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Quality and Quantity of Hydroponic Rice Forage Ciherang and IR64 Varieties at Different Harvest Ages

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ABSTRACT: The purpose of this study is to determine how different harvest ages and varieties affect the quantity and quality of fodder produced by hydroponically cultivated rice plants. The study design was a 2 x 3 factorial, completely randomized design (CRD) experiment with five replications. Tiller count, plant height, plant weight, and graph power were among the characteristics that were observed. The data were analyzed using analysis of variance (ANOVA), and any differences were found using Duncan's multiple area test. The plant height, number of tillers, plant weight, and dry matter production were all significantly impacted by the harvest age factor, according to the data. The variety factor is significantly influenced by the observation variables. The interaction between the parameters at 60 days of yield after planting (DYAP) has a significant impact on the variables plant height, plant weight, number of tillers, and dry matter production. The IR64 variety outperformed the Ciherang variety, according to the results of the proximate analysis, and the best harvest age in terms of crude protein, crude fiber, and crude fat content was at 40 days after planting, while the best TDN was at 60 DYAP. The IR64 cultivar produced the most biomass at a harvest age of 60 DYAP. In summary, the study's findings suggest that hydroponically grown paddy forage has great promise in terms of the nutrients it can produce, yet biomass output is still lower than that of cutter grass, while dry matter production is higher than that of fodder.

KEYWORDS: Ciherang; Hydroponic; IR64; Paddy; Quality; Quantity

INTRODUCTION

A livestock's ability to produce enough milk, eggs, or body weight depends on what they are fed. The main source of feed for ruminant livestock is forage; approximately 90% of ruminant feed comes from forage, while the rest is in the form of additional feed (Sirait *et al.*, 2005). The main obstacle for breeders, especially in increasing ruminant livestock productivity, is the limited availability of quality forage. One effort to provide forage for livestock so that its quality and continuity are maintained is by using hydroponic technology. According to Salo (2019) and Kide *et al*. (2015), hydroponic technology produces high-quality forage free from disease and chemical residues originating from insecticides, herbicides, fungicides, and artificial growth hormones. Hydroponic technology to produce forage for livestock in a short time (7–14 days) in liquid and controlled media is known as hydroponic fodder (Wahyono & Sadarman, 2020). One of the disadvantages of hydroponic fodder is that the dry matter production produced is lower or the same as the dry matter of the seeds (Sneath and McIntosh, 2003). Rayani *et al*. (2021) reported that the biomass of rice fodder at harvest age of 14 days was 1,165 g from 300 g of rice seeds. There was an increase in fresh weight production of 4 times the weight of the seeds; however, if we look at the dry matter production, there was a decrease. Animal feed requirements are calculated based on dry matter, so to meet livestock needs, more rice seeds are needed. This can cause competition with the need for rice seeds as food.

One way to try to boost dry matter production is to raise the harvest age. Increasing the harvest age provides more time for plants to carry out photosynthesis. The photosynthesis process increases plant growth and development, which automatically has an impact on increasing plant production and also the production of fresh weight and dry weight (Triyanto, 2013; Kustyorini *et al*., 2020). Apart from that, selecting suitable rice varieties that have superior characteristics, such as having a large number of tillers, can help increase fresh weight and dry weight production. First and foremost, rice plants have the advantage of being easier to obtain seeds from than other cereal plants. Secondly, rice plants can develop vegetative, meaning that they will produce tillers, which are made up of primary tillers. Primary tillers then produce rice tillers that emerge from the segments of the primary tillers, which are called children. Secondary tillers produce tertiary tillers (Sutoro *et al*., 2015). Thirdly, rice is a C3 plant, which has a higher plant protein content compared to C4 plants such as corn and wheat (Nio Song, 2012). This potential allows rice plants to be used as forage for livestock grown hydroponically; however, information regarding the productivity and quality of hydroponic rice forage is not yet widely available, so further research is needed.

MATERIALS AND METHODS

Time and Research Location

The study was conducted between February and April of 2023 in the Animal Science Field Laboratory greenhouse at the Faculty of Animal Husbandry, Brawijaya University, Jalan Apel Dusun Semanding, Sumber Sekar Village, Dau District, Malang Regency. In the Animal Nutrition and Forage Laboratory of the Faculty of Animal Husbandry, Brawijaya University, nutritional content and digestibility analyses were conducted in May and June of 2023.

Materials

This research used certified rice seeds of the IR64 variety and Ciherang variety, well water, hydroponic nutrient solution (A B mix), and materials used for proximate testing.

Tools

The research equipment used is a hydroponic installation with an NFT system using a 4" paralon; the hole diameter is 6 cm; the distance between planting holes is 25 cm; the number of holes for each paralon is 15; the planting medium is rockwool, which is inserted into a netpot made from used mineral drink glass; a 1000 liter capacity nutrient water reservoir; an aquarium water pump; a PH meter; an EC meter; a ruler; a tray measuring 30 x 23 x 4 cm; an oven; and laboratory equipment for proximate analysis.

Research Procedure

In an experimental environment, this study uses a 2x3 factorial fully randomized design (CRD) methodology with five replications. The two components are: three rice harvest ages (DAT = 40, 50, and 60 days after planting) as factor 2, and two rice varieties (Ciherang and IR64) as factor 1. To find the average weight of a single rice grain, this study started by weighing 100 rice seeds and then did so four times. The following methods are used to plant or produce pasture rice using a hydroponic NFT system with an irrigation flow thickness of 1 cm, in accordance with Aini and Azizah's (2018) instructions:

1. Soak the rice seeds in water for 24 hours
2. Prepare a tray that has been serialized with detergent. The tray that has been washed is then coated with tissue in 5 layers evenly and then sprinkled with water until everything is wet.
3. Sow the soaked rice seeds into a tray that has been covered with tissue and has been given water, sowing is carried out for 3 days, after 3 days the seeds that have sprouted are transferred to a planting medium in the form of rockwool measuring 2.5 x 2.5 x 2.5 cm which has been filled with holes. In the middle, each rockwool is filled with 1 rice seed that has sprouted, then the rockwool is filled with water until it is wet.
4. After 4 days, the rockwooll is put into a netpot and then transferred to a hydroponic installation which has been sterilized using detergent and has been supplied with nutrient water using a water pump.
5. 400 L of nutrient water is made from well water, then added with AB-MIX hydroponic nutrients which are in prepared form, stir until evenly mixed then measure the nutrient content of the hydroponic water with a TDS meter until you get a TDS value of 900 ppm for plants aged less than 14 days to 60 DYAP, the water content of hydroponic nutrients is increased to 1250 ppm. Nutrient water quality measurements are carried out every 5 days and if the TDS content is not appropriate, adjustments will be made by adding water if the TDS content is higher than the provisions and AB Mix preparation will be added if the TDS content decreases.
6. Measure production parameters such as plant height, plant weight and number of tillers. Measurements are carried out every 5 days.
7. Measure plant height using a ruler 1 m long and measure from the top of the rockwool to the tallest leaf in one netpot. Measure the weight of the plants every five days by draining water on the rockwool and roots until there are no water droplets, then weighing them on a digital scale.
8. Harvest according to the treatment (40, 50 and 60 days) and weigh the total weight, root weight and crown weight of each plant.
9. Harvested hydroponic rice is dried in an oven at 60° C for 48 hours then ground using hammermills for sample analysis.

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Research Variables

Two variables were identified. First, biomass production includes measurements of fresh weight, plant height, number of tillers, and dry matter production. The second parameter, namely forage quality, includes dry matter content, crude protein, crude fiber, and total digestible nutrients (TDN).

Data Analysis

The results obtained were subjected to *Analysis of Variance* (ANOVA) in accordance with the RAL factorial design, and in order to demonstrate a significant effect, the Duncan Test (Duncan New Multiple Range Test) was performed on the treatment components. The SPSS (*Statistical Package for the Social Sciences*) computer tools, version 26, were used to conduct both analyses.

RESULTS AND DISCUSS

Plant Height

In terms of both genetic potential and environmental potential, plant height can serve as an indicator of a plant's capacity to produce biomass. In this study, plant height was measured from the top of the rockwool to the tallest part of the leaf. The results of statistical analysis in Table 1 show that the harvest age factor and the interaction between factors at 60 DAT had a significant effect on plant height at the level of P<0.05. These findings are consistent with Suryana's (2012) belief that as plants age, their height increases, which is accompanied by an increase in plant cell wall components, the number of tillers, and the number of leaves, resulting in increased production. Figure 1 provides a clear picture of how harvest age greatly influences plant height. The treatment that produced the highest plants was the IR64 variety at 60 days of 80.00 ± 2.55 cm. This result is better than the research results reported by Humaerah (2013), which were 72 cm. The following data is presented in Table 1. Height of rice plants cultivated hydroponically at different varieties and harvest ages.

Table 1. Height of rice plants cultivated hydroponically at different varieties and harvest ages.

Varieties	Harvest Ages			
	40	50	60	Average ± SD
	-------------------------------- cm ----------------------------------			
Ciherang	59.10 ± 3.17^{p}	66.24 ± 1.13^{q}	74.60 ± 2.88^{r}	66.65 ± 6.97^{a}
IR64	58.94 ± 4.86^{p}	63.38 ± 2.18^{q}	80.00 ± 2.55^{s}	67.44 ± 9.90^{a}
Average ± SD	59.02 ± 3.87^{a}	64.81 ± 2.23^{b}	77.30 ± 3.83^{c}	

$^{a-b,\ p-q}$: Different superscripts in the same row and column are significantly different at the level (P<0.05)

The influence of variety factors on plant height in this study showed no significant effect (P<0.05). This may be because the Ciherang and IR64 varieties are superior rice varieties that have almost the same specs, where plant height ranges from 107 to 115 cm for the Ciherang variety and 115 to 125 cm for the IR64 variety (DPKP Jogjakarta, 2023). Apart from that, the plant potential of increasing height is still there because 60 days of age is the beginning of the reproductive phase. According to Patria et al. (2021), the reproductive phase is marked by an increase in the length of the plant stem. Plant height has significantly increased, as seen in the following graphic image of plant height provided by Ciherang and IR64.

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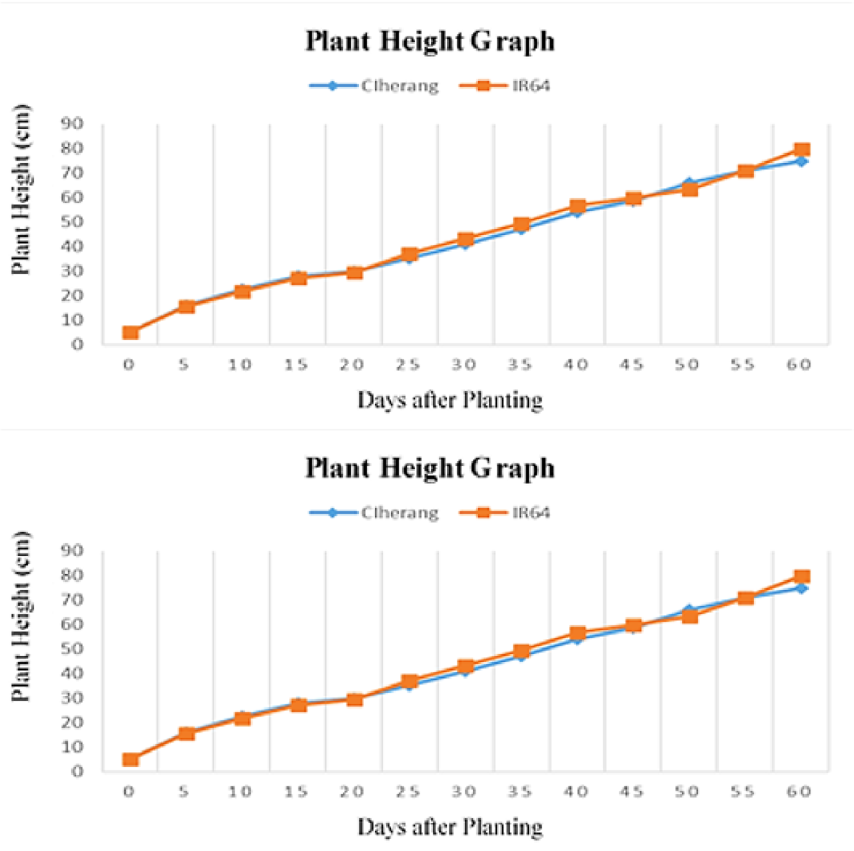

Picture 1. Growth graph of Ciherang and IR64 rice varieties

Weight of Race Plants

The results of a statistical analysis of the weight of rice plants grown hydroponically at various varieties and harvest ages revealed significant differences between the Ciherang and IR64 varieties. Below are presented in Table 2 the results of the analysis, as follows:

Table 2. Results of statistical analysis of the weight of rice plants cultivated hydroponically at different varieties and harvest ages

Varieties	Harvest Ages			
	40	50	60	Average ± SD
	g / planting hole			
Ciherang	10.36±1.82^{p}	28.54±2.65^{r}	29.90±1.55^{r}	22.93±9.41^{a}
IR64	12.26±2.95^{p}	24.01±5.63^{q}	35.17±1.94^{s}	23.81±10.31^{a}
Average	11.31±2.52^{a}	26.27±4.79^{b}	32.53±3.24^{c}	

$^{a-b,\ p-q}$: Different superscripts in the same row and column are significantly different at the level (P<0.05)

Table 2 above shows that the interaction between the Ciherang and IR64 varieties at harvest ages 50 and 60 DYAP had a significant effect (P<0.05) on the canopy weight of rice plants. The IR64 variety produced the highest plant crown weight (35) at a harvest age of 60 DYAP. 17 ± 1.94 g/planting hole, or equivalent to 33.6 tons/ha/year of fresh weight. This result is still lower than the research results reported by Moningka et al. (2020), where at the same age it produced a fresh weight of 62.46 g/planting hole. This could be due to differences in nutrition, variety, temperature, or humidity (Rosliani and Sumarni, 2005). Even though the variety factor had no significant effect, the IR64 variety produced a heavier plant canopy than the Ciherang variety. This is in accordance with the characteristics of superior rice varieties, where the IR64 variety is better in number of tillers and plant height (DPKP Jogjakarta, 2023).

Number of Rice Plant Tillers

The statistical analysis of the number of rice tillers grown hydroponically at various varieties and harvest ages reveals significant differences between the Ciherang and IR64 varieties. Below are the results of the analysis presented in Table 3, as follows:

Table 3. Number of rice tillers cultivated hydroponically at different varieties and harvest ages

Varieties	Harvest Ages			
	40	50	60	Average ± SD
	Tiller / planting holes			
Ciherang	$9.40±1.67^{p}$	$15.80±1.79^{q}$	$17.40±1.67^{qr}$	$14.20±2.39^{a}$
IR64	$10.60±1.81^{p}$	$16.20±2.17^{qr}$	$19.00±2.91^{r}$	$15.27±4.22^{a}$
Average	$10.00±1.76^{a}$	$16.00±1.89^{b}$	$18.20±2.39^{c}$	

$^{a-b,\ p-q}$: Different superscripts in the same row and column are significantly different at the level (P<0.05)

The number of tillers is an indicator of rice and forage production because more tillers result in more panicles, which means more opportunities to produce rice grains and biomass. The statistical analysis presented in Table 3 indicates a significant effect of the harvest age factor at (P<0.05) on the number of tillers in rice plants; the variety factor does not significantly influence the number of tillers; and there is an interaction between treatment factors at harvest ages of 50 and 60 DYAP. The IR64 variety yielded the most tillers at a harvest age of 60 DYAP with 19 fruit, while the Ciherang variety yielded an average of 17.4 tillers. The results of this research show that the IR64 variety is still better than the Ciherang variety. This result is better than the research results reported by Humaerah (2013), which produced a total of 14 productive rice seedlings.

Dry Material Production

According to Table 4's statistical analysis results, harvest age and variety have a significant impact (P<0.05) on the dry matter production of rice forage, as well as that the interaction between the two factors has a significant effect at the age of 60 DYAP.

Table 4. Dry matter production of green rice cultivated hydroponically at different varieties and harvest ages

Varieties	Harvest Ages			
	40	50	60	Average ± SD
	g dry matter / planting holes			
Ciherang	$1.83±0.28^{p}$	$5.41±0.38^{q}$	$6.54±0.43^{r}$	$4.59±2.11^{a}$
IR64	$2.31±0.50^{p}$	$4.90±1.11^{q}$	$7.84±0.62^{s}$	$5.02±2.45^{b}$
Average	$2.07±0.46^{a}$	$5.16±0.83^{b}$	$7.19±0.85^{c}$	

$^{a-b,\ p-q}$: Different superscripts in the same row and column are significantly different at the level (P<0.05)

The IR64 variety tends to have a higher average compared to Ciherang at harvest ages of 40 and 60 days, but not at harvest ages of 50 days. In addition, harvest ages of 60 days tend to produce more dry material for rice than harvest ages of 40 and 50 days. The definition of dry matter is defined as a decrease in cell content components and an increase in cell wall components. Crowder and Chheda (1982) and Cheeda (2021) both state that an increase in plant age is correlated with one another. This is consistent with their findings. Islami et al. went into more detail about it. (2021) that the optimal cutting age for forage is in the final phase of vegetative growth, or before flowering, because in this phase the production of forage dry matter is large and the quality is still quite

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good. According to Patria et al. (2021), 55–60 days is the final age of the vegetative growth phase for rice with a short maturity, such as the Ciherang and IR64 varieties. The variety known as IR64 produced the maximum amount of dry matter (7 kg) at a harvest age of 60 days. 84 ± 0.62 grams per hole. This result is compared to the dry matter weight of 1 seed (0.025 grams), and it can be concluded that the weight of rice plants cultivated hydroponically and harvested at the age of 60 days produces dry matter production 300 times the dry matter weight of the seeds. This result is more efficient than rice fodder harvested at the age of 14 days, which produces a fresh fodder weight of 1,164 g/300 g seeds, or 1,042,94 g body weight/284.31 g seed weight, or 3.66 times the dry matter of seeds (Rayani et al., 2021).

Quality of Hydroponic Rice Forage

The nutrients in the feed, such as crude protein, crude fat, energy/TDN, minerals, and the presence or absence of anti-nutrient compounds, can be used to assess the quality of the feed. The nutrient content of rice forage cultivated hydroponically is shown in Table 5.

Table 5. Nutrient content of Proximate Analysis results of hydroponic rice forage and rice seeds at various ages and varieties (% Dry Matter Basis)

Varieties	Nutrient				
	Dry Matter	Crude Protein	Crude Fiber	Crude Fat	TDN
	---------------------------------- % ----------------------------------				
Ciherang age 40 days	15.31	25.95	21.75	4.27	56.61
Ciherang age 50 days	16.99	24.94	22.87	3.96	60.16
Ciherang age 60 days	18.14	21.65	25.51	2.98	61.40
IR64 age 40 days	16.38	26.04	23.74	4.16	56.40
IR64 age 50 days	17.41	25.71	25.03	4.34	64.95
IR64 age 60 days	18.07	21.98	30.45	4.19	66.34
Ciherang seeds	85.70	9.61	11.21	2.46	81.12
IR64 seeds	87.03	8.42	11.31	2.35	77.89

Notes:

Formula TDN seeds = -202,686 – 1,357 Crude Fiber + 2,638 Crude Fat + 3,003 BETN + 2,347 Crude Protein + 0,046 Double Crude Fiber + 0,647 Crude Fat_2 + 0,041 Crude Fiber BETN – 0,081 Crude Fat BETN + 0,553 Crude Fat, Crude Protein – 0,046 Crude Fat_2 Crude Protein (Hartadi *et al.*, 1980)

Formula TDN forages = -54,572 + 6,769 Crude Fiber – 51,083 Crude Fat + 1,851 BETN – 0,334 Crude Protein – 0,049 Double Crude Fiber + 3,384 Crude Fat_2 – 0,086 Crude Fiber BETN + 0,687 Crude Fat BETN + 0,942 Crude Fat, Crude Protein – 0,112 Crude Fat_2, Crude Protein (Hartadi *et al*., 1980)

Table 5 above demonstrates the very high quality of rice forage produced in this study. This can be seen from the crude protein content in both the Ciherang and IR64 varieties, which is in the range of 21–26%. This crude protein content is higher than the crude protein content in the seeds and is also higher than forage originating from the Gaminea nation, such as king grass (*Pennisetum purpurhoides*) at 9.85 ± 1.66% (Waluyo et al., 2017) and odot elephant grass at 13.94% (Sirait, 2018). The crude fiber content produced is 21.75–30.45%; this result is lower than that of other grass species, such as elephant odot grass, at 32.97% (Arifin et al., 2022). Total digestible nutrients are important nutrients that are always used as a standard in determining the forage that will be used. The research findings revealed that the IR64 variety produced the highest TDN content at a harvest age of 60 DYAP, amounting to 66.34%. This nutritional content was higher than that of forage from the Gaminea breed.

Effect of Cut Grass Dry Matter

Dry matter of cut grass has several potentials for the quality and quantity of harvested crops, including nutrition, structure of the planting medium, water holding capacity, and influence on microorganisms. You also need to pay attention to the cut grass during the harvest period so that the protein in the cut grass is still maintained. Cut grass nutrition is rich in fiber and nitrogen; these two elements are very important for optimal vegetation, good seedling development, and flowering. Apart from that, planting media using hydroponics can increase the porosity and aeration of the media. It allows the roots of rice plants to grow even better due to the optimal absorption of water and nutrients by the roots. The presence of hydroponic growing media can also help increase water retention, thereby reducing the frequency of watering and helping maintain the humidity of the growing media.

Biomass Production in Hydroponic Rice Plants

Research conducted by Rini et al. (2017) explains that the Ciherang variety of rice is genetically very suitable for planting in flooded land or rice fields. According to Maryani (2012), genetic factors are factors that stimulate plant growth. The research results showed that Ciherang variety rice plants planted in flooded land produced 48.80% higher harvested dry grain weight compared to Ciherang variety rice plants planted in dry land. Meanwhile, studies by a number of researchers at Brawijaya University demonstrate that the hydroponically grown Ciherang rice variety, when grown using the Deep Flow Technique (DFT) system, yields 30.4 tons/ha of biomass. However, studies carried out by scientists at Gadjah Mada University demonstrate that the IR64 rice variety, when grown hydroponically using the Nutrient Film Technique (NFT) system, yields a biomass of 28.8 tons/ha. The biomass production of hydroponic rice plants is generally higher than that of conventionally grown rice. This is due to a number of variables, such as:

a. Nutrient Absorption Efficiency

The hydroponic system allows rice plants to absorb nutrients more efficiently. The type and concentration of the solution can influence the growth and biomass production of rice. In addition, nutrients are dissolved in water and available directly to plants, so plants do not need to expend energy to search for and absorb nutrients from the soil.

b. Optimal Setting of Growth Factors

In a hydroponic system, factors such as pH, water, and light intensity can be controlled so that the photosynthesis process is more optimal. This allows rice plants to grow in ideal conditions, thereby increasing biomass production.

c. Minimal Pests and Diseases

Rice plants grown hydroponically are protected from pests and diseases that usually attack rice in rice fields. This is because the plants do not come into contact with the soil, which is a source of pests and disease. Varieties that are disease-resistant and have fast growth generally produce higher biomass.

d. High Plant Density

In comparison to rice fields, rice can be planted at a higher density using the hydroponic system. This increases biomass production per unit area. Different hydroponic systems have different efficiencies and effectiveness in producing biomass.

CONCLUSIONS

Hydroponically grown rice forage has enormous potential in terms of the nutrients it can produce, but it still produces less biomass than grass forage; yet, it produces more dry matter than fodder. When it comes to biomass production, 60 DYAP is the ideal harvest age. However, the quality of the fodder is comparable to that of pruning ages 40 and 50 DYAP. In comparison to the Ciherang variety, the IR64 type produces more biomass and has higher nutritional value.

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