

# Soil Quality Dynamic and Rice Production of Three Different Rice Farming Systems in Sragen District, Central Java Province

## *Dinamika Kualitas Tanah dan Hasil Brangkas Padi dari Tiga Sistem Budi Daya Padi di Kabupaten Sragen, Provinsi Jawa Tengah*

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### INFORMASI ARTIKEL

#### Riwayat artikel:

Diterima: 12 November 2019

Disetujui: 15 Juli 2020

Dipublikasi online: 4 Agustus 2020

#### Keywords:

Organic farming  
Semi organic farming  
Conventional rice farming systems  
Soil quality  
Rice biomass production

#### Kata Kunci:

Budidaya organik  
Budidaya semi organik  
Budidaya konvensional  
Kualitas tanah  
Produksi biomasa padi

#### Direview oleh:

Linca Anggria, Eni Maftu'ah

**Abstract.** The farmers realize that green revolution technology with high inputs is no longer sustainable, expensive, and the yield decrease. Some farmers move to organic rice farming, semi organic, and the rest remain doing conventional rice farming. The research aim was to monitor soil quality dynamic and rice productions under three rice farming systems. This study was conducted in Vertisols at Sambung Macan Sub District, Sragen Regency. The treatments were arranged in randomized complete block design with three replications. The treatments were organic, semi organic, and conventional rice farming systems. The results indicated that in organic field, the soil quality in 2019 was more superior than in semi organic and conventional in 2018 and 2017, and soil qualities of semi organic system was better than conventional in terms of soil chemical, physical and biological including soil pH, organic C and total N, P and K total, soil bulk density, particle density, soil porosity and permeability. Similar finding was observed for rice biomass productions in 2019. In 2019 the rice grains yields were 12.68, 7.43, and 7.0, rice straw were 7.25, 6.55, and 6.25, and for rice residues were 4.15, 3.20, and 3.15 tons ha<sup>-1</sup> season<sup>-1</sup> in organic, semi organic, and conventional systems, respectively. Compared to the conventional system, the organic increased about 81, 16, and 32% for rice grains, rice straw, and rice residues, respectively. Compared to conventional, semi organic improved about 6, 5, and 2% for rice grains, rice straw, and rice residues, respectively.

**Abstrak.** Petani menyadari bahwa *green revolution technology* tidak lumintu, biaya produksi mahal, dan hasil panen menurun. Sebagian petani beralih ke budidaya padi organik, semi organik dan sebagian bertahan pada sistem konvensional dengan perbaikan. Penelitian bertujuan untuk mengetahui perkembangan kualitas tanah dan hasil brangkas padi pada sistem padi organik, semi organik, dan konvensional. Penelitian dilaksanakan pada tahun 2017, 2018, dan 2019 pada tiga sistem budidaya padi di Kecamatan Sambung Macan, Sragen. Penelitian menggunakan rancangan acak kelompok, dengan tiga ulangan dan sebagai perlakuan tiga budidaya padi. Hasil penelitian menunjukkan bahwa kualitas tanah pada budidaya organik pada tahun 2019 lebih unggul dibandingkan semi organik dan konvensional pada tahun 2018 dan 2017. Begitu juga kualitas tanah pada semi organik pada 2019 lebih baik dibandingkan budidaya konvensional. Hasil brangkas padi pada budidaya organik tahun 2019 lebih tinggi dibandingkan dengan tahun 2018 dan 2017, baik pada budidaya padi semi organik maupun konvensional. Hasil gabah, jerami, dan sisa panen dari ketiga sistem budidaya padi pada tahun 2019 masing masing sebesar 12,68; 7,43; dan 7,0; jerami 7,25; 6,55; dan 6,25; dan sisa panen 4,15; 3,20; dan 3,15 ton ha<sup>-1</sup> musim<sup>-1</sup> untuk budidaya padi organik, semi organik dan konvensional. Dibandingkan dengan konvensional sistem, budidaya organik meningkat sekitar 81, 16, dan 32% untuk gabah, jerami dan sisa panen. Dibandingkan dengan konvensional, budidaya semi organik meningkat 6, 5, dan 2% untuk gabah, jerami, dan sisa panen.

## Introduction

Soil quality is defined as the capacity of soil to function (Karlen and Andrews 2000). Soil quality can also be defined as the capacity of the soil to function within

ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plants and animals health (Doran and Perkin 1994; Sharma *et al.* 2008). In the past, soil quality is understood as inherent capacity of the soil to supply essential plant nutrients.

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Afterward, it is viewed as an abstract characteristic of soil that could not be defined of its dependence on external factors such as land use and soil management practices, ecosystem and environmental interaction, socioeconomic and political priorities, and so on (Doran *et al.* 1996). Thus, soil quality cannot be measured directly, but the indicator may directly monitor the soil. The indicators which directly monitor soil quality are grouped into four categories as visual, chemical, physical, and biological indicators (Dalal and Moloney 2000). Crop production depends largely on soil and is affected greatly by the quality of that soil. Soil quality also plays a role in the environmental effects of crop production. Traditional measures of soil quality include land capability and suitability, prime land, productivity, erodibility, and vulnerability to leach pesticides and nitrates (USDA 2009). More comprehensive measures are needed that consider physical, chemical, and biological properties, and also economic factors. Indicators of land quality include: the dynamics or management of the presence of soil chemical properties (especially nutrients and soil organic carbon), physical properties (soil aggregates, availability of water, BD, infiltration, soil structure and soil pores, especially macro pores), and soil biological properties: respiration, enzymes, micro community, and PLFA (USDA 1996; Herrick 2000; Doran and Zeiss 2000). Furthermore, according to Amalia (2011) soil quality in rice planting is a combination of soil organic matter and total N soil with enzyme dehydrogenase,  $\beta$ -glucosaminidase and microbial biomass C (MBC) and phospholipids fatty acids (PLFA). However, PLFA is not a suitable indicator for vegetable crops.

Green revolution technology with high rate mineral fertilizers and synthetics pesticides are no longer sustainable and production cost is too expensive. Therefore, most farmers want to move to other rice farming systems. Some farmers want to change to organic rice farming system, some of them to semi organic and the rest still doing conventional rice farming systems (Sukristiyonubowo *et al.* 2016). Recently, both in organic rice and vegetables farming systems have become more fashionable responding to environmental concerns particularly in developing country that has claimed significant effects of agriculture land degradations, food security, and farmers income. Therefore, organic farming has become a model to sustain agricultural products, improve farmers' income and environmental problems (Sukristiyonubowo *et al.* 2011). Therefore, in modern agriculture systems, organic farming (rice, vegetables or fruits) is chosen by the farmers because of some

advantages. Not only bring some benefits in environment and in agronomic point of view, but also it gives benefits in term of socio economic and soil aspects.

In some countries, research in organic farming system have been developed both in plot, farm, and community scales with different purposes. Some benefits of organic rice, vegetables, and fruits are reported by researchers. According to Sukristiyonubowo *et al.* (2018a) soil chemical-physical fertilities in organic field in Kopeng Village, Semarang Regency, is more superior than in conventional vegetables farming system including soil pH, C organic and N, P and K total, bulk density, particle density, soil porosity, and permeability (slow and fast drainage). In Bogor Regency, the soil chemical, physical, and biological properties of organic vegetable farming are better than conventional farming systems in term of soil pH, organic C, total N, P, and K extracted with HCl 25%, bulk density and dehydrogenase enzyme (Sukristiyonubowo *et al.* 2015). Similar results are reported in rice farming in Sambiredjo Sub District, Sragen Regency, the soil chemical-physical fertility in organic field in Sambiredjo Sub District, Sragen Regency, is more superior than both in semi organic and conventional and in semi organic is better than in conventional system in terms of soil pH, organic C and N, P and K total, bulk density, particle density, soil porosity and permeability. The similar finding is also observed in rice biomass production. Future research question is how long the organic farming system without external input sustains the production and soil fertility (Sukristiyonubowo *et al.* 2018b). Kajimura *et al.* (1995) reported that the low densities of *Brown Plant Hopper* and *White Backed Plant Hopper* are observed in organically farmed fields. Similar finding is reported by Alice *et al.* (2004). Chino *et al.* (1987) found that asparagine's content of plant phloem sap is significantly lower under organic cultivation. Related to the milling and cooking quality of rice, Prakhas *et al.* (2002) noted that rice planted in organic system significantly has better milling and cooking quality like total and head milled rice recovery, protein content, kernel elongation, and lower in amylose content than cultivated with commercial fertilizers. Furthermore, Zhang *et al.* (2005) reported that higher protein grains content will result in higher head rice recovery and lower amylose content. In line with soil aspects, organic farming is usually associated with a significant higher level of biological activities and soil organic matter (Sukristiyonubowo *et al.* 2018c.; Oehl *et al.* 2004; Mäder *et al.* 2002; Hansen *et al.* 2001; Stolze *et al.* 2000).

In Indonesia, the organic foods markets are going up quite fast due to growing demand for rice, vegetables, and fruits of organics and their high premium obtained. Besides the consumers need healthy foods and free from chemical, for example IR 64 and Mentik Wangi varieties are planted in organic rice farming system in Boyolali and Sragen District because of have high selling price and have many advantages.

In the past, during application of the green revolution technology, combination between high external input and high yielding variety are promising way to elevate rice yields (Sukristiyonubowo and Tuherkih 2009; Min *et al.* 2007; Cho *et al.* 2002; 2000; Soepartini 1995; Adiningsih 1992; Adiningsih *et al.* 1989; Prawirasumantri *et al.* 1983; Cooke 1970; Uexkull 1970). In vegetables growing areas, the application of inorganic fertilizers are also tremendously significant, for instance the use of N fertilizers in leafy vegetables, K in tuber crops both are very high. This technology is considered not sustainable for the long term, cost production is too expensive and the yields tend to decrease. In conventional rice growing centers are showing a levelling-off, even a decline or loss in productivity. Now in Indonesia, there are organic farming and conventional systems both for rice, vegetables, and fruits. The yield and quality of rice, vegetables, and fruits of organic farming is better than conventional system, many commodities are sold abroad. This paper discussed dynamic of soil quality and rice grains yields of organic, semi organic, and conventional farming systems in Sragen Regency, Central Java Province.

## Materials and Methods

The study was carried out in three farmers at Sambung Macan Sub District, Sragen Regency, Central Java Province for organic, semi organic, and conventional rice farming systems. They have conducted organic rice farming since 1999 and semi organic rice farming since 2004, respectively. In semi organic rice farming, they still apply nitrogen fertilizer as much as 50 kg ha<sup>-1</sup> season<sup>-1</sup>, before vegetative maximum phase. In organic rice farming the farmers only apply organic fertilizer (straw compost, manure) as much as 3 tons ha<sup>-1</sup> every cropping season. In conventional rice farming systems, they usually apply mineral fertilizer and organic fertilizer as much as 200 kg ha<sup>-1</sup> urea, 150 kg ha<sup>-1</sup> PONSKHA (15:15:15), 50 kg KCl ha<sup>-1</sup> season<sup>-1</sup>, and 0.5 ton ha<sup>-1</sup> rice straw compost or

manure. They used organic pesticides to manage organic and semi organic rice farmings.

The composite soil samples of 0-20 cm in depth were taken after plant harvest, in middle of June 2019, before soil preparation for the third rice planting. One kg soil composite was collected from five sampling points of every site and mixed. The similar procedures were done for year 2017 and 2018. These samples were submitted to the Soil Analytical Laboratory of the Yogyakarta Assessment Institute for Agricultural Technology for chemical and physical analyses and in Gadjah Mada University for biological analyses. Chemical analyses included the measurement of pH (H<sub>2</sub>O and KCl), organic matter, phosphorus, and potassium. Organic matter was determined using the Walkley and Black method, pH (H<sub>2</sub>O and KCl) was measured in a 1:5 soil-water suspension using a glass electrode, total P and soluble P were measured colorimetrically, extracted using HCl 25% and Olsen methods, respectively. The total K was extracted using HCl 25% and subsequently determined by flame-spectrometry (Indonesian Soil Research Institute 2009). Physical analyses included the measurement of water level, particle density (PD), bulk density (BD), and total pore space. Soil water content was measured by Gravimetric method, particle density was measured using Richards and Fireman method (1943), bulk density was measured by Richards method (1947), and total pores space was measured using De Boodt method (1967). All measurement of physical properties adopted from Indonesian Soil Research Institute (2009). The biological parameter includes nematode population, and C microbial activities. C microbial activities were determined with fumigation incubation method (Jenkinson and Powlson 1980). Soil samples were fumigated with CHCl<sub>3</sub> free from alcohol. After fumigation, soil samples were incubated with alkali solution and then were titrated with HCl. Total microbial C was counted as number of C-CO<sub>2</sub> was absorbed in this solution. Nematode extraction was following Cobb method. This method was used to extract active nematode in the soils and nematode in the coagulated was measured under microscope then was counted (van Beijooijen 2006).

The current experiment, INPARI 33 rice variety was cultivated as plant indicator. Transplanting was carried out in the beginning of March 2019 and harvest in the end of May 2019. Twenty-one-day old seedlings were transplanted at about 25 x 25 cm cropping distance with about two seedlings per hill.

Rice biomass production including grains, straw, and residues (roots and left rice straw) were measured at harvest. When water content in rice grains was 16%, was harvested, and for measurement the constant weight of rice grains yield, the water content of 14% was used. These were measured with *Seed Moisture Tester*. Sampling units (1 x 1 m plot), were randomly selected at every rice systems. Rice plants were manually cut about 15 to 20 cm above the ground surface. The samples were manually separated into rice grains, rice straw, and rice residues. Rice residues included the roots and the part of the stem (stubble) left after cutting. Fresh weights of rice grain, rice straw, and rice residues were immediately weighed at harvest at each sampling unit. Rice productions were statistically analysed in Randomized Complete Block Design (RCBD). All data were statistically examined and computed using SPSS software. Means were compared using the Duncan test (5%).

## Results and Discussion

### Soil Quality

The soil quality assessment included soil chemical, soil physical, biological, and plant productivity. The soil chemical parameters are presented in Table 1. Generally in 2019, 2018, and 2017 soil pH of the organic rice farming system were 6.65; 7.63; and 6.90, and classified as neutral, but in semi organic and the conventional rice farming system netral to slightly acid. The neutral of the soil in organic rice farming may be due to continues applying manures. While in semi organic and conventional, the soil pH were about 6.59 and 6.57. These may be due to the farmers using straw compost. Similar results were reported by Syukur (2005).

These acidity of soils may be due to the application of mineral fertilizer (urea) by the farmers. The level of soil

organic carbon (SOC) and total N was classified as medium in organic rice farming system than in both semi organic and conventional rice farming systems. While in organic rice farming system, the soil organic carbon (SOC: 2.90%) and total N (0.22%) was considered as the highest and the lowest was at conventional rice field about 1.72% for soil organic carbon and 0.17% for the total N. According to Sommerfeldt *et al.* (1988) and Clark *et al.* (1998) they stated that the higher soil organic matter (SOM) levels in the soils managed with manure and cover crops than in soils without such inputs.

For the rice conventional farming system, the total P classified as medium, and was lower than rice organic and semi organic rice farming systems, suggesting that for moment application of organic fertilizers about 3 tons compost ha<sup>-1</sup> season<sup>-1</sup> were superior to application of mineral fertilizer (SP-36). While, the total P in conventional rice farming system (112 ppm) was also lower than in organic rice farming (184 ppm) and in semi organic rice farming, P extracted with HCl 25% (63 ppm) was lower than in conventional because P was fixed by lower pH.

Total K in organic rice farming system was about 180 mg 100 g<sup>-1</sup> and classified as the highest, followed by semi organic about 40 mg 100 g<sup>-1</sup> and conventional farming systems about 40 mg 100 g<sup>-1</sup>, indicating that application of 3 tons straw compost was enough to increase the total K in the soil. It was also suggesting that straw compost applied in organic rice farming was rich in K content. Whereas, the total K in the soil of conventional rice farming system was considered low indicating addition of about 50 kg KCl ha<sup>-1</sup> season<sup>-1</sup> cannot increase the total K in the soil. Clark *et al.* (1998); Rasmussen and Parton (1994); and Wander *et al.* (1994) also reported similar findings. Therefore, it may be concluded that in the rice organic farming system in general were healthy and the chemical soil fertility were

Table 1. The soil chemical dynamic under three rice farming systems in Termas Village Sambung Macan, Sragen Regency, Central Java Province

Tabel 1. Dinamika kimia tanah pada ketiga budi daya padi di Desa Termas, Sambung Macan, Kabupaten Sragen, Provinsi Jawa Tengah

Parameters	Organic			Semi organic			Conventional		
	2017*	2018*	2019	2017*	2018*	2019	2017*	2018*	2019
pH <sub>(H2O)</sub>	6.90	7.63	6.65	6.6	6.56	6.59	6.0	5.40	6.57
C-Organic	3.20	3.15	2.90	2.7	3.04	2.17	1.3	2.61	1.72
N-Total	0.28	0.43	0.22	0.25	0.37	0.20	0.17	0.33	0.17
P extracted with 25% HCl	62.3	134	184	48.9	90	63	41.7	81	112
K extracted with 25% HCl	37.7	170	180	32.3	65	40	19.7	64	40
CEC (cmol kg <sup>-1</sup> )		38.40	31.67		15.73	26.71		13.38	25.63

Source: \*Damasus *et al.* (2019); Sukristiyonubowo *et al.* (2019)

better than in semi organic and conventional rice farming system including the pH, organic matter content (nitrogen content), and high available K concentrations. In addition, in the conventional rice farming system applications of proper mineral fertilizers to improve inherent soil fertility leading to rice yield is needed.

The similar finding was observed in 2018 and 2017, the soil pH, soil organic carbon (SOC), N total, P and K extracted with 25% HCl and CEC. In organic rice fields was better than both in semi organic and conventional rice fields and in semi organic was superior than in conventional rice fields.

### Soil Physical Properties

The soil physical parameters are presented in Table 2. There were showed that in 2019, organic rice field were better than physical soil properties in semi organic and conventional rice field systems. This can be happened, because soil organic matter could arrange aggregates incorporated each other and become physically stabilized within macro aggregates, hence the soil was more porous and total soil porosity was more higher compared to the soil structure on conventional rice farming practice.

Pirngadi (2009) stated that the organic matter applied to the rice farm can contribute to increase water holding capacity, improve the soil structure to be crumbly, prevent the soil agregates become more slowly. The soil has enough C (soil organic carbon) content can be easily plowing and usually more porous compared to semi organic and conventional rice farming system, which usually has lower C organic content.

Compare to 2018 and 2017, in 2019 soil physical properties was better than in 2018 and 2017 including bulk

density, particle density, soil porosity, permeability, and soil texture.

### Soil Biological Properties

The biological soil parameter in 2018 was not observed and is presented in Table 3. The biological showed in organic rice field was the best in biological soil properties compared to both conventional and semi organic rice farming systems. It was indicated from the amount of total soil microbes' population. In organic rice field was higher than semi organic and conventional rice farming systems. The optimal microbe population due to enough of food for microbes and the environment condition to support the growth of microbes and also because of higher soil organic carbon in organic compared to semi organic and conventional rice farming (Kartasapoetra and Suttedjo 2005).

The soil organic matter content and food as energy supply for microbes play an important role in determining not only the number and type of organism but also their activities. It influenced of the soil structure and soil porosity threere by the activity of the microorganisms became more increased. Mujiyati and Supriyadi (2008) stated that almost all micro organisms obtain their food and energy from the plant residues or organic matter, which added from wasted harvesting susbtances of farming field to the soil. Energy is required for metabolic activities of some microorganisms in the soil.

Compared to 2017, the amount of total soil microba population, total population of fungi and population of bacteria in Organic, Semi Organic and Coventinal rice farming decreased in 2019. This was due to soil organic carbon and pH soil in 2019 was lower than 2017 (Kartasapoetra and Suttedjo 2005).

Table 2. The soil physical properties under three rice farming systems in Sambung Macan Sragen Regency, Central Java Province

Tabel 2. Kesuburan fisik tanah dari tiga budi daya padi di Sambung Macan, Kabupaten Sragen, Provinsi Jawa Tengah

Parameters	Organic			Semi organic			Conventional		
	2017*	2018*	2019	2017*	2018*	2019	2017*	2018*	2019
Bulk density (gr cm <sup>-3</sup> )	0.95	0.88	0.85	1.10	0.89	0.95	1.21	0,97	0.99
Particle density (gr cm <sup>-3</sup> )	2.44	1.86	1.88	2.52	2.28	2.25	2.59	2.26	2.30
Soil porosity (%)	68.7	68	80	56.1	56	57	50.2	53	55
Permeability (cm hour <sup>-1</sup> )	1.14	1.09	1,60	0.48	0.58	0.69	0.56	0.41	0.60
Soil texture	Clay loam	Clay loam	Clay loam	Clay loam	Clay	Clay	Clay loam	Clay	Clay
Sand	29	30	29	27	18	19	28	16	14
Silt	36	35	35	35	28	27	31	27	28
Clay	35	36	36	38	54	54	41	57	58

Source: \*Damasus *et al.* (2019)

Table 3. The biological soil dynamic of different rice farming systems at Sambung Macan Sub District, Sragen regency, Central Java Province

Tabel 3. Dinamika sifat biologi tanah pada ke tiga budi daya padi di Kecamatan Sambung Macan, Kabupaten Sragen, Provinsi Jawa Tengah

Parameters	Organic farming		Semi organic		Conventional system	
	2017	2019	2017	2019	2017	2019
Total soil microbe population (Log CFU gr <sup>-1</sup> soil)	8.35	6.80	7.42	3.90	5.71	2.60
Total population of fungi (Log CFU gr <sup>-1</sup> soil)	5.32	4.05	4.47	2.05	4.12	0.80
Total population of bacteria (Log CFU gr <sup>-1</sup> soil)	2.96	2.75	2.64	1.85	3.13	1.80

Table 4. Rice biomass production of there different rice farming systems at Termas Village, Sambung Macan Sub District, Sragen Regency, Central Java Province

Tabel 4. Hasil biomassa padi dari ketiga budi daya padi di Dusun Termas, Kecamatan Sambung Macan, Kabupaten Sragen, Provinsi Jawa Tengah

Treatments	Rice biomas productions								
	Rice grains			Rice straws			Rice residues		
	2017 <sup>*)</sup>	2018 <sup>*)</sup>	2019 <sup>**)</sup>	2017	2018	2019	2017	2018	2019
	.....t ha <sup>-1</sup> season <sup>-1</sup> .....								
Organic rice farming	6.80	7.53	12.68	9.04	7.97	7.25	4.48	4.20	4.15
Semi organic rice farming	6.40	6.60	7.43	8.67	7.63	6.55	3.24	3.30	3.20
Conventional rice farming	6.07	5.77	7.00	8.63	6.93	6.25	2.92	3.25	3.15

Source: <sup>\*)</sup>2017 and 2018: Sukristiyonubowo *et al.* 2019

Note:

<sup>\*)</sup>2017 and 2018: Ciherang rice varieties as plant indicators

<sup>\*\*)</sup>2019: INPARI 33 rice variety as plant indicator

### Plant Productivities

The plant productivities especially in organic rice farming may be obtained from observation during rice plants from vegetative phase to rice harvest. Rice plants were growing well (have a lot tiller numbers in average about 15 tiller numbers and leaves looked greens and healthy), they were strong and no diseases and insect were not attacked, and produced filled and pithed grains.

### Rice Biomass Production

In 2019 organic rice farming system showed the highest rice biomass productions namely rice residues, rice straw, and rice grains productions. Furthermore, the organic rice system also showed significantly different with other treatments. The rice biomass yield reached about 4.15, 7.25, and 12.68 ha<sup>-1</sup> season<sup>-1</sup> for rice residues, rice straws, and rice grains, respectively. The different in rice biomas productions may be due to different in rice variety. Compared to Conventional rice farming system, the organic rice farming increased about 5.88 t ha<sup>-1</sup> season<sup>-1</sup>

<sup>1</sup> or 86%, 1 t ha<sup>-1</sup> season<sup>-1</sup> or 16%, 1 t ha<sup>-1</sup> season<sup>-1</sup> or 31% for rice grains, rice straw, and rice residues, respectively. This was due to in organic rice farming the soil quality including soil chemical, physical, and biological fertilities was better than both in semi organic and conventional rice systems. If we compared conventional rice farming to Semi organic, the improvement was 0.43 kg ha<sup>-1</sup> season<sup>-1</sup> or 6%, 0.3 kg ha<sup>-1</sup> season<sup>-1</sup> or 5 %, and 0.05 kg ha<sup>-1</sup> season<sup>-1</sup> or 2% for rice grains, rice straws, and rice residues, respectively.

Compared to year 2018 and 2017, in 2019 was better than 2018 and 2017 including rice grains, rice straws and rice residues.

### Conclusions

In the organic field, the soil quality in 2019 was better than in semi organic and conventional in 2018 and 2017 and soil quality of semi organic system was better than of the conventional in terms of soil chemical, physical and

biological properties including soil pH, organic C and total N, P and K, soil bulk density, particle density, soil porosity, and permeability. Similar finding was observed for rice biomass productions in 2019. In 2019 the rice grains yields were 12.68, 7.43, and 7.0, rice straw were 7.25, 6.55, and 6.25, and rice residues were 4.15, 3.20, and 3.15 tons ha<sup>-1</sup> season<sup>-1</sup> in organic, semi organic, and conventional systems, respectively. Compared to the conventional system, the organic increased about 81, 16, and 32% rice grains, rice straw, and rice residues, respectively. Compared to conventional, semi organic improved about 6, 5, and 2% for rice grains, rice straw and rice residues, respectively.

## Acknowledgment

We thank to the Minister of Agriculture of Republic of Indonesia for funding this experiment. We thank also to Mr. Ryan Christie for helping us take soil sample and harvest product. This manuscript was written by Sukristiyonubowo as the “Main Contributor,” while Sugeng Widodo, Arif Anshori and Damasus Riyanto are the “Contributors.”

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