 https://doi.org/10.1051/bioconf/202515803016

Rice Quality of Green Super Rice (GSR) Lines and Ciherang Variety at Moisture Contents of Paddy

Aditya Agung Ferdian[1], *Suwarto*[1*], and *Agus* Riyanto[1]

[1]Agrotechnology Department, Faculty of Agriculture, Jenderal Soedirman University, Purwokerto.

Abstract. The moisture content of paddy is an important factor that determines the quality of rice produced from milling. The objectives of this study are to determine the effect of moisture content of paddy on the physical quality of GSR Unsoed rice line and Ciherang variety, to identify differences in the physical quality response of paddy between GSR Unsoed line and Ciherang variety at various moisture contents of paddy, and to determine the optimal moisture content of paddy. This research used a Randomized Block Design. The factor studied was the moisture content of paddy, which consisted of 3 levels (15%, 14%, and 13%), and the types of varieties/lines used consisted of 2 levels (GSR Unsoed line and Ciherang variety). This resulted in 6 treatment combinations and 3 replications. The components of quality observed included head rice, broken rice, brewers rice, yellow rice, chalky rice, grains, milled rice yield. The results of the study showed that various moisture contents of paddy did not significantly affect the rice quality of GSR Unsoed. Meanwhile, Ciherang variety showed that various moisture contents of paddy affected the rice quality, especially head rice, broken rice, and brewers rice at moisture content of 13%.

1 Introduction

The phenomenon of climate change has affected rainfall patterns and caused more frequent and severe droughts, thereby reducing the availability of water for irrigation and potentially hindering plant growth. Indications of climate change include the increased frequency of extreme events such as floods, droughts, and issues closely related to resource management, particularly water resources during the growth stages of rice plant [1]. The excessive use of chemical fertilizers has also caused significant land degradation, reduced soil fertility, and led to environmental degradation. These damaged agricultural lands require innovative solutions to restore their productivity [2]. Under these conditions, conventional rice varieties struggle to survive and yield optimally. Therefore, it is necessary to develop rice varieties that can grow optimally under various land conditions, such as nutrient and water deficiencies, and to increase rice production yields.

Green Super Rice (GSR) is a genotype of rice designed to have high yield potential, tolerance to biotic and abiotic stresses, and efficient use of fertilizers and water. Jenderal

* Corresponding author: suwarto@unsoed.ac.id

Soedirman University has contributed to the development of GSR. Through research and innovation conducted by Unsoed researchers, a GSR line that is resistant to drought conditions and capable of growing in suboptimal land has been successfully developed. This line, named GSR Unsoed, was created by crossing the Ciherang variety with one of a line from China. Based on this, GSR lines are expected to excel under suboptimal conditions, such as drought stress, pest and disease attacks, less fertile land, and low fertilizer application [3].

The moisture content of paddy is a component that affects the physical quality of milled rice. One of the common issues in rice production is the low quality of rice. This low quality results in a lower milling yield and a higher percentage of broken rice during the milling process. The quality of rice produced during milling is influenced by the moisture content of the paddy [4]. Each variety has a different response in terms of rice quality in different paddy moisture content. Different rice moisture levels on local Siam Sabah variety can affect the physical quality of milled rice, especially if the paddy moisture content does not reach the optimal level of 14% [5]. Meanwhile, the effective moisture content of paddy for milling is between 10.5% and 14% [6].

This research focused on two varieties/lines, namely the GSR Unsoed line and the Ciherang variety. Although the Ciherang variety is common and many studies have been done regarding its optimal paddy moisture content, information on the optimal paddy moisture content for the GSR Unsoed rice line is still lacking. Therefore, further research is necessary to achieve the desired objectives.

2 Material and Methods

This research was conducted from October to December 2023 at the Department of Agriculture and Food of Bojongsari Village and the Plant Breeding and Biotechnology Laboratory of Jenderal Soedirman University. The experiments were carried out on the Seed and Food Crop Garden, owned by Seed and Horticultural Crop Center, Banyumas, East Java.

The materials used in this research include dried rice of the GSR Unsoed line and the Ciherang variety, fertilizer, plastic bags, plastic twine, and water. The tools used in this research were buckets, the RB Rice RR-18 rice milling machine, the Crown TA-5 moisture tester, a digital scale, a tweezer, and writing tools.

This research was a factorial study consisting of 2 factors. The design used was a randomized complete block design (RCBD) factorial with 3 replications. The first factor was the moisture content of paddy and the second factor was the type of line or variety. The research was conducted using block groups. The moisture content factor consisted of 3 treatment levels: 1) K1= 15% moisture content, 2) K2= 14% moisture content, 3) K3= 13% moisture content, and the types of varieties/lines used consisted of 2 treatment levels: 1) V1= GSR Unsoed line, 2) V2= Ciherang variety. This resulted in 6 treatment combinations, which were: K1V1, K1V2, K2V1, K2V2, K3V1, and K3V2.

2.1 Research Variables

The variables observed in this study referred to the rice quality standards of SNI (6128-2015), as well as the research by Firdaus *et al*. (2022) [7] and Handayani *et al*. (2018) [8]. These variables included head rice, broken rice, brewers rice, yellow rice, chalky rice, grains, and milling yield. Data on head rice, broken rice, brewers rice, yellow rice, chalky rice, and paddy were obtained by taking a 100-gram sample and then determining the weight of each variable. Meanwhile, data on milling yield were obtained by milling a 500-gram paddy sample and then dividing the results by the weight of the milled samples.

Table 1. Rice Quality Standard (SNI 6128-2015)

No	Quality Components	Quality Class			
		Premium	Medium		
			1	2	3
1	Level of Polishing (%, min)	100	95	90	80
2	Water content (%, max)	14	14	14	15
3	Head rice (%, min)	95	78	73	60
4	Broken (%, max)	5	20	25	35
5	Brewer (%, max)	0	2	2	5
6	Red grain (%, max)	0	2	3	3
7	Yellow/damaged grains (%, max)	0	2	3	5
8	Chalky rice (%, max)	0	2	3	5
9	Foreign objects (%, max)	0	0.02	0.05	0.2
10	Unhusked grains (grains/100g, max)	0	1	2	3

3 Results and Discussion

3.1 Head Rice

Table 2 indicated that paddy moisture content significantly affected the head rice. Moisture content of 14% showed the highest average percentage compared to 13% and 15%. This is supported by the graph (Fig 1.), which showed that the percentage of head rice in the GSR Unsoed line did not differ significantly and tended to be more stable at every moisture content level of paddy. However, in the Ciherang variety, there was a significant decrease at 13% moisture content. Therefore, a moisture content of 14% was optimal for rice milling. Paddy with lower moisture content tended to break easily during milling. Head rice yield is a critical factor in determining grain quality as it determined the amount of rice weight produced and the economic value of the rice. Paddy moisture content significantly influences milling outcomes, impacting rice quality. Thus, it is crucial to carefully manage moisture content during the milling process [9]. The moisture content of paddy for milling should ideally be at least 13% and no more than 15%. High moisture content could led to damage to the husk breaker rolls, resulting in faster wear of the polishing cylinder [10].

Overall, GSR Unsoed tended to produce more stable head rice at each level of paddy moisture content, while the Ciherang variety experienced a significant decrease at 13% paddy moisture content, as supported by Fig. 1. According to the rice quality requirements of SNI (6128-2015), both GSR Unsoed and Ciherang fall into the medium 1 quality category because the head rice produced exceeded the minimum requirement of 78%.

Table 2. Percentage of head rice at various moisture content of paddy and types of rice line/variety

Moisture content of paddy	GSR Unsoed Line (%)	Ciherang Variety (%)	Average of head rice
Paddy moisture content of 15%	87,06a x	84,90a y	85,98B
Paddy moisture content of 14%	89,13b xy	84,79a y	86,96B
Paddy moisture content of 13%	89,99b y	57,31a x	73,65A

Average of variety	88,73B	75,67A	82,20

Note: The numbers followed by the same lowercase letter in the same column (x, y, z), the same lowercase letter in the same row (a, b, c), and uppercase letters in the average variable (A, B, C) indicate no significant effect based on the DMRT at a 5% error level.

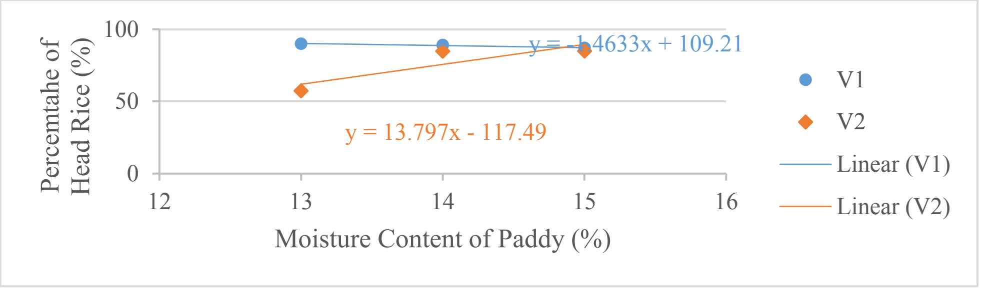

Fig 1. Percentage of head rice at various moisture content of paddy

3.2 Broken Rice

Table 3 indicated that moisture content of paddy significantly influenced the broken rice. Moisture content of 13% resulted in the highest average percentage of broken rice, while a moisture content of 15% yielded the lowest average percentage of broken rice. This is supported by the graph (Fig. 2), which indicated that the percentage of broken rice for both the GSR Unsoed line and the Ciherang variety did not differ significantly at 14% and 15% moisture content of paddy. However, there was an increase at 13% moisture content, especially in the Ciherang variety, resulted in the GSR Unsoed line producing fewer broken rice on average and tended to be more stable compared to the Ciherang variety. This contrasted with the research from Alsharifi *et al.* (2017) [11], who reported a positive correlation between moisture content and broken rice, indicating that higher moisture content results in higher percentages of broken rice. The high percentage of broken rice was suspected to be caused by imperfect milling processes [12]. Additionally, broken rice could also occur due to pressure applied to the paddy [13].

Overall, GSR Unsoed tended to produce more stable broken rice at each level of paddy moisture content, while the Ciherang variety showed a significant increase at 13% paddy moisture content. According to the rice quality requirements of SNI (6128-2015), both GSR Unsoed and Ciherang fell into the medium 1 quality category because the broken rice produced was lower than the maximum requirement of 20%.

Table 3. Percentage of broken rice at various moisture content of paddy and types of rice line/variety

Moisture content of paddy	GSR Unsoed Line (%)	Ciherang variety (%)	Average of broken rice
Paddy moisture content of 15%	4,00a x	6,24a x	5,12A
Paddy moisture content of 14%	6,25a x	6,75a x	6,50A
Paddy moisture content of 13%	4,01a x	12,55b y	8,28A
Average of variety	4,75A	8,51B	6,63

Note: The numbers followed by the same lowercase letter in the same column (x, y, z), the same lowercase letter in the same row (a, b, c), and uppercase letters in the average variable (A, B, C) indicate no significant effect based on the DMRT at a 5% error level.

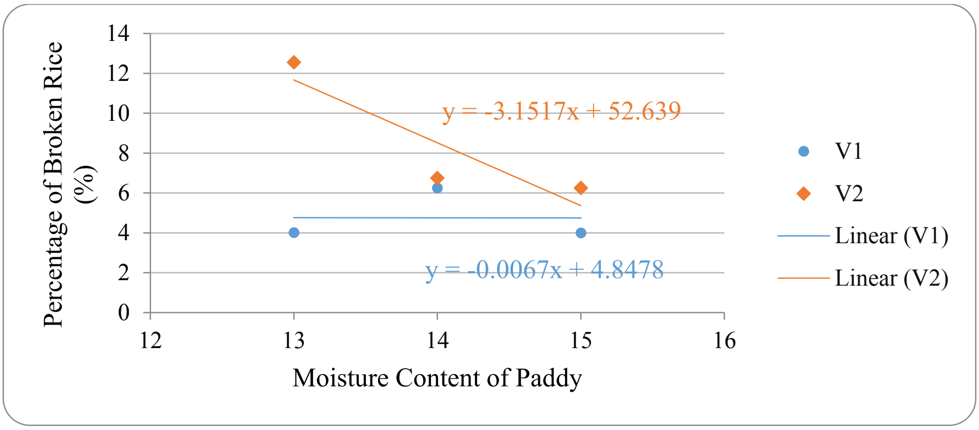

Fig 2. Percentage of broken rice at various moisture content of paddy

3.3 Brewer Rice

Moisture content of paddy significantly influenced the chalky rice variable as it showed on Table 4. Paddy moisture content of 13% resulted in the highest average percentage of chalky rice, while a paddy moisture content of 14% yielded the lowest average percentage of chalky rice. This is supported by the graph (Fig. 3), which indicated that the percentage of chalky rice in the Ciherang variety was higher at 13% paddy moisture content. Chalky rice produced by the GSR Unsoed line was higher at 15% moisture content of paddy but did not significantly differ from the Ciherang variety at the same moisture content. Thus, overall, the GSR Unsoed line produced the lowest average percentage of chalky rice. According to, the percentage of broken and chalky rice is influenced by high (>14%) or low (<14%) moisture content of paddy [14]. High percentage of chalky rice is caused by imperfect drying processes and prolonged polishing time. At moisture content of 14%, the husk removal process becomes easier, resulting in shorter polishing time and minimizing broken and chalky rice [12].

The husk removal process for paddy became easier and faster at 14% paddy moisture content, resulting in fewer broken rice and brewer. GSR Unsoed produced a smaller amount of groats at each level of paddy moisture content compared to Ciherang, which showed a significant increase at 13% paddy moisture content. According to the rice quality requirements of SNI (6128-2015), GSR Unsoed fall into the medium 3 quality category because the groats produced at the optimum paddy moisture content were lower than the maximum requirement of 5%. Meanwhile, the Ciherang variety did not qualify for medium 1, medium 2, or medium 3 quality categories.

Table 4. Percentage of brewer rice at various moisture content of paddy and types of rice line/variety

Moisture content of paddy	GSR Unsoed line (%)	Ciherang variety (%)	Average of brewer rice
Paddy moisture content of 15%	7,27a y	7,48a x	7,38A
Paddy moisture content of 14%	2,90a x	6,8b x	4,85A

Paddy moisture content of 13%	4,45a x	28,9b y	16,68B
Average of variety	4,87A	14,39B	9,64

Note: The numbers followed by the same lowercase letter in the same column (x, y, z), the same lowercase letter in the same row (a, b, c), and uppercase letters in the average variable (A, B, C) indicate no significant effect based on the DMRT at a 5% error level.

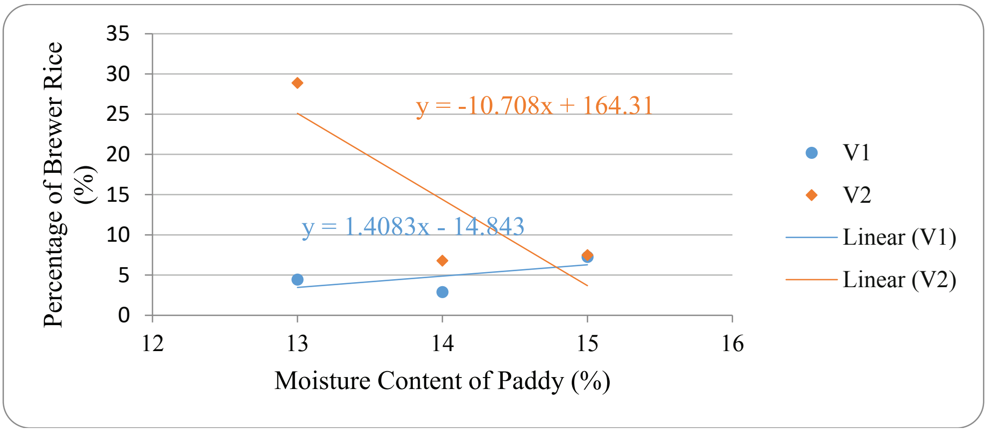

Fig 3. Percentage of brewer rice at various moisture content of paddy

3.4 Yellow Rice

Moisture content did not significantly affect the yellow rice (Table 5.) and still qualify for medium 1 quality for both genotypes. Moisture content of 13% resulted in a lower average percentage of yellow rice compared to 14% and 15%, but the differences were not statistically significant. Meanwhile, the percentage of yellow rice in the GSR Unsoed line did not differ significantly across different paddy moisture content levels, and the same applied to the Ciherang variety. The presence of yellow rice was influenced by storage process and the quality of rice processed [10]. Unripe or undercooked grains of rice, and delayed drying processes leading to fermentation of the grains, resulted in milled rice containing chalky grains, yellowish tint, and black spots [10].

Table 5. Percentage of yellow rice at various moisture content of paddy and types of rice line/variety

Moisture content of paddy	GSR Unsoed line (%)	Ciherang variety (%)	Average of yellow rice
Paddy moisture content of 15%	0,83	0,75	0,79A
Paddy moisture content of 14%	1,03	1,23	1,13A
Paddy moisture content of 13%	0,74	0,50	0,62A
Average of variety	0,87A	0,83A	(-)

Note: The numbers followed by the same uppercase letter (A, B, C) indicate no significant effect in the DMRT at a 5% error level

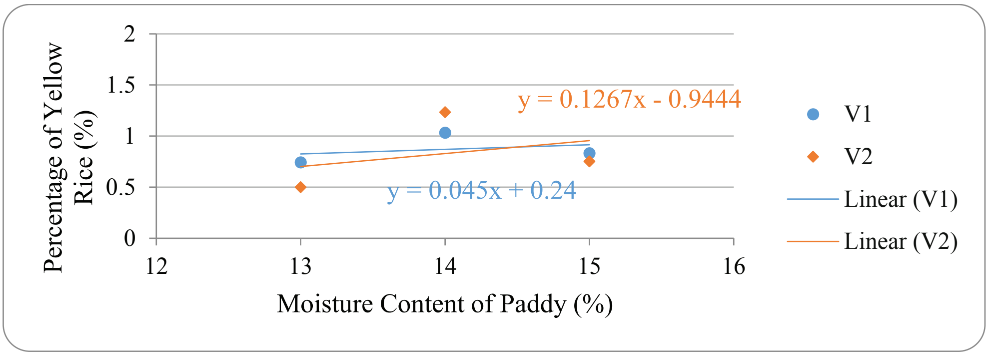

Fig 4. Percentage of yellow rice at various moisture content of paddy

3.5 Chalky Rice

Table 6 showed that moisture content of paddy did not significantly affect the chalky rice and still qualify for medium 1 quality for both genotypes. Moisture content of 14% resulted in a lower average percentage of chalky rice compared to 13% and 15%, but the differences were not statistically significant. Meanwhile, the average percentage of chalky rice in the GSR Unsoed line did not significantly differ from the Ciherang variety. The formation of chalky rice was influenced by genetic factors, environmental conditions, harvesting age, disease infestations, and rapid grain filling and maturation due to high air temperatures [15]. Suboptimal harvesting time can result in greenish grains, which lead to chalky white rice when processed [4]. These factors cause the rice to be more brittle and prone to breaking during milling, making it less desirable to consumers [16]. This is because rice with a high percentage of chalky rice is susceptible to insect infestation during storage, leading to shorter shelf life [4].

Table 6. Percentage of chalky rice at various moisture content of paddy and types of rice line/variety

Moisture content of paddy	GSR Unsoed line (%)	Ciherang variety (%)	Average of chalky rice
Paddy moisture content of 15%	0,67	0,55	0,61A
Paddy moisture content of 14%	0,42	0,31	0,37A
Paddy moisture content of 13%	0,43	0,74	0,59A
Average of variety	0,51A	0,53A	(-)

Note: Numbers followed by the same uppercase letters (A, B, C) indicate no significant effect in the DMRT at a 5% error level.

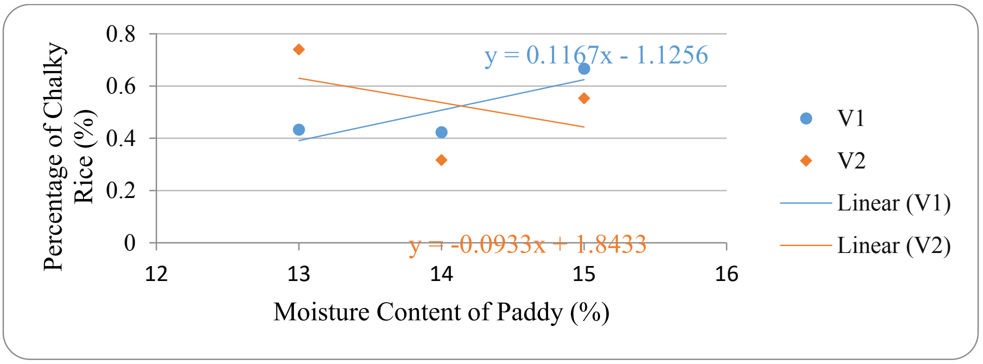

Fig 5. Percentage of chalky rice at various moisture content of paddy

3.6 Unhusked Grains

Table 7 showed that moisture content did not significantly affect the unhusked grains and still qualify for medium 1 quality for both genotypes. Moisture content of 15% resulted in lower unhusked grains, but the difference was not significantly different. Meanwhile, the Ciherang variety produced slightly lower unhusked grains, but this difference was also not statistically significant. High moisture content made it difficult to husk the grains, resulted in more unhusked grains [17]. However, the quantity of unhusked grains after milling is influenced by environmental factors, harvesting practices, post-harvest handling, in addition to genetic factors [16].

Table 7. Percentage of grains at various moisture content of paddy and types of rice line/variety

Moisture content of paddy	GSR Unsoed line (%)	Ciherang variety (%)	Average of unhusked grains
Paddy moisture content of 15%	0,17	0,06	0,12A
Paddy moisture content of 14%	0,26	0,11	0,19A
Paddy moisture content of 13%	0,37	0	0,19A
Average of variety	0,27A	0,06A	(-)

Note: Numbers followed by the same uppercase letter (A, B, C) indicate no significant effect in the DMRT at a 5% error level.

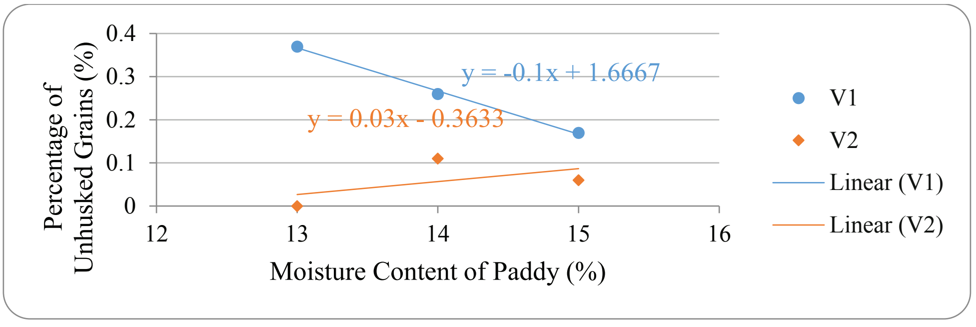

Fig 6. Percentage of unhusked grains at various moisture content of paddy

3.7 Milled Rice Yield

Moisture content of paddy did not significantly affect the milled rice yield (Table 8). Moisture content of 15% resulted in a higher milled rice yield compared to 13% and 14%. Meanwhile, the GSR Unsoed line produced a milled rice yield that was not significantly different from the Ciherang variety. This is supported by the graph (Fig. 7), which showed that the Ciherang variety yielded higher milled rice at 15% moisture content compared to 13% and 14%. According to Lestari and Kurniawan (2021) [14], the milled rice yield is affected by low (<14%) and uneven moisture content of the grains. Incorrect moisture content during the milling process directly impacts milling yield, degree of milling, and the quality of the produced rice. Milling at low moisture content results in a higher percentage of broken rice, small fragments, and bran, leading to a decrease in milling yield.

Table 8. Percentage of milled rice yield at various moisture content of paddy

Moisture content of paddy	GSR Unsoed line (%)	Ciherang variety (%)	Average of milled rice yield
Paddy moisture content of 15%	66,00	68,53	67,27A
Paddy moisture content of 14%	65,33	64,87	65,10A
Paddy moisture content of 13%	66,20	65,80	66,00A
Average of variety	65,84A	66,40A	(-)

Note: Numbers followed by the same uppercase letters (A, B, C) indicate no significant effect in the DMRT at a 5% error level

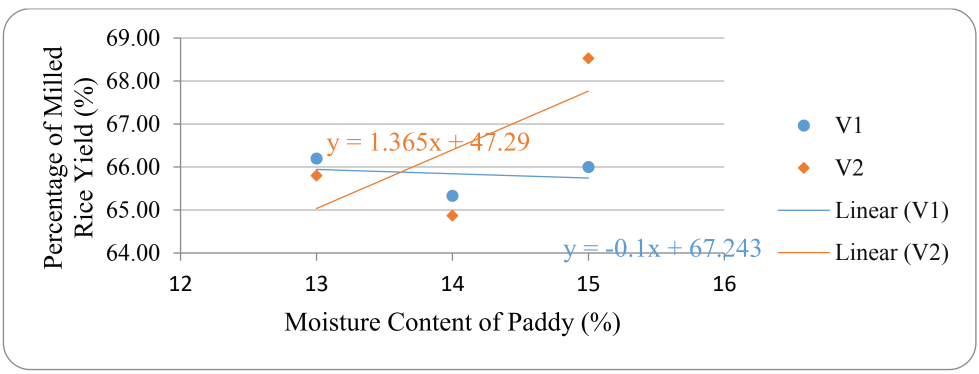

Fig 7. Percentage of milled rice yield at various moisture content of paddy

4 Conclusion

The variation of paddy moisture contents affected the average physical quality of the resulting rice, with a 13% moisture content producing lower head rice yield and higher broken rice and milled rice compared to 14% and 15% moisture content. Meanwhile, variables such as yellow rice, chalky rice, paddy, and milling yield were more influenced by other factors such as grain quality, storage process, suboptimal harvesting process, environment, and genetics.

The percentage of head rice in the GSR Unsoed line was higher at 13% moisture content, the percentage of broken rice was higher at 14% moisture content, and the percentage of milled rice was higher at 15% moisture content. Meanwhile, the Ciherang variety showed significant differences in head rice, broken rice, and milled rice variables at each moisture content level. The 13% moisture content in the Ciherang variety resulted in lower head rice and higher broken rice and milled rice compared to 14% and 15% moisture content.

The optimal moisture content for maintaining good physical quality in the GSR Unsoed line is between 13% and 14%. Meanwhile, the optimal moisture content for maintaining good physical quality in the Ciherang variety is between 14% and 15%.

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