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Rice Quality and Yield at Various Application Times of Organic Rice Management System

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ABSTRACT

The higher national rice demand encourages various efforts to increase rice production. This increase in rice production occurs in line with increasing public awareness of healthy foods, especially organic rice. Rice field management with an organic system is expected to provide a higher yield and quality of rice. This study aims to determine the effect of the long-time application of an organic rice management system on rice yield and quality. Descriptive exploratory research is supported by laboratory analysis of samples of organic rice plants with three periods (10 years, 7 years, and 4 years), semi-organic and conventional. The parameters observed were dry harvested grain, dry milled grain, the weight of 1000 grains, unfilled grain, protein content, amylum, amylopectin, and reducing sugar. The most prolonged organic rice field management with the application of 10 years gives better results with a protein content of 6.14%, amylum 71.71%, and amylopectin 49.35%. While the application of organic farming for 7 years gives the highest rice yield, the difference is not confirmed with the application of organic 10 years, with the weight of dry grain harvest 10.44 Mg ha^{-1}, dry milled grain 8.15 10.44 Mg ha^{-1}, the weight of 1000 grains 24 g, and unfilled grain 3.8%.

Keywords: Rice grain production, rice content, rice field management system

INTRODUCTION

Rice is a staple food for most of the world's population, whose needs continue to increase in line with population growth. The increasing demand for national rice needs is not accompanied by increased rice production, and based on BPS (2022), Indonesia's rice crop production in 2021 amounted to 54.42 million tons, while in 2020 amounted to 54.65 million tons, this indicates a decrease in production by 0.42%. Awareness of healthy food consumption is increasing, along with the emergence of various efforts to increase rice production. One is the fulfillment of plant nutrients by providing organic fertilizers, inorganic or a combination of both. According to Padmanabha et al. (2014), the provision of organic and inorganic fertilizers has a significant effect on the soil's nutrient content and the results of plant growth and rice production. The application of organic rice field management systems is expected to provide better rice yield compared to semi-organic and conventional rice field management systems.

This study aims to determine the yield and quality of organic rice with a time difference in the application of rice field management. Previous research was conducted by Aziez *et al*. (2016), which examines the quality of rice with several varieties cultivated organically and conventionally, with results showing that the yield of the organic rice grain is no different from the yield of a conventional rice grain. However, the organic rice cultivation system can increase the protein content of rice and tends to improve the quality of rice, including taste, texture, and aroma. However, research on the effect of differences in the old organic rice management system on rice yield and rice quality is still limited, so this study needs to be done to determine whether the differences in the old application of organic management systems can improve the quality of rice in Gentungan Village, Mojogedang, Karanganyar.

MATERIALS AND METHODS

The study was conducted from May to November 2021 in Gentungan Village, Mojogedang, Karanganyar. Descriptive exploratory research with plant sampling was conducted on organic rice fields for 10 years (A), organic for 7 years (B), organic for 4 years (C), semi-organic (D), and conventional (E), using a basic system of tiles 1 m × 1 m. Each paddy field was sampled with five replications. Differences in agricultural activities in paddy fields can be seen from the difference in the dose of organic fertilizer of 4.8 Mg ha^{-1} for organic fields with the management of 10 years, 7 years, and 4 years, 2.4 Mg ha^{-1} of organic fertilizer and 80 kg ha^{-1} of inorganic fertilizer for semi-organic paddy fields, and 600 kg ha^{-1} of inorganic fertilizer for conventional paddy fields. Variable observed include dry grain harvest and dry grain milled resulting from the weighing process of grain yield per plot to be converted into units of hectares (Palobo et al. 2019). The weight of 1000 grains is determined by taking dry milled grain at random, which is the weight ratio of 1000 grains and aims to determine the quality of quality and seed requirements per hectare (David and Krisdianto 2008). The calculation of the percentage of empty grains is generated from the ratio of the weight of empty grain (A) to the total weight of 1000 grains (B), with the formula A / B × 100% (Fauzana et al. 2016).

Rice amylum content was calculated using the Direct Acid Hydrolysis method through a screening process to obtain starch content, then in hydrolysis using HCl 25% (AOAC 2000). Analysis of protein levels was performed using the Kjeldhal method based on guidance from Balai Penelitian Tanah (2009), with a conversion factor of 5,95. Determination of amylopectin levels was determined using the Iodo colorimetric method calculated using the standard amylose-amylopectin curve with a wavelength of 625 nm (Lestari et al. 2018). The reduced sugar content in rice was analyzed using the -Somogyi method with the addition of nelson and arsenomolybdate reagents and the determination of the standard glucose curve with a wavelength of 540 nm (BeMiller 2018).

RESULTS AND DISCUSSION

Nutrient content N, P, K in Soil and Plant Tissue

The rice field management system significantly influences the nutrient content of N, P, and K in soil and plant tissue. The results of total N and P available in organic rice fields with 10 years of application provide higher values than other organic applications and semi-organic and conventional systems with total N content ranging from 0.24% – 0.45% and P available between 1.44 ppm - 2.77 ppm. However, the K content available in organic rice fields with various application periods has a lower value than in semi-organic and conventional systems (Table 1).

The difference in the length of application of organic systems significantly affects the N, P, and K content of soil and tissues. An organic management system with a lengthy application of 10 years can provide a higher value of available soil's total N and P content due to organic fertilizer in manure. The availability of K in the soil in conventional systems has a higher value than in other systems; this is due to the provision of chemical fertilizers in the form of KCl fertilizer in conventional rice fields, which can help accelerate the availability of K in the soil and strengthen the content (Ansoruddin et al. 2017).

Rice Yield

Organic rice field management systems with various long-term applications of natural effect on dry harvested grain and dry milled grain but did not

Table 1. N, P, K nutrient content in soil and Plant Tissue.

System	N total (%)	P available (ppm)	K available (me 100 g^{-1})	N tissue (%)	P tissue (ppm)	K tissue (%)
An (Organic 10 years)	0.45 d	2.77 b	1.31 a	1.26 d	0.06 c	0.89 ab
B (Organic 7 years)	0.39 c	2.76 b	1.42 a	1.08 c	0.06 bc	0.86 a
C (Organic 4 years)	0.30 b	2.07 ab	1.67 b	0.99 bc	0.05 ab	0.95 ab
D (Semi Organic)	0.26 a	1.76 a	1.85 b	0.95 b	0.05 ab	1.03 bc
E (Conventional)	0.24 a	1.44 a	1.86 b	0.84 a	0.04 a	1.11 c
significance	*p=0.000***	*p=0.016**	*p=0.000***	*p=0.000***	*p=0.005***	*p=0.015**

Note: the numbers followed by different letters in the same column showed significantly different in the DMRT Test at Level 5%, *= significant, **= highly significant, ns= not significant.

have a natural effect on the weight of 1000 and unfilled grain (Table 2). The organic management system with a lengthy application of 7 years gives better results for dry harvested and milled grain than other systems. Dry harvested grain results ranged from 5.2 Mg ha^{-1} to 10.44 Mg ha^{-1}, with a dry-milled grain of 3.98 to 8.5 Mg ha^{-1}.

The provision of organic fertilizer in the organic rice field management system can provide higher yields of harvested dry grain and milled dry grain compared to semi-organic and conventional rice field management systems. The calculation results show the shrinkage process of grain weights from dry harvested grain to dry milled grain with an average shrinkage of 22.65%. The nutrient content that is very influential on rice plants' yield of rice grain weight is the element of phosphorus. This result is indicated by the correlation test (Table 3) between P plant tissue with dry harvested grain and dry milled grain (r=0.549** and r=0.502*), as well as the content of P available soil with dry harvested grain and dry milled grain (r=0.466* and r=0.448*). Based on research by Siwanto et al. (2015), dry harvested grain and dry milled grain with organic fertilizer treatment give a higher yield than inorganic fertilizer treatment. The difference in the results of dry harvested grain and dry milled grain is influenced by the content of P nutrients in the soil that play a role in the distribution of energy in the biochemical processes of rice plants, including at the stage of ripening and development of grain seeds so that grain yields can increase.

Lengthy application of organic rice fields and differences in rice field management system does not affect the yield weight of 1000 grains. These results follow research by Sugiono and Saputro (2016), which states that the difference in planting system shows no real difference in the weight of grain 1000 grains. According to Datta (1933), factors that significantly affect the quality of the grain, including the weight of 1000 grains, are environmental factors, such as temperature, light intensity, and rainfall. Nevertheless, in addition to environmental factors, the weight of 1000 grains can be determined by the amount of photosynthate stored in the plant, and there are genetic factors that can affect the yield of grain weight of 1000 grains. The same rice plant varieties show the same genetic factors; this is what causes the weight of 1000 grains in all rice management systems to have different results, not actually because the shape and size of the grain are influenced by plant genetic factors (Li et al. 2019).

The difference in the length of application of organic rice does not significantly affect the yield

Table 2. Rice yield in various rice field management systems.

System	Dry Harvested Grain (Mg ha^{-1})	Dry Milled Grain (Mg ha^{-1})	Weight 1000 grains (g)	Unfilled Grain (%)
An (Organic 10 years)	9.31 b	7.44 b	22	4.04
B (Organic 7 years)	10.44 b	8.15 b	24	3.80
C (Organic 4 years)	6.59 a	4.96 a	21	4.78
D (Semi Organic)	5.2 a	3.98 a	22	4.71
E (Conventional)	6.88 a	5.29 a	23	4.33
significance	*p=0.000**	*p=0.000**	*p=0.450*^{ns}	*p=0.167*^{ns}

Note: the numbers followed by different letters in the same column showed significantly different in the DMRT Test at Level 5%. *= significant. **= highly significant. ns= not significant.

Table 3. Correlation between N. P. and K nutrients with rice yield.

Nutrient	Dry Harvested Grain	Dry Milled Grain	Weight 1000 grains	Unfilled Grain
N total	0.693**	0.687**	-0.013^{ns}	- 0.412*
P available	0.466*	0.448*	-0.017^{ns}	0.054^{ns}
K available	- 0.710**	- 0.685**	0.034^{ns}	0.349^{ns}
N tissue	0.478*	0.464*	-0.118^{ns}	-0.078^{ns}
P tissue	0.549**	0.502*	-0.090^{ns}	-0.114^{ns}
K tissue	- 0.486*	- 0.534**	-0.141^{ns}	0.218^{ns}

ns=not significantly different *= significantly different at 1% significance level. **= significantly different at 5% significance level.

of unfilled grain percentage. Organic rice fields with a lengthy application of 7 years have a percentage of an empty grain of 3.80%, while organic rice fields with a lengthy application of 4 years have a percentage of 4.78%. The greater the percentage of empty grain indicates that the more seeds are empty, so organic rice fields with a lengthy application of 7 years have the best grain yield compared to other systems. The high percentage of empty grain in the application of organic rice for 4 years can be caused by environmental factors such as *walang sangit* (*Leptocorisa oratorius*) pest attacks that interfere with the process of grain seed formation. Paputungan et al. (2020) said the high attack of walang sangit pests on organic rice fields for 4 years is thought to be due to a large number of saplings, causing micro-climatic conditions to be better and more favored by *walang sangit* pests. According to Wahyuddin and Riadi (2015), the percentage of empty grain is influenced by the time difference in the emergence of grain seeds, which resulted in the harvest; there are still immature seeds that become seeds/empty grain. Nitrogen nutrient content is one factor that significantly affects the percentage of unfilled grain. Efforts to reduce the percentage of grain vacuum can be made by applying organic fertilizer to increase the content of N in the soil, as evidenced by the negative correlation Test between N total soil with the percentage of empty grain (r= -0.412*). This result shows that a higher total N content in the soil can reduce the percentage of empty seeds/grain on land.

Rice Quality

According to Zhang et al. (2021), the quality of rice is usually measured and evaluated through the content of amylum and protein contained in rice. The results showed that the difference in the length of application of organic rice management systems significantly affects the quality of rice in the form of protein, amylum, amylopectin, and sugar reduction (Table 4). An organic paddy field management system with a lengthy application of 10 years gives significantly higher levels of amylum than other systems, but the levels of protein, amylopectin, and reducing sugars in the organic system of 10 years, 7 years, and 4 years have different values not actual.

Differences in time management of organic rice fields affect the protein content indicating that the longer management of organic systems can increase protein levels in rice. According to Pangerang and Rusyanti (2016), the standard value of protein content in rice is about 7%. Organic rice field management

Table 4. Rice quality in various rice field management systems.

System	Protein (%)	Amylum (%)	Amylopectin (%)	Reducing Sugar (%)
An (Organic 10 years)	6.14 c	71.71 c	49.35 b	2.03 ab
B (Organic 7 years)	5.94 bc	62.65 b	43.63 b	2.46 b
C (Organic 4 years)	5.83 abc	64.97 b	42.68 b	2.31 b
D (Semi Organic)	5.69 ab	62.65 b	42.16 b	2.19 ab
E (Conventional)	5.50 a	56.44 a	32.12 a	1.82 a
Anova	*p=0.005***	*p=0.000***	*p=0.001***	*p=0.031**

Note: the numbers followed by different letters in the same column showed significantly different in the DMRT Test at Level 5%. *= significant. **= highly significant. ns= not significant.

Table 5. Correlation between N. P. and K nutrients with rice quality.

Nutrient	Protein	Amylum	Amylopectin	Reducing Sugar
N total	0.626**	0.597**	0.274 ns	0.176 ns
P available	0.707**	0.180 ns	0.071 ns	0.237 ns
K available	- 0.524**	- 0.417*	- 0.615**	-0.167 ns
N tissue	0.814**	0.622**	0.700**	0.065 ns
P tissue	0.621**	0.354 ns	0.387 ns	0.036 ns
K tissue	- 0.459*	-0.385 ns	- 0.533**	- 0.398*

ns=not significantly different *= significantly different at 1% significance level. **= significantly different at 5% significance level systems with lengthy applications of 10 years, 7 years, and 4 years have different protein levels and are not real, but they give better results than semi-organic and conventional systems. The difference in protein level is because the total N content in organic rice fields in this research has a higher value than in other systems. Rice plants planted in rice fields containing high N elements tend to produce rice with high protein content. Rice containing high levels of protein can help grow and form cells and antibodies in the body. Based on the correlation test (Table 5), results of total N nutrient content in soil and N tissue have a positive correlation to protein levels (r = 0.626** and 0.814**), in addition to the nutrient content of plant tissue P also has a positive correlation with protein content (r = 0.621**). The result follows the research of Zhu et al. (2017), who found that high levels of N content can lead to increased protein content in rice.

Organic rice field management with 10 years of application has higher amylum levels than other rice field management systems. One factor that is very influential on amylum levels is the increased availability of N content in tissues that can improve the reaction of photosynthesis of plants, so the result of photosynthesis will also increase. According to Sari et al. (2008), amylum levels are carbohydrates strongly influenced by the reaction of plant photosynthesis. This is evidenced by a positive correlation between N tissues with amylum content (r= 0.622**).

The quality of good rice can be seen from the taste, aroma, and texture of fluffy rice. The content of amylopectin is a polysaccharide constituent of amylum which is very influential on the texture of rice. According to Fitriyah et al. (2020), rice with a higher amylopectin content will cause the rice to become more sticky, soft, and clumpy in cold conditions. Conversely, rice that has a low amylopectin content will produce hard rice (*pera*). This is why the rice that is often consumed generally has a moderate level of amylose and amylopectin, with a fluffy rice texture. Organic rice field management with a lengthy application of 10 years has a higher content of amylopectin than other systems. Research conducted by Wrasiati and Hartiati (2014) produced amylopectin levels ranging from 25.37 to 46.64. The results showed that an increase in amylum levels would be followed by an increase in amylopectin levels, as evidenced by the correlation test (r = 0.849**). The formation of amylum and amylopectin is influenced by K content. This is supported by the research of González et al. (2019), who found that a high endogenous K content can increase the amylum content of foods.

The lengthy application of organic management systems significantly affects the reduction of sugar levels in rice, affecting the sweetness of cooked rice. According to Hasbullah et al. (2016), the reduced sugar content in rice is around 2.45%. Based on the DMRT test results, the reduction sugar produced by organic rice fields has significantly different results from semi-organic and conventional rice fields, but seen from the percentage value of sugar reduction in organic rice field management with a lengthy application of 7 years gives a higher reduction sugar content than the semi-organic and conventional management system. This is due to differences in the provision of fertilizers in the form of organic and inorganic fertilizers. According to Hastuti (2003), continuous application of inorganic fertilizers with increasing doses can reduce the level of reducing sugars. This is what causes the reduced sugar content in semi-organic and conventional systems to have a lower value than in organic rice fields. The nutrient that affects the sugar content in rice is potassium nutrient. According to Marvelia et al. (2006), potassium nutrient acts as an enzyme activator that helps optimize the performance of enzymes so that the formation of sugar in rice is maximized.

CONCLUSIONS

The longer the application of organic farming shows a better quality of rice compared to semi-organic and conventional systems. The most prolonged organic rice field management with the application of 10 years gives better results with a protein content of 6.14%, amylum 71.71%, and amylopectin 49.35%. While the application of organic farming for 7 years gives the highest rice yield, the difference is not confirmed with the application of organic 10 years, with the weight of dry grain harvest 10.44 Mg ha^{-1}, dry milled grain 8.15 Mg ha^{-1}, the weight of 1000 grains 24 g, and unfilled grain 3.8%.

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