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Grain Quality of Three Rice Genotypes Grown in Organic and Non-Organic Systems

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Abstract

Grain quality is essential for assessing the overall quality of the grain produced and determining the market value of the final product. The objective of this study was to evaluate the physical quality of grains cultivated using both organic and non-organic methods. The research employed grains from red, white, and black rice genotypes planted during the third period. Each sample consisted of 100 grams, with three replicates. Data analysis involved variance testing using T and BNT tests, with a significance level set at 5%. Parameters for assessing the physical quality of grains included moisture content, empty grains, damaged kernels (yellow), calcified kernels (young kernels), foreign matter, other varieties, odors, and pests. The research took place at the Polytechnic Organic Farm and Plant Laboratory of Politeknik Negeri Lampung from January to April 2022. The findings indicated that the grain yields of red, white, and black rice genotypes quantitatively exhibited lower levels of yellow/damaged kernels and calcified/young kernels when cultivated organically compared to non-organic methods. However, for other analyses, the results did not show significant differences between the two cropping systems. Nevertheless, the grains of red, white, and black rice genotypes met the quality standards outlined in SNI 01-0224-1987, classified as grade II for organic cultivation and grade III for non-organic cultivation.

Keywords: genotype, grain quality, non-organic, organic

Introduction

As of 2020, the total population of Indonesia stood at 270.2 million people, and this number is expected to continue increasing annually (BPS, 2020). The population growth has significant implications for consumption patterns and food availability. Among the primary staples for the Indonesian populace are rice, maize, and cassava (Handayani et al., 2018). Recognized as the most vital basic necessity, food holds both direct and indirect correlations with human health, intelligence, and overall productivity. Moreover, ensuring the fulfillment of food requirements for the entire Indonesian population serves as a fundamental pillar for shaping human quality and upholding the fundamental right of every individual to access food

Rice stands as the primary staple for the majority of Indonesians, and its consumption is on the rise, paralleling the growth in population (Putra and Wardana, 2018). The starch content present in rice proves beneficial for the body, serving as a valuable energy source. In Asian countries, rice contributes up to 75% of the daily caloric intake for individuals. As a food item, rice provides 63.1% of energy, protein, and iron each, accounting for 37.7% and 25.30% of total body requirements (Sumartini et al. 2018). Additionally, over 50% of the global population relies on rice as their primary source of calories (Aminah et al., 2019). Rice comes in various types based on color, including white rice (*Oryza sativa* L.) and brown rice (*Oryza nivara*) (Hernawan et al., 2016), as well as black rice (Kristamtini et al., 2014).

Continuous efforts to enhance rice productivity in Indonesia are crucial for aligning with the escalating demand, projected to reach 41.5 million tons to 65.9 million tons of dry-milled grains (GKG) by 2025 (Tombe, 2009). The improvement in rice plant productivity traces back to the green revolution (Hasanuzzaman et al., 2010), primarily through the adoption of conventional farming systems, involving substantial use of inorganic fertilizers and pesticides. By implementing a cultivation system with heavy inputs of fertilizers and pesticides in the 1980s, self-sufficiency in rice was achieved, earning global acclaim. Despite the preference among farmers

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for methods yielding quick and satisfactory yields, this approach has negative implications for the sustainability of the cropping system.

Efficiency in input utilization is imperative given the escalating issues of pollution and the diminishing quality of rice fields. Achieving nutrient management through integrated, balanced fertilization serves as the cornerstone for enhancing fertilizer use efficiency, productivity, and farmer incomes. This approach has the potential to transform land-based agriculture into a system focused on the development of soil fertility. It is essential to align the fulfilment of food needs with environmental sustainability. The institutionalized and internationalized promotion of a healthy lifestyle necessitates guarantees that agricultural products are safe for consumption, rich in nutrition, and environmentally friendly. Consequently, consumer preferences are steering cultivation practices towards a more environmentally sustainable organic farming system. The organic farming approach prioritizes pest and disease prevention over eradication, aiming to minimize the use of pesticides that may harm the environment. This not only reduces production costs but also safeguards soil fertility and the sustainable availability of organic matter, while minimizing harm to other living beings (Priadi et al., 2007).

Organic farming systems have demonstrated the potential to enhance soil chemical properties by elevating levels of available phosphorus, total nitrogen, available potassium, carbon content, humic acid, sulfuric acid, and maintaining soil pH stability (Utami and Handayani, 2003). While numerous studies have explored various facets of organic rice cultivation, a notable gap exists in specific investigations focusing on the quality of organically grown grain. Hence, there is a pressing need to conduct comprehensive research delving into the cultural aspect of yield quality as a critical indicator of food security. This would contribute valuable insights into the overall impact of organic farming practices on the quality of the harvested grain, furthering our understanding of sustainable agricultural approaches.

Material and Methods

This research was conducted at the Polytechnic Organic Farm (POF) of Lampung State Polytechnic from January to April 2022. The tools used in this study were tweezers, analytical balances, plastic trays, moisture testers and stationery. The material used in this study was the grain produced by three rice genotypes (red, white and black) that were grown organically and non-organically.

The study was organized using a randomized block design with a single factor treatment, i.e. rice genotypes: red (G1), white (G2) and black (G3), each with three replicates. The research was conducted on two cropping systems: organic (BO) and non-organic (BNO), so the combination of treatments are BOG1 = organic red rice genotype; BOG2=organic white rice genotype; BOG3= organic black rice genotype; BNOG1 = non-organic, red rice genotype; BNOG2 = non-organic, white rice genotype; BNOG3 = non-organic, black rice genotype.

Determination of grain moisture content was measured using a moisture tester. The proportion of empty kernels, damaged kernels, young kernels, foreign objects, other varieties, was conducted by weighing 100 grams of grain sample (B), followed by manual separation using tweezers and weighing according to the formula according to the SNI for Grain Quality (SNI 01-0224-1987):

$$\text{Percentage of grain content} = \frac{Observation\ Grain\ Weight}{Grain\ Sample\ Weight\ (B)} \text{x} 100\%$$

The data were analyzed using analysis of variance (ANOVA) to determine differences between the treatments. HSD test was carried out at a significant level of 5%. Differences between the cultivation systems were determined using t-test.

Table 1. Quantitative requirements for grain quality according to SNI 01-0224-1987

Quality Components	Quality		
	I	II	III
Water content (%)	14.0	14.0	14.0
Empty grain (%)	1.0	2.0	3.0
Broken grain/yellow grain (%)	2.0	5.0	7.0
Calcifying grains/young grains (%)	1.0	5.0	10.0
Red item	1.0	2.0	4.0
Foreign objects	-	0.5	2.0

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Result and Discussion

Quantitative Grain Quality of Rice Genotypes in Organic and Non-organic Cropping Systems

Grain quality has been determined at the national level by the National Standards Agency, the Indonesian National Standard SNI 01-0224-1987. Based on the SNI, grain quality is classified into three quality classes, Quality I, II and III. The results of grain quality analysis for several genotypes grown in organic and non-organic agriculture are presented in Table 2. The quantitative grain quality in Table 2 demonstrated that each genotype has different responses to the cropping systems. The grain moisture content in the organic cultivated rice genotypes was not significantly different from that of the non-organic cultivated rice genotypes, but the results meet the standard requirements of 14%.

Determining the correct harvest age under optimum ripening conditions greatly affects grain quality, in this case empty grains and young grains. In Table 2, empty grains were not significantly different between organic and non-organic cultivation, whereas young grains were significantly different between organic and non-organic cultivation. Empty grains and young unhusked rice are affected by harvest age (Kamil, 1979). In this state, the grain is fully ripe, so the grains are empty, and the young grains are small.

According to Darmajati et al. (1981), rice harvested before optimum maturity will produce low quality grains because it contains a lot of empty grains and young unhusked rice, if the grain is milled under these conditions, it will produce low milled yields and more of his. The results showed that the cropping system had a significant effect on the young grain of the three rice genotypes analyzed. It is believed that the organic cultivation system provides better supply of nutrients and plant conditions so that the grain filling process is more perfect and does not cause a lot of young grains. Percentage of damaged kernels and young kernels are shown in Figure 1.

Table 2. Average moisture content, empty kernels, damaged kernels, young kernels, and foreign matter in organic and non-organic cropping systems

Genotype	Water content (%)		Empty grains (%)		Broken grains (%)		Young grains (%)		Foreign objects (%)	
	BO	BNO	BO	BNO	BO	BNO	BO	BNO	BO	BNO
Red grain rice	13.67	13.60	1.20	0.73	1.43	1.73	2.46	4.73	0.40	0.60
White grain rice	13.20	13.70	2.33	2.33	1.63	2.13	1.86	5.46	0.93	1.00
Black grain rice	13.06	13.04	1.93	1.60	1.83	2.73	2.46	3.26	0.46	0.60
Average	13.31	13.45	1.82	1.55	1.63	2.20	2.26	4.48	0.60	0.73
St dev.	0.32	13.60	1.20	0.73	1.43	1.73	2.46	4.73	0.40	0.60

Note: BO = organic cropping system; BNO = non-organic cropping system; ns = not significant; * = significant, ** = highly significant according to ANOVA at α=0.05

The grain moisture content is the main element that must be considered when carrying out the milling process to produce milled rice. Moisture content is the amount of water contained in the grains expressed as a percentage. Milling done at low water content will result in a high percentage of broken rice, groats and bran, thus causing a decrease in milled rice yield. Moreover, water content is also an important characteristic of foodstuffs because water can affect the appearance, texture, and taste of foods (Saud and Arsyad, 2020).

Empty grains and young unhusked rice are components of grain quality according to the quantitative requirements of SNI 01-0224-1987. Empty kernels are kernels that are not fully developed so that they do not contain rice even if the two cupped husks are closed or open, while young non-hulled kernels are kernels that are not fully ripe but have been harvested so that the grains are still green, calcified and easily broken (Mardiah, 2018).

Damaged kernels greatly affect grain quality. Included in the damaged grains are those with yellowish color caused by mechanical and physiological damage so the grain color changed from its original color. The grain quality of rice grown in organic and non-organic met the requirements of SNI 01-0224-1987, i.e. a maximum damage of 7%. Damages are usually caused by the grains that were not immediately dried, resulting in chemical reactions and microorganism activities such that the grains turned yellow (Rohmat et al., 2012).

Foreign matters are included in the physical grain quality indicators. Foreign objects are all objects that are not classified as grains, such as dust, grains of

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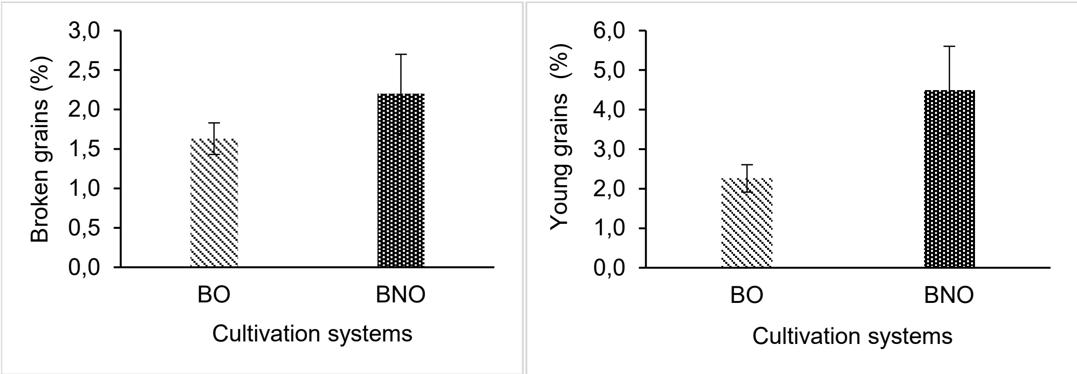

Figure 1. Percentage of damaged kernels and calcified kernels in organic (BO) and non-organic (BNO) cropping systems

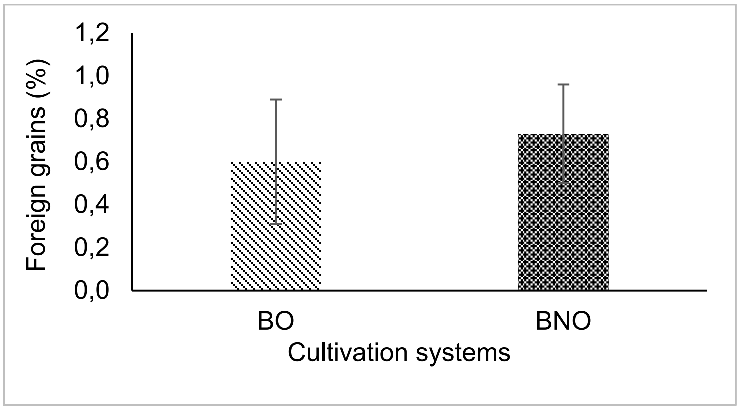

Figure 2. Percentage of foreign grains in organic and non-organic cultivation systems

soil, small stones, rice stalks and others. Observations showed that extraneous material produced from the organic culture was not significantly different from the non-organic culture. The percentage of foreign grains are shown in Figure 2.

Grain Quality of Rice Genotypes in Organic and Non-organic Cropping Systems

High grain quality must be pest and disease free, free of odors and chemicals including residues of fertilizers, insecticides, and other chemicals, and free from other cereal grains (Table 3). Overall, the three genotypes met the grain quality standards according to SNI 01-0224-1987, therefore the quality of the red, black and white rice from organic cultivation is qualitatively not inferior to that of non-organic cultivation.

Rice Grain Quality from Organic and Non-organic Cropping Systems

The comprehensive analysis of variance and the HSD test results are detailed in Table 4, providing insights into the simultaneous presentation of the physical quality of grains, including moisture content, empty grains, damaged grains, young grains, and foreign matter. Notably, for parameters such as moisture content, empty kernels, and foreign matter, no significant differences were observed between organic and non-organic cropping systems. However, substantial distinctions were identified in damaged kernels and young kernels, indicating that the organic cultivation system has the potential to reduce the percentage of damaged and empty kernels across all tested genotypes. Table 4 reveals that the red rice genotype in the organic cropping system (BOG1) exhibits superior suitability for development compared to other genotypes. The grain quality of red, white, and black rice genotypes adheres to the SNI 01-0224-1987 standard, classified as grade II in organic cultivation and grade III in non-organic cultivation. As emphasized by Munarso et al. (2020), ensuring the quality of both rice and paddy rice is crucial, as deviations from standards can jeopardize the safety of the product, especially during the storage phase and market entry.

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Table 3. Presence of pests, odors, and foreign grains of several rice genotypes in the organic and non-organic cropping systems.

Genotype	Pest		Smell		Other varieties	
	BO	BNO	BO	BNO	BO	BNO
Red grain rice	-	-	Normal	Normal	-	-
White grain rice	-	-	Normal	Normal	-	-
Black grain rice	-	-	Normal	Normal	-	-

Note: BO = organic cropping system, BNO = non-organic cropping system.

Table 4. Average moisture content, percentage of empty kernels, damaged kernels, young kernels, and foreign objects in organic and non-organic cropping systems.

Genotype	Water content (%)	Empty grains (%)	Broken grains (%)	Young grains (%)	Foreign objects (%)
Organic system					
Red grain rice	13.67 ± 0.12	1.20 ± 0.53	1.43 ± 0.31	2.47 ± 1.33 b	0.40 ± 0.35
White grain rice	13.20 ± 0.05	2.33 ± 0.81	1.63 ± 0.38	1.87 ± 0.61 b	0.93 ± 0.12
Black grain rice	13.06 ± 0.05	1.93 ± 0.23	1.83 ± 0.25	2.47 ± 0.12 b	0.47 ± 0.12
Non-organic system					
Red grain rice	13.60 ± 0.05	0.73 ± 0.23	1.73 ± 0.25	4.73 ± 0.76 a	0.60 ± 0.40
White grain rice	13.70 ± 0.05	2.33 ± 0.42	2.13 ± 0.31	5.47 ± 0.76 a	1.00 ± 0.20
Black grain rice	13.04 ± 0.05	1.60 ± 0.20	2.73 ± 0.21	3.27 ± 1.45 a	0.60 ± 0.35

Notes: values followed by the same letter were not significantly different based on the 0.05% HSD test at α=0.05.

Conclusion

The analysis of physical grain quality across the read, white and black rice genotypes revealed no significant differences in terms of moisture content, empty grains, red grains, and foreign matter. However, noteworthy distinctions were observed in yellow/damaged and calcified/young kernels between organic and non-organic cultivation systems. The physical grain quality of all three rice genotypes (red, white, black) successfully met the stipulations outlined in SNI 01-0224-1987, attaining grade II in organic cultivation and grade III in non-organic cultivation. Particularly promising was the performance of the BOG1 treatment, representing the organic cultivation system of the red rice genotype. This genotype exhibited a favorable response, suggesting its suitability and superiority in terms of physical grain quality under the organic cultivation approach.

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