higher margin of profit at 0.32 USD/kg as compared to conventional rice cultivation, which is about 0.12 USD/kg. In organic rice cultivation, farmers have to spend more time in the cultivation process as opposed to the conventional forms of cultivation. This is mainly due to the time-consuming manure preparation process as well as plant protection. Agrochemical residues are detected only in conventional rice cultivation. Diazinon, Aldrin, Heptachlor, and Dieldrin were detected as the major chemicals present. Diazinon was detected in the water, soil and plants with a frequency of occurrence at 60%, 80% and 40%, respectively. Aldrin, Heptachlor and Dieldrin were detected in plants with the frequency of occurrence at 40%, 60% and 60%, respectively. Furthermore, heavy metals such as Mercury (Hg) and Arsenic (As) were also detected in the water with a frequency of occurrence at 10% and 40%.

1. Introduction

Rice is one of the most important food crops for over half of the world's population, especially in and around Asian countries, as a staple source of nutrition, providing carbohydrates, protein, fat, vitamin, and minerals. In modern agriculture, agrochemicals (both pesticides and synthetic fertilisers) play an important role in intensive agriculture. Indonesia is an agricultural country with approximately 8.087 million hectares of land area used for rice cultivation (BPS, 2018). Large amounts of agrochemicals are used to control pests, weeds, and diseases to protect the crops and increase agricultural production. In 2016, over 3.930 agrochemicals were registered in Indonesia (DSPKP, 2016). Pesticides of various kinds have been used on a large scale in Indonesia since the beginning of the green revolution between 1980–1990 (David & Ardiansyah, 2017a). Green revolution refers to the set of research and technology transfer in agriculture to increase agriculture production. They are used globally in the industrial agricultural system to control pest population; they protect crops from losses/yield reduction, improve the quality of rice and prolong shelf-life (Abdollazadeh et al., 2015; Onojoh, 2013). According to Aktar et al. (2016), there are different types of pesticides including insecticides, fungicides, herbicides, rodenticides, molluscicides, and nematicides. The uses of chemical fertilisers have become an essential component of modern rice production technology to provide appropriate nutrients for higher rice productivity (Singh & Singh, 2017). Food Agricultural Organization (FAO) reported that the use of fertiliser, such as Nitrogen (67%), Phosphate (33%) and Potassium (22%) increased significantly from 2002 to 2014 worldwide (FAOstat, 2018).

Pesticides have played an essential role in improving public health through disease vector reduction and increased food production (World Bank, 2008). Despite its benefits, the use and disposal of pesticides have resulted in the undesirable release of these toxic chemicals directly into the environment. While beneficial in farming, it produces several negative effects such as environmental pollution and risks to human health owing to their agrochemical residue in rice. Recently, farmers have begun to shift towards organic farming; they have begun fertilising soils and protecting crops with organic and sustainable techniques to offer healthier food and ensure environmental sustainability. This condition is followed by a massive demand for organic rice of premium quality (Hazra et al., 2018).

Organic rice is the second most purchased organic product in Indonesia (David & Ardiansyah, 2017b). The increase of organic food product consumption is triggered by the consumers' awareness of healthy foods and their concern regarding environmental protection (David & Ardiansyah, 2017b). Many studies have reported health as the foremost reason behind the increase in consumers purchasing organic foods. Baudry et al. (2018) suggested that an organic food-based diet may help reduce dietary pesticide exposure for at least a few organo-chemicals, such as those belonging to the organophosphate and pyrethroid families. However, Benbrook and Baker (2014) stated that organic food is not entirely free of pesticide residue. Data shows that organic foods are more likely to have pesticide residues than conventional, though far less likely to have multiple residues of pesticides. Additionally, on average, the pesticide level in organic foods is significantly lower than in inorganic foods (Smith-Spangler et al., 2012).

Studies have also compared organic farming with conventional farming systems across different parts of the world in terms of soil nutrient contents, yields, economics, biodiversity, environmental impact, greenhouse gas emission, carbon sequestration, energy use, groundwater pollution and food quality (Jahanban & Davari, 2013). On the one hand, farmers are aware of the health concerns caused by pesticide use and feel concerned about plant diseases (Luck & Grimm, 2018). The consumption of pesticide-contaminated foods may pose potential health risks; therefore, the contamination of the environment and food by pesticide residues is a significant issue in many parts of the world (Rice et al., 2007; Li et al., 2008; Karunamoorthi et al., 2011; Mohanthy et al., 2013).

The understanding of farmers' perceptions about the risk of pesticides and the determinants of pesticide overuse are important aspects that can help to modify their behaviour towards reducing the usage of pesticides (Jallow et al., 2017). The determination of pesticide residue in food becomes the essential requirement for consumers, producers and authorities. Therefore, to address consumer expectation of lesser agrochemical residue in organic agriculture in Indonesia, this study compares organic and conventional rice cultivation in the context of agrochemical residue.

2. Materials and Methods

2.1.Study sites

The study was conducted in the Southeast part of Tasikmalaya Regency in the West Java Provinces. Tasikmalaya Regency is one of the most critical organic agricultural areas in Java. Recently, it has been reported as one of the regencies that exports organic rice to Europe. This study focuses on two groups of farmers; one group of organic farmers and the other group of conventional farmers. The first group is an organic farmers' group named 'Sriwantani', located in Kampung Cipalegor Kecamatan Sukehening, and the second group is a conventional farmers' group named 'Jati Karya' Kecamatan Jamanis. The distance between both groups is 7 km. Both areas are located approximately 500 m above sea level, and the rate of rainfall is about 2.000 mm/year. The daily temperature on average is 18^0C–25^0C. These areas were selected for this study because these regions have similar geographical, cultural and practical characteristics but with differ-

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ent modes of cultivation. Data were collected between June–July 2018.

2.2. Ampling procedure

This study has been divided into four steps: (1) Survey diagnostic by using Rapid Rural Appraisal (RRA), (2) Focus Group discussion with farmers, (3) Collecting sample (plant, soil and water), and (4) Agrochemical residue determination.

2.2.1. Rapid rural appraisal (RRA)

RRA aims to examine the extent of contamination in organic farmlands as well as conventional ones. It generates information such as dosage, area of usage, type of agrochemical used, frequency of usage, productivity and rice varieties cultivated.

2.2.2. Focus group discussion (FGD)

FGD aims to gather information from farmers regarding their strategy when using pesticides and other agrochemicals. Furthermore, FGD also attempts to confirm the information gathered from RRA.

2.2.3. Sampling of soil, water, plant

Based on the RRA and FGD, soil, water and plant samples were collected by using grid systems. The soil was collected at a depth of 0–20 cm. One soil sample consisted of five sub-samples, which were taken from a 100-meter radius. Each subsampling was mixed, of which only 0.5 kg was collected. Water samples were collected from the river and from the water that flows through channels. Each water sample consisted of five sub-samples, which were mixed, of which only 500 ml was collected. Plant samples were collected by cutting the leaves and stems of paddy stalks. Each sample consisted of five sub-samples, that were mixed and, only 100 gr were collected. Each sub-sample consisted of 20 gr. All the sub-samples were stored in a tube container that was subsequently placed in a 50 L cool box. For one day, the samples were transported by car to the laboratory.

2.3. Agrochemical residue analysis determination

2.3.1. Gas Chromatography Mass spectrometry analysis (GC MS)

The analysis of agrochemicals was performed using the GC method. This method of analysis was described by Cid et al. (2007). Two kinds of extraction were used: Solid Phase Extraction (SPE) and Liquid-Liquid Extract (Falaki, 2019). Each sample was injected in the split mode on a Thermo Finnigan GC equipped with a 63 Ni-μ electron capture detector (ECD). The GC analysis employed a DB-5 MS capillary column (30 m x 0.25 mm; with a film thickness of 0.25 μm). The GC column temperature was programmed from 150^0 C to 300^{0}C at 8^{0}C/min and held at 300^{0}C for 10 min. The injector and detector temperatures were 250^0 to 300^{0}C. The Helium carrier and Nitrogen making up the gas flow were set at 150^{0}C at 2 and 3 mL/min. All samples were analysed for 16 OCPs.

2.3.2. High-Performance Liquid Chromatography-UV detection (HPLC)

Agilent Technologies 1220 infinity high-performance liquid chromatography with a UV/visible detector was used for the identification and quantification of pesticides. The separation was performed on a reversed-phase C-18 column (Water). The samples were injected manually. The detector was connected to the computer for data processing. In this study, a reversed-phase semi-micro column was used for simultaneous determination, reducing the solvent volume and measurement time and obtaining high separation. These pesticides, capable of determination by HPLC, were mainly selected among other pesticides to set a regulated value in Japan. Recovery tests from samples were ultimately performed for 27 pesticides. These were divided into five groups because the retention times of some of the pesticides were very close. The working condition of HPLC was binary gradient; the mobile phase was acetonitrile: water (60:40), the flow rate was 0.3 mL min-1, the injection volume was 25 μL, and the wavelength of the UV/visible detector was fixed at 254 nm for the pesticides.

2.3.3. Heavy metal analysis

Hg and As levels in the soil and plants were analysed by a two-step process: dry-ash and acid digestion. First, samples (5 g) in a crucible were dry ash by removing moisture at 105°C for 6 h. After, the dried samples were placed in the furnace at 500~600 °C for another 12-14 h until they turned into a white ash mineral. For the second step of acid digestion, the ash samples were dissolved in concentrated nitric acid or HNO3/H2O2 with appropriate dilution (the samples being diluted to 25 mL with deionised water). Heavy metals in the acid-resolved samples were determined by using an atomic absorption spectrophotometer.

2.4. Data analysis

Descriptive analysis and cross-tabulations were used to simplify and compare the quantitative data, observation and measurement. Data are presented as mean ± SEM.

3. Result and Discussion

3.1 Observation

In both organic and conventional rice cultivation, the crops are irrigated by water spring. Water is available throughout the year, and both groups use similar varieties of seed "Sintanur". Wet rice cultivation is the most common type of agriculture (crop) in both groups. Based on FGD, the farmers admitted that the use of agrochemicals was higher in the conventional groups. This condition is confirmed by the study conducted by Luck and Grimm (2018) in Tasikmalaya. They stated that nearly 97% of respondents used synthetic fertilisers during the last planting period in the year of 2017. They also reported that the use of organic manure and organic pesticides was lower than 9% within the total number of respondents.

Most of the farmers in both groups have been farming for 13–20 years. However, the organic farming group began only four years before the study. The average land ownership is only 0.18 hectares for organic farming and 0.21 hectares for regular farming. The ownership of organic agriculture is lower than the national average of land ownership (BPS, 2018), which reported that the average amount of land owned by Indonesian farmers is 0.20 Hectares. A challenge here was that 0.20 Hectares of land was, in most cases, owned by farmers only as sharecroppers, as shown in Table 1.

The average respondent in our study is male, married and 54 years old. The average household size is three hectares for organic farmers and 4–5 hectares for conventional farmers. Organic rice cultivation only needs, on average, 0.8 USD/ha cost for plant protection by using organic pesticides. This is considered lower than conventional cultivation, which is up to 16.17 USD/ha. The cost is only calculated from how much farmers need for pesticide usage (organically or synthetic pesticide). Even though the cost for plant protection for organic farmers was lower than conventional farmers, the working time for plant protection was three times higher than for conventional farmers.

The margin of profit is calculated from the price gap between unhulled rice with a final selling price. The organic farmers gain a higher margin of profit compared to the conventional farmer. According to Tashi and Wangchuk (2016), the case study of organic and conventional rice production in Buthan found that the benefit-cost ratio was significantly higher in conventional cultivation. Furthermore, Pattabaont and Shivakoti (2009) found that organic rice production increases labour costs. Organic farmers believed that they have to spend more time on plant protection compared to conventional farmers.

According to Luck and Grimm (2018), who researched Tasikmalaya, on an average, households retained around half of their harvest for their consumption and the other half was sold or handed over to their landlord, based on the sharecropping arrangement. This condition was also prevalent in the area of our study, where both organic and conventional farmers sold half of their harvest to middlemen and kept the other half for consumption.

3.2.Focus Group Discussion (FGD)

Based on FGD, eighteen farmers in each group voluntarily participated in FGD. The farmers admitted that they often have to discuss their strategies on managing pests and diseases prior to cultivation (Table 2). Almost 55.5% of conventional farmers possess knowledge of the detrimental impact of pesticides on the environment. However, they continue adapting to the use of synthetic fertilisers and pesticides. In contrast, most of the organic farmers understand the gravity of the adverse impact of synthetic pesticides on their environment.

In Table 2, both groups' strategies for plant protection, as explained by the farmers, has been provided. Organic farmers use spice and other organic pesticides that are self-prepared. Most of the organic farmers

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Table 1. Comparison of organic and conventional farmers

Characteristic	Organic (n=18)	Conventional (n=18)
Farmers Age (years old)	54.94 ± 9.997	54.64 ±8.85
Education	Elementary School (n=15) Junior High School (n=3) Senior High School (n=0)	Elementary School (n=16) Junior High School (n=1) Senior High School (n=1)
Land (m^2)	1868.13 ± 863.29	2162.35± 959.58
Average of HH (persons)	3	4.5
Farming (years)/Organic (years)	19.83 ± 13.62 / (3.55± 0.78)	13.82 ±7.86
Land ownership	Owner (n=10) sharecroppers (n=8)	Owner (n=8) sharecroppers (n-10)
Cost for plant protection (USD ha^{-1})	0.8 ± 0.43	16.17 ± 3.12
Time spending for plant protection (hr)	4±0.08	1±0.5
Cost for Manure/fertiliser (USD ha^{-1})	20.03	92.85
Yield (kg/ha)	4246.03±456.52	6100.05±30.01
Margin of profit (USD kg^{-1})	±0.32	±0.21
Selling price of unhulled rice (USD kg^{-1})	0.41±0.016	0.31±0.010
Final Selling price of rice (USD kg^{-1})	0.73±0.075	0.52±0.075

HH: Households

have the required knowledge about different organic pesticides. Conversely, conventional farmers use insecticides, fungicides and herbicides frequently. Pesticides were the most frequently used agrochemical.

Both groups were exposed to organic rice production; there is a program of the local government of Tasikmalaya to increase organic rice production. However, only a group of farmers called Sriwantani agreed to convert their land completely and change to organic methods. The reason for the farmers' conversion is mainly due to a belief that the soil dries with the use of synthetic pesticides as well as syntenic fertilisers. Organic experts supervised the conversion. Meanwhile, a group of farmers called Jati Karya argued that they do not have a strong enough reason to convert their land to accommodate organic cultivation. So far, this group believes no issues have arisen from the use of synthetic fertiliser, both cost or environmental concerns. The degree of the 'do not' awareness about pesticides is strongly affected and influenced by their pest management methods. The implementation of alternative methods of pest control as determined by the farmers is based on the knowledge of the pros (beneficial effects) and cons (harmful effects) of using pesticides. Several variables have influenced their pest control strategies and attitude regarding pesticide use. It is entirely subjective and may depend on their socio-economic characteristics, farm characteristics, personal beliefs, tradition, perceptions and preferences (Abdollahzadeh et al., 2015). Pesticides enter and pollute any component of the environment in several ways, including application, accidental spillage or through the unauthorised dumping of pesticide products right on their container (Akoto et al., 2016).

According to Shahnaj (2010), the more educated farmers are, the more aware they are of the pesticide residue problem. However, in this study, the level of education of farmers does not reflect their motivation in converting from conventional to organic cultivation. Convincing farmers that their perceptions of crop-yield loss due to pest-related disease are over-estimated and helping them improve their knowledge of pest management and pesticide safety do not, thus, serve as adequate arguments. Based on FGD, the organic farmers admitted that they were willing to convert from conventional to organic cultivation owing to the desire to keep the spring free from pesticide contamination and wanting to get better prices in the sale of produce as well.

3.3.Agrochemical residue

3.3.1 Organophosphates

The most common types of synthetic pesticides used are chlorinated hydrocarbons, organic phosphorus pesticides, and carbamate pesticides (Sawyer et al., 2003). Among the organophosphate pesticides, Diazinon was found to be a frequently recurring pesticide with 60% of presence from the total sampling in the water sample, 80% in the soil sample, and 40% in the plant sample (Table 3, Table 4, and Table 5). However, the Indonesian pesticide residue standard SNI 7313: 2008 regulated that the amount of maximum residue is allowed to vary based on a particular chemical compound. The occurrence of Diazinon is high in the soil sample, which is 80%, followed by 60% in the water samples. The residue levels of Diazinon exceeded the Indonesia national standard in water and soil samples. Organophosphorus pesticides, such as Diazinon, are more resistant to microbial degradation (Akoto et al., 2016).

Table 2. Frequency and plant protection strategy by farmers

List of Strategy	Organic	Conventional
Type of organic pesticide	Lemongrass, Dioscorea hispida Dennst, Cosmos caudatus, Nicotiana spp., L, Annona squamosa L., Annona muricata L., Allium sativum L., Tinospora crispa (L.)	Insecticide (n=7) (Peritroid, Carbamate, organo Organophospate Fenil Phenylpyrazole) Fungicide (n= 2) Herbicide (n= 1)
Frequency of spraying (times/weeks)	Lemongrass (1-2) Depending on how often the occurrence of pest	Insecticide (1-3) Fungicide (1) Herbicide (1)
Planting duration (days)	45	45
Pesticide dosage (ml/tank)	No pesticides	Insecticide (15 ml/tank) Herbicide Fungicide
Knowledge of pesticide residue	Knowing the negative impact: n=18	Knowing the negative impact: n=10, Not Sure there is a negative impact n=8

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Table 3. Organophosphates in water sample organic vs conventional

No. of samples (n)	Chlorpyriphos (mg/l)		Diazinon (mg/l)		Profenofos (mg/l)		Parathion (mg/l)	
	Or	Co	Or	Co	Or	Co	Or	Co
1	ND	ND	ND	0.47	ND	ND	ND	ND
2	ND	ND	ND	ND	ND	ND	ND	ND
3	ND	ND	ND	0.18	ND	ND	ND	ND
4	ND	ND	ND	0.42	ND	ND	ND	ND
5	ND	ND	ND	ND	ND	ND	ND	ND
mean ±SD	ND	ND	ND	0.35±0.15	ND	ND	ND	ND
Freq= % n	0%	0%	0%	60%	0%	0%	0%	0%
SNI7313:2008 SNI7387:2007	0.5		0.1		n.r		n.r	

ND: Not Detected; n.r: not yet regulated
SNI 7313:2008 and SNI 7387:2007: Indonesian Standard Limitation of Contaminant

Table 4. Organophosphates in soil sample organic vs conventional

No. of samples	Chlorpyriphos (mg/kg)		Diazinon (mg/kg)		Profenofos (mg/kg)		Parathion (mg/kg)	
	Or	Co	Or	Co	Or	Co	Or	Co
1	ND	ND	ND	ND	ND	ND	ND	ND
2	ND	ND	ND	0.73	ND	ND	ND	ND
3	ND	ND	ND	0.51	ND	ND	ND	ND
4	ND	ND	ND	0.89	ND	ND	ND	ND
5	ND	ND	ND	0.80	ND	ND	ND	ND
mean ±SD	ND	ND	ND	0.73±0.16	ND	ND	ND	ND
Freq= % n	0%	0%	0%	80%	0%	0%	0%	0%
SNI7313:2008 SNI7387:2007	0.5		0.1		n.r		n.r	

ND: Not Detected; n.r: not yet regulated
SNI 7313:2008 and SNI 7387:2007: Indonesian Standard Limitation of Contaminant

Table 5. Organophosphates in plant sample organic vs conventional

No. of samples	Chlorpyriphos (mg/kg)		Diazinon (mg/kg)		Profenofos (mg/kg)		Parathion (mg/kg)	
	Or	Co	Or	Co	Or	Co	Or	Co
1	ND	ND	ND	0.0019	ND	ND	ND	ND
2	ND	ND	ND	ND	ND	ND	ND	ND
3	ND	ND	ND	ND	ND	ND	ND	ND
4	ND	ND	ND	ND	ND	ND	ND	ND
5	ND	ND	ND	0.0025	ND	ND	ND	ND
mean ±SD	ND	ND	ND	0.0022±0.00	ND	ND	ND	ND
Freq= % n	0%	0%	0%	40%	0%	0%	0%	0%
SNI7313:2008 SNI7387:2007	0.5		0.1		n.r		n.r	

ND: Not Detected; n.r: not yet regulated
SNI 7313:2008 and SNI 7387:2007: Indonesian Standard Limitation of Contaminant

3.3.2. Organochlorine

Among the organochlorine pesticides, Lindan, Aldrin, Heptachlor, Dieldrin, Endrin, DDT, Endo-Sulfan I and Corbofuran were not detected both in the organic and conventional water and soil samples (Table 6 and Table 7). Aldrin, Haptaclor and Dieldrin were detected in plant samples in conventional farming with a frequency of occurrence at 40%, 60%, 60%, respectively (Table 8). Pesticides may gain access to groundwater and surface water supplies through direct application or percolation and run-off from treated areas. Concentrations are typically higher in surface water than in groundwater (Sawyer et al., 2003). According to Mackay et al. (2006), the distribution of pesticides between the water and the sediments depends on the physical-chemical properties of the compounds such as the sediments of organic carbon position coefficients (log Koc). Studies have shown that pesticides with log Koc values > 5 are primarily transported in the environment and are bound to suspend sediments (Schafer et al., 2008). According to the Indonesian Standard of pesticide contamination, Aldrin, in the plant samples were lower than the Indonesia National Standard (SNI 7387, 2007) (SNI 7313, 2008). Meanwhile, the minimum residue of Heptaclor has not been regulated yet. Dieldrin was detected to be higher than the Indonesian Standard and had the most occurrences in the organochlorine sample. In general, the chlorinated pesticides are the most resistant to biological degradation and may persist for months or even years, following application (Sawyer et al., 2003).

Table 6 Organochlorine in water sample organic vs conventional

No. of samples	Lindan (mg/l		Aldrin (mg/l)		Heptachlor (mg/l)		Dieldrin (mg/l)		Endrin (mg/l)		DDT (mg/l)		EndoSulfan I (mg/l)		Carbofuran (mg/l)	
	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co
1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
mean ±SD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freq= % n	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SNI7313:2008 SNI7387:2007	0.01		0.02		n.r		0.02		n.r		0.01		0.01		0.01	

ND: Not Detected; n.r: not yet regulated
SNI 7313:2008 and SNI 7387:2007: Indonesian Standard Limitation of Contaminant

Table 7. Organochlorine in soil sample organic vs conventional

No. of samples	Lindan (mg/kg)		Aldrin (mg/kg)		Heptachlor (mg/kg)		Dieldrin (mg/kg)		Endrin (mg/kg)		DDT (mg/kg)		EndoSulfan I(mg/kg)		Carbofuran (mg/kg)	
	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co
1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
mean ±SD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Freq= % n	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SNI7313:2008 SNI7387:2007	0.01		0.02		n.r		0.02		n.r		0.01		0.01		0.01	

ND: Not Detected; n.r not yet regulated
SNI 7313:2008 and SNI 7387:2007: Indonesian Standard Limitation of Contaminant

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Table 8. Organochlorine in plant sample organic (or) vs. conventional (co)

No. of samples	Lindan (mg/kg)		Aldrin (mg/kg)		Heptachlor (mg/kg)		Dieldrin (mg/kg)		Endrin (mg/kg)		DDT (mg/kg)		EndoSulfan I (mg/kg)		Carbofuran (mg/kg)	
	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co	Or	Co
1	ND	ND	ND	ND	ND	ND	ND	0.15	ND	ND	ND	ND	ND	ND	ND	ND
2	ND	ND	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	ND	ND	ND	0.0019	ND	0.01	ND	0.16	ND	ND	ND	ND	ND	ND	ND	ND
4	ND	ND	ND	ND	ND	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	ND	ND	ND	0.001	ND	ND	ND	0.15	ND	ND	ND	ND	ND	ND	ND	ND
mean ±SD	ND	ND	ND	0.0019 ±0.00	ND	0.02 ±0.01	ND	0.153 ±0.05	ND	ND	ND	ND	ND	ND	ND	ND
Freq= % n	0%	0%	0%	40%	0%	60%	0%	60%	0%	0%	0%	0%	0%	0%	0%	0%
SNI7313:2008 SNI7387:2007	0.01		0.02		n.r		0.02		n.r		0.01		0.01		0.01	

ND: Not Detected; n.r: not yet regulated
SNI 7313:2008 and SNI 7387:2007: Indonesian Standard Limitation of Contaminant

3.3.3. Heavy metals

Heavy metals, such as As and Hg, were not detected in organic rice cultivation. However, in conventional rice cultivation, they were detected frequently, with an occurrence at 10 % and 40 % for Mercury and Arsenic (Table 9). The level of heavy metals found in the sample was lower than the Indonesian National Standard, which was 0.5 mg/l for Arsenic, and 0.2 mg/l for Mercury. In this study, conventional farming did not violate national regulations (SNI 7387, 2007).

There is a broad debate on the contribution of agrochemicals to crop production and the negative impact of their use on the environment and human health. Ardiwinata and Nursyamsi (2012) studied pesticide residue central in Java. They found organochlorine and organophosphate residue, as well as carbamate insecticides residue in the rice, soil and water. Based on the Pesticides Commission, there are 1082 pesticide formulations, that were legally distributed across Indonesia, with insecticides being the highest in number (Komisi Pestisida, 2005). Meanwhile, according to the Ministry of Agriculture (2016), for subsidised fertilisation, there were five types of fertilisers distributed: urea, SP36, NPK, ZA and organic fertilisers. The

Table 9. Heavy metal in water sample organic (or) vs conventional (co)

No of Sample	As (mg/l)		Hg (mg/l)	
	Or	Co	Or	Co
1	ND	ND	ND	0.009
2	ND	0.01	ND	ND
3	ND	ND	ND	ND
4	ND	0.01	ND	ND
5	ND	ND	ND	ND
mean ±SD	ND	0.01±0.00	ND	0.009±0.00
Freq= % n	0%	40%	0%	10%
SNI7313:2008 SNI7387:2007	0.5		0.2	

ND: Not Detected
SNI 7313:2008 and SNI 7387:2007: Indonesian Standard Limitation of Contaminant

realisations of subsidised fertiliser distribution are increasing, except for urea. Numerous monitoring studies from Europe and Japan have provided evidence that paddy rice cultivation is responsible for surface and groundwater contamination, with pesticide concentrations exceeding 0.1 µg /L (Lamers et al., 2011).

4. Conclusions

Based on our findings, we conclude that the levels of education of farmer did not reflect their awareness on converting conventional rice cultivation to organic rice cultivation. The primary reason for their motivation to cultivating organic crops owes to their awareness about the selling price and use of spring water. Organic rice cultivation has lower agrochemical residue and has specific benefits concerning the lower cost for plant protection as well as better selling price, economically as well as ecologically. Even though agrochemical residues in conventional farming are higher than organic farming, in particular, the level of the residue is still lower than the Indonesian National Standard. Organic farmers spend more time preparing their manure and organic pesticides compared to conventional farmers. The occurrence of heavy metals Hg and As was high in conventional rice cultivation as compared to organic rice cultivation.

Conflict of Interest

The authors declare no conflict of interest. In addition, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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