Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 2, Number 02, Juli 2023
doi.org/10.58471/esaprom
E.SSN 2828-9463 (Online)

Selection of Intermittent Irrigation to Increase Growth and Yield of Some Local Rice Varieties (*Oryza sativa* L.) in the Rainy Season

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ABSTRACT

This study aims to examine the influence of various varieties and methods of irrigation on the response to rice growth and yield. The research was conducted in the Experimental Land of the Faculty of Agriculture, University of Muhammadiyah Yogyakarta, in January 2020. The study was conducted in the area using a factorial strip plot design in a Randomized Completely Block Design with three replications. Thirty-six experimental units were obtained. This research consists of two factors. Factor I consists of 4 methods of irrigation, namely continuous flooding, ten days flooding, six dry days, eight days flooding, eight dry days, and six days flooding, ten dry days. Factor II consists of 3 varieties: Ciherang, Cempo Hitam, and Mentik Susu. The observed parameters are the height of plants, number of tillers, leaves area, length of roots, fresh weight of plants, dry weight of plants, harvest index, panicle number, and weight of grain/ hectare. This study showed that Cempo Hitam and Mentik Susu varietas rice plants were higher, and the leaves were more expansive than the Ciherang variety. Irrigation does not affect plant height, number of tillers, leaf area, root length, or rice panicles. There is a mutual influence between variety with irrigation on the fresh and dry weight of rice plants, panicle length, harvest index, and yield per hectare of rice. A variety of Mentik Susu with conventional irrigation, ten days flooded, six days dry, six days flooded, and ten days dry, showed higher yields per hectare compared to the combination of other varieties and irrigations.

Keywords:
Local rice varieties, rice physiology, plot strips, intermittent irrigation, and plant growth analysis

INTRODUCTION

Rice (Oryza sativa L.) is an important food crop commodity that is the staple food of more than half of the world's population, including in Indonesia. Most Indonesians consume rice as the main staple food because it contains nutrients the body needs. According to BPS-Statistics Indonesia (2023), the area of land used for rice cultivation in 2021 decreased to 10.41 million hectares compared to the 2020 census of 10.66 hectares. The location of land that has reduced again increased in 2022, where the area of rice fields used by farmers increased to 10.45 million hectares. Rice production in 2021 was 54.42 million tons of dry grain, a slight decrease of 0.13 million tons or 0.42% compared to 2020, 54.65 million tons of dry grain. Rice production in 2022 was 54.75 million tons of dry grain, a slight increase of 0.1 million tons or 0.18% compared to 2021 (BPS-Statistics Indonesia, 2023).

Every year the total population growth rate in Indonesia increases. In mid-2021, the population reached 272.68 million, while in mid-2022, the population reached 275.77 million. In the middle of 2023, the population will reach 278.70 million people, an increase in the last two years of 50.06 million people. Every year the population of Indonesia increases by an average of 3.01 million people or 1.17% (BPS-Statistics Indonesia, 2023). The increasing population can affect the increase in community food production, especially in the commodity amount of rice.

The cultivated rice plant (Oryza sativa L.) be- longs to the tribe Oryzeae under the sub-family Pooideae in the grass family Gramineae (Poa- ceae). O. sativa was categorized under the series Sativa in section Sativae when biosystematists recently separated the genus Oryza into various sections. Asia is the native home of O. sativa (Chang and Bardenas, 1995).

Farmers in Indonesia generally apply conventional planting methods in crop cultivation. Another method that can be used to increase rice production is the application of the System of Rice Intensification (SRI) planting method, namely the intensive and efficient cultivation of rice plants with a cultivation process that takes into account all the components in the cultivation process, both soil, plant and water processing. Several nations have adopted SRI practices after being modified and tailored to specific local circumstances (Anas *et al.*, 2011). Through adjustments to crop, soil, nutrient, and water management, the "System of Rice Intensification" (SRI) created in Madagascar has been displaying significant production gains and other advantages (Uphoff, 2011).

Water management in rice cultivation by regulating irrigation and drainage. The primary water supply during the dry season is irrigation, which is also utilized to augment rainfall during the wet season (Dobermann and Fairhurst, 2000). Scanning electron microscopy was used to examine the structure and histology of the aerenchyma of two different rice cultivars, which varied in their ability to transfer gas through the aerenchyma (Butterbach-Bahl, Papen and Rennenberg, 2000).

The response of rice to irrigation differs depending on the variety. The government has released some rice varieties in Indonesia. Ciherang is one of Indonesia's national high-yielding rice varieties, while local rice varieties include Mentik Wangi, Mentik Susu, Rojolele, and Cempo hitam. Ciherang is an excellent cultivar because it is resistant to leaf blight bacteria and planthopper pests, and it can be planted in the wet and dry seasons at altitudes lower than 500 m above sea level (Romdon *et al.*, 2014).

The objectives of this study were to (1) Examine differences in rice varieties on rice growth and yield. (2) Assessing the differences in SRI intermittent irrigation on rice growth and yield in the rainy season. (3) Assessing the interaction between varieties and types of irrigation in the rainy season.

METHODS

This research was conducted at the Research Area of the Faculty of Agriculture of UMY in Kasihan, Bantul Regency, Yogyakarta. Laboratory analysis was carried out at the FP UMY Production Laboratory. The research was carried out from January to July 2020. Materials used include Ciherang rice seeds, Mentik Susu, black rice, POC, manure, Urea fertilizer, SP-36, KCL, etc. The tools used are a tractor, hoe, 0.01 g electric scale ruler, LICOR -6400 leaf area meter, Genesis 60 UV spectrophotometer, grain moisture meter, measuring cup, and oven.

This research was conducted with field experiments using a 4x3 factorial experimental method with a strip plot design arranged in a Randomized Completely Block Design (RCBD) with three replication orders to obtain 36 experimental units. The factors and treatment, namely factor 1 (irrigation), include four treatments, including conventional irrigation, ten days of stagnation, six days of dryness, eight days of flooding, eight dry days, and six days of inundation of ten dry days. Factor 2 (variety) includes three treatments: Ciherang, Cempo ('Cempo Hitam'), and Mentik Susu types.

RESULTS AND DISCUSSION

a. Plant height

The results of the analysis of variance show that there is no interaction between varieties and irrigation, meaning that there is no relationship between varieties and irrigation. The type of irrigation does not significantly affect plant height. Varietas significantly affect the height of rice plants. Varietas Cempo Hitam and Mentik Susu have significantly higher plant heights than the Ciherang variety (Table 1).

Ariwibawa (2012) stated that High plants do not imply high crop yields. Plants that can grow well are plants that can absorb nutrients in large quantities, therefore the availability of nutrients in planting can affect plant activities. One of the plant activities is the process of photosynthesis, so plants can increase growth and production. According to Lakitan (2008), the amount of water, light, CO2, and available air temperature can all impact the photosynthetic process. If these resources are scarce, competition between them may have an effect on the products of photosynthesis.

Table 1. Average Height of 10 Weeks Rice Plants (cm).

Treatment	Ciherang	Cempo	Mentik Susu	Average
Konvensional	81.23	118.10	160.80	120.04 a
10-6	80.67	114.90	88.43	94.67 a
8-8	66.90	101.87	85.53	84.77 a
6-10	79.53	112.23	94.87	95.54 a
Average	77.08 q	111.78 p	107.41 p	(-)

Note: The numbers followed by the same letter in one row or column show no significant difference based on the results of variance and DMRT at the α = 5% level

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b. Number of Tillers

The results of the variety analysis showed no real interaction between varieties and irrigation, meaning there was no interplay between varieties and irrigation. Genotypic factors and the environment around the plant influence the number of saplings. Biotic environmental factors that can suppress the large number of saplings are due to damage caused by pests such as rats. Rats can damage parts of plants by eating parts of stem stalks.

Table 2. Average Number of tillers number at 10 Weeks

Treatment	Ciherang	Cempo	Mentik Susu	Average
Konvensional	29.50	30.70	34.65	31.62 a
10-6	27.00	30.85	37.30	31.72 a
8-8	30.85	24.70	31.50	29.07 a
6-10	31.30	31.70	37.30	33.43 a
Rerata	29.62 p	29.49 p	35.19 p	(-)

Note: The numbers followed by the same letter in one row or column show no significant difference based on the results of variance and DMRT at the α= 5% level. (-): There is no interaction between treatments.

The results of DMRT show that a variety treatment and irrigation have no significantly effect on the total number of rice saplings (Table2). The total number of rice saplings in various irrigations did not differ markedly, nor did the varieties differ markedly. Damage can cause a loss in the number of saplings in rice plants. According to Budiyono (2006), there were fewer saplings generated the more plant stalks were injured and lost.

c. Leaf area

Based on the results of the analysis of leaf area fingerprints, there is no real interaction between irrigation and variety, meaning that there is no real relationship between variety and irrigation.

Table 3. Average Leaf Area of Rice Plants at 12 Weeks (cm2)

Treatment	Ciherang	Cempo	Mentik Susu	Average
Konvensional	332.7	629.7	730.3	564.2 a
10-6	326.0	762.3	878.3	655.5 a
8-8	288.7	635.7	703.3	542.6 a
6-10	462.7	742.7	790.0	653.1 a
Average	352.5 q	692.6 p	775.5 p	(-)

Note: The numbers followed by the same letter in one row or column show no significant difference based on the results of variance and DMRT at the α = 5% level. (-): There is no interaction between treatments.

The irrigation treatment showed no noticeable effect on the leaf area, while the varietal treatment showed a noticeable difference. Based on further DMRT test results, the leaf area shows that Cempo Hitam and Mentik Susu rice varieties have a significantly wider leaf area than Ciherang varieties (Table 3). Hariyono and Isnawan research results (2018), who researched The Ciherang rice variety under study, revealed that the leaf area of Memberamo, Inpari 19, and Rojolele did not differ significantly.

d. Root Length

Based on the results of root length fingerprints, there is no real interaction between irrigation and variety, meaning there is no real mutual influence between irrigation and variety. The length of the roots absorbs water by maximizing the root system. One of the primary methods for determining how deep the roots can penetrate the soil layer in search of water and nutrients is to measure the length of the roots (Munarso, 2011).

Based on the results of the F test, the root length shows that there is no interaction between variety treatment and irrigation. Irrigation and variety showed no significant effect on rice root length (Table 4).

Table 4. Average Root Length of 12 Week Rice Plants (cm)

Treatment	Ciherang	Cempo	Mentik Susu	Average
Konvensional	25.33	26.67	28.67	26.89 a
10-6	25.33	27.33	28.00	26.89 a
8-8	27.67	27.33	32.00	29.00 a
6-10	27.33	28.67	34.33	30.11 a
Average	26.42 p	27.50 p	30.75 p	(-)

Note: The number followed by the same letter in one column shows the results that are not significantly different based on the results of variance and DMRT at the α 5% level. (-): There is no interaction between treatments.

e. Fresh Weight of Plants

Based on the results of the analysis of the variety of fresh weight of plants, it shows a real interaction between varieties and irrigation, meaning that there is a relationship between the treatment of varieties and irrigation of fresh weight of plants.

Table 5. Average Fresh Weight of Rice Plants at 12 Weeks (g)

Treatment	Ciherang	Cempo	Mentik Susu	Average
Konvensional	127.27 cd	260.94 abc	244.61 abc	210.94
10-6	128.71 cd	368.65 a	245.40 abc	247.59

8-8	91.25 d	193.71 bcd	205.97 bcd	163.64
6-10	182.55 bcd	323.04 ab	203.21 bcd	236.27
Average	132.45	286.59	224.80	(+)

Note: The numbers followed by the same letter in a row and column show not significantly different based on the results of variance and DMRT at the α=5% level. (+): There is a real interaction between treatments

Based on the DMRT test, the fresh weight of plants shows that in conventional irrigation treatment, 8 days of flooding, 8 days of dryness, and 6 days of flooding, 10 days of dryness between varieties showed a fresh weight of plants that did not differ markedly (Table 5). In irrigation of 10 days of inundation 6 days of dryness, the fresh weight of plants of the Cempo Hitam variety showed significantly heavier than the Ciherang variety.

In the treatment of Ciherang and Mentik Susu varieties, each irrigation showed relatively the same results, while in the cempo Hitam variety, watering for 8 days was flooded for 8 days and showed significantly different results from the 10-day irrigation treatment was flooded for 6 days.

f. Plant Dry Weight

Based on the results of the analysis of the variety of dry weight of plants, it shows that there is a significant interaction between varieties and irrigation, which means that there is an effect given from the treatment of varieties and irrigation on the dry weight of plants (Table 6). Because they produce more photosynthate at first, plants with a greater leaf area will grow more quickly. Larger photosynthate will enable the formation of larger plant organs, increasing the amount of dry matter produced (Sitompul and Guritno, 1995).

Table 6. Average Dry Weight of Rice at 12 Weeks (g)

Treatment	Ciherang	Cempo	Mentik Susu	Average
Konvensional	30.09 cd	64.21 ab	53.70 bcd	49.33
10-6	54.50 bcd	94.06 a	54.94 bcd	67.83
8-8	19.30 d	39.35 bcd	39.10 bcd	32.58
6-10	37.02 bcd	72.51 ab	45.28 bcd	51.60
Average	35.28	67.53	48.26	(+)

Note: The numbers followed by the same letter in a row and column show not significantly different based on the results of variance and DMRT at the α=5% level. (+): There is a real interaction between treatments

Based on the DMRT test, the dry weight of plants shows that in the irrigation treatment of 8 days flooded, 8 days dry, and six days flooded, 10 days dry, each variety showed results that did not differ markedly, while in conventional irrigation, the Cempo Hitam variety had a heavier dry weight than the Ciherang variety. In irrigation, 10 days of inundation 6 days dry, the Cempo Hitam variety has a higher dry weight compared to the Mentik Susu and Ciherang varieties.

The Ciherang and Mentik Susu varieties, each irrigation showed relatively the same plant dry weight. In contrast, in the Cempo Hitam variety, watering was flooded for 10 days, and 6 days of drying showed relatively heavier fresh weight than 8 days of irrigation and 8 days of watering.

g. Number of Panicles Per Clump

The analysis of the variety of panicles per clump shows no real interaction between type and irrigation, meaning that there is no interplay between irrigation and variety on the number of productive rice tillers. Based on test F, the number of panicles per clump shows that the variety of treatment and irrigation do not significantly affect the number of productive rice tillers (Table

7). Panicles per square meter were inversely correlated with minimum temperature (P 0.01) but not with radiation or maximum temperature (P > 0.10) (Peng *et al.*, 2004)

Table 7. Average Number of Panicles per Clump

Treatment	Ciherang	Cempo	Mentik Susu	Average
Konvensional	14.90	18.87	22.90	18.89 a
10-6	16.63	18.47	17.97	17.69 a
8-8	20.03	22.90	18.00	20.31 a
6-10	20.00	19.00	20.20	19.73 a
Average	17.89 p	19.81 p	19.77 p	(-)

Note: The numbers followed by the same letter in one row or column show no significant difference based on the results of variance and DMRT at the α= 5% level. (-): There is no interaction between treatments.

h. Harvest Index

Based on variety analysis, it shows that there is a real interaction between varieties and irrigation in the harvest index, meaning that the two factors provide a relationship with the mutual influence of i on the rice harvest index.

Table 8. Average Rice Harvest Index

Treatment	**Ciherang**	**Cempo**	**Mentik Susu**	**Average**
Konvensional	0.789 d	0.753 e	0.898 a	0.813
10-6	0.827 c	0.724 ef	0.899 a	0.817
8-8	0.820 cd	0.708 fg	0.895 a	0.808
6-10	0.853 bc	0.685 g	0.874 ab	0.804
Average	0.822	0.718	0.891	(+)

Note: The numbers followed by the same letter in a row and column show not significantly different based on the results of variance and DMRT at the α5% level. (+): There is a real interaction between treatments

Based on the results of DMRT, the harvest index shows that in the Ciherang variety, irrigation of 10 days of inundation, 6 days of dryness, and 6 days of inundation, ten days of dryness, is markedly higher than conventional irrigation. In the Cempo Hitam variety, conventional irrigation is relatively higher than eight days of inundation, 8 days of dry, and 6 days of inundation, 10 days dry. In the Mentik Susu variety, the type of irrigation showed a harvest index that was not significantly different (Table 8).

In conventional irrigation treatment, 10 days of inundation, 6 days of dryness, and 8 days of inundation, 8 days of dryness showed that the Mentik Susu variety had a significantly higher harvest index than the Ciherang variety. The harvest index of the Ciherang variety is markedly greater than the Mentik Susu variety. In irrigation six days of inundation 10 days dry, it shows that the Mentik Susu Variety has significantly harvest index higher than Cempo Hitam. In 2017, the RC (Ratoon cropping) harvest index was lower than the MC (Maincrop) harvest index; however, the difference between the two was relatively small in 2016 (Wang *et al.*, 2019).

i. Grain yield per hectare

Based on the analysis of variance, grain yield per hectare shows a real interaction between varieties and irrigation, meaning there is a real relationship between types and irrigation.

Table 9. Grain yield per hectare (ton)

Treatment	**Ciherang**	**Cempo**	**Mentik Susu**	**Average**
Konvensional	3.92 e	4.93 cd	6.72 a	5.19
10-6	4.32 de	5.17 cd	6.47 a	5.32

8-8	3.93 e	5.13 cd	5,36 bc	4.81
6-10	4.52 cde	6.15 ab	6.41 a	5.69
Average	4.17	5.35	6.24	(+)

Note: The numbers followed by the same letter in one row and column show no significant difference based on the results of variance and DMRT at the α5% level. (+): There is a real interaction between treatments

Based on DMRT results, grain yield per hectare showed that at eight days of inundation, eight days of drought, and six days of inundation, ten varieties of Cempo Hitam and Mentik Susu produced significantly higher grain than the Ciherang variety. In irrigation, ten days of inundation, and six days of dryness, the Mentik Susu variety has significantly higher grain than the Cempo Hitam and Ciherang varieties. In conventional irrigation, the Mentik Susu variety produces higher grain than Cempo Hitam, and the Cempo Hitam variety has a higher grain weight than the Ciherang variety (Table 9).

In the Ciherang variety, all irrigations show grain yield per hectare does not differ markedly. In the Cempo Hitam variety, irrigation of 6 days of flooding, and ten days of drying, produces grain yields per hectare considerably heavier than other types of irrigation. In the Mentik Susu variety, conventional irrigation, ten days flooded, six days dry, six days flooded, and ten days dry produced grain per hectare markedly lower than the type of irrigation eight days flooded and eight days dry. By optimizing nutrition or water management during the reproductive stage, SRI could enhance yields even more (Nugroho *et al.*, 2018).

CONCLUSION

The results of this study showed that the height of the Cempo Hitam and Mentik Susu variety rice plants was higher, and the leaves were wider than the Ciherang variety. Watering does not affect plant height, number of tillers, leaf area, root length, or rice panicles. There is a mutual influence between types of irrigation on the fresh and dry weight of rice plants, panicle length, harvest index, and yield per hectare of rice. Varieties of Milk Picking with conventional irrigation, ten days flooded, six days dry, six days flooded, and ten days dry, showed higher yields/hectares compared to the combination of other varieties and irrigations.

Acknowledgments

We want to express our gratitude to the University of Muhammadiyah Yogyakarta for providing research funding for the implementation of this research.

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