



Growth and Yield of Rice under Different Irrigation Intensity and Purple Nutsedge (*Cyperus rotundus* L.) Density

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ABSTRACT

Background: The water requirements for *Oryza sativa* L. need to be known to support its growth. Furthermore, water conditions in rice plantations can affect weed growth. *Cyperus rotundus* L. is an important weed of rice, so it needs to be controlled so as not to disrupt rice growth.

Methods: This research aims to obtain irrigation intensity that is effective in suppressing the growth of *Cyperus rotundus* L. and identify its density of it, which can reduce rice yields. The research was conducted in a greenhouse at the field laboratory of the faculty of agriculture, Sebelas Maret University, from December 2022 to March 2023 using a factorial randomized block design using two factors. The first factor is irrigation intensity with three levels (daily irrigation, irrigation every 4 days and irrigation every 8 days), while the second factor is the weed density of *Cyperus rotundus* L. with four levels (without weeds, 1 weed, 2 weeds and 3 weeds), each repeated three times. The data obtained were analyzed using a variance test and if significant differences were found, then a 5% duncan multiple range test was carried out.

Result: The results showed that daily irrigation with a density of 2 weeds increased the height of rice plants and the number of rice panicles. However, a density of 1 or 2 weeds reduced the number of tillers by 18.2% in rice plants. A density of 3 sedge weeds resulted in a more significant reduction of tillers by 45.96% and a decrease in the dry grain weight per clump by 34.97%.

Key words: Growth, Irrigation, *Oryza sativa* L, Weeds, Yield.

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the commodities that is widely cultivated because rice is the staple food of the Indonesian people. The population growth rate demands an increase in both the quality and quantity of rice production per year. According to the National Statistical Agency (2022), rice production in 2021 was 31.36 million tons, down 140.73 thousand tons or 0.45% compared to production in 2020 of 31.50 million tons. The growing water crisis in rice-cultivating countries poses a severe threat to food security (Udimal *et al.*, 2017). Rice is a crucial crop for food security in many developing countries and the shortage of water supply can lead to a decrease in rice production, thereby affecting food security (Surendran *et al.*, 2021). Water scarcity also affects the quality of rice produced and can lead to increased prices, making it unaffordable for the poor. The depletion of water resources for rice cultivation can lead to soil degradation and reduced agricultural productivity.

A decrease in rice yields can occur due to several factors, such as the decreasing rice area due to land conversion and abiotic as well as biotic disturbances. Irrigation is a key factor in maintaining the environment for rice cultivation because wetland rice is a crop that requires a significant amount of water (Kima *et al.*, 2014). Research on innovative irrigation management technologies to enhance water use efficiency in rice farming has been ongoing for almost two decades, but there are still some knowledge gaps that need to be addressed. These gaps include a lack of detailed review on the performance of

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various innovative irrigation management technologies on water use efficiency in rice farming. In addition to water use efficiency, it is essential to review the impact of these technologies on rice yield and quality comprehensively. On the other hand, biotic factors are a problem in rice cultivation, so a deeper study is needed regarding the influence of weeds, especially grass. Weeds will compete in utilizing nutrients in the soil for their growth, so that the availability of nutrients in the soil will decrease (Duary *et al.*, 2015). Purple nutsedge (*Cyperus rotundus* L.) has been described as the world's worst weed. It is highly competitive, especially under high soil nitrogen conditions. The presence of weeds in rice cultivation can reduce rice yields by as much as 43 to 51% (King Donayre *et al.*, 2022). Therefore, this study aims to determine the relationship

between water requirements that can increase rice growth and yield and suppress weed growth.

MATERIALS AND METHODS

The research was conducted from October 2022 to March 2023 at the Greenhouse of the Faculty of Agriculture, Sebelas Maret University Surakarta. The coordinates are Latitude 07°37'831" S and Longitude 110°56'905" E and an average elevation of 148 Meters Above Sea Level (MASL). The materials used are the IR-32 rice variety and grass weed seeds. Rice was planted using pots.

The research was designed in a randomized complete block design (RCBD) with two factors. The first factor was irrigation intensity with three levels namely P1 = Irrigation once a day, P4 = Irrigation every 4 days and P8 = Irrigation every 8 days. The second factor was the density of weeds with four levels namely G0 = without nut grass weeds, G1 = 1 nut grass weed, G2 = 2 nut grass weeds and G3 = 3 nut grass weeds. The treatments were used 12 times, each repeated three times, so there was a total of 36 treatment with three pots for each plant.

Cultural practices carried out include preparation of planting media, rice seedlings are planted at the age of 20 days after sowing. Rice planting is carried out simultaneously with planting of nutsedge tubers with the amount and distance determined in the treatment. Planting is done by making a hole 4 cm deep and planting in the planting hole. Nut density treatment is carried out by selecting uniform nutsedge tubers. Purple nutsedge tubers are sown first until shoots grow. The planting distance between tubers and rice is 3 cm and the planting distance between tubers is 5 cm. Maintenance activities include weeding, fertilization and pest and disease control. Data collection was conducted once a week at plant height. The dry weight of rice was measured at the end of observation, which was 120 days after planting (DAP). Data collection at harvest time focused on rice plant yields with parameters such as the number of panicles per hill, the number of rice tillers, the weight of grain per hill and weight of 100 grains.

The data was analyzed using variance analysis. If there are significant differences between treatments, further analysis is carried out using Duncan's Multiple Range Test at a significance level of 5%.

RESULTS AND DISCUSSION

Soil analysis

Table 1 shows that the soil has low fertility. The soil pH level was slightly acidic, measuring 6. According (Alvernia *et al.*, 2017) at low pH, the availability of phosphorus (P) is affected because under acidic conditions, P exists in the form of Al-P and Fe-P compounds, which can be toxic to plants. The total nitrogen (N) content was very low at 0.08%, with a moderate total phosphorus (P) content of 29.214 mg/100 g. The total potassium (K) content was low, measuring 12.26 mg/100 g. The soil has a very low organic carbon (C-organic) content of 0.387%, with a very low C/N ratio of 4.48 and a moderate porosity of 43.93%. According (Suryono *et al.*, 2015) In general, Alfisols have low total nitrogen (N), very low available phosphorus (P) and currently low available potassium (K). The additions of these nutrients are required to maintain optimal plant growth.

Environmental condition

Based on Table 2, it was shown that the highest optimum air temperature at the research location occurs in February, at 29.24°C and the lowest was in December, at 28.45°C. According (Gonçalves *et al.*, 2019), the ideal air temperature for rice plant growth ranges from 19-27°C, with around 23°C being the most ideal. This means that the research environment has a temperature that is not ideal compared to the ideal temperature for rice plants. The research location has the highest average daily relative humidity at 75.8% in March and the lowest at 68.62% in January. The optimal relative humidity for rice cultivation ranges from 60 to 80%, with humidity levels exceeding 85% being more critical. This suggests that the humidity inside the greenhouse is suitable for optimal rice cultivation (Pathak *et al.*, 2020).

Table 1: The results of initial soil status.

Soil properties	Unit	Content value	Dignity
pH	-	6.00	Acidic
N total	%	0.08	Very low
P total	mg/100 g	29.21	Moderate
K total	mg/100 g	12.26	Low
C- organic	%	0.38	Very low
C/N ratio	-	4.48	Very low
Bulk density	g/cm ³	2.14	Clay minerals
Volume weight	g/cm ³	1.20	Mineral soil
Porosity	%	43.93	Moderate

Note: Chemical laboratory analysis and soil fertility Sebelas Maret University (2023), grading according to the Soil Research Institute, 2009.

Growth of parameters

Plant growth is a process of increasing in size and quantity and it possesses irreversible characteristics. Plant height is one of the indicators of plant growth. Plant height increases as the plant ages. The tallest plant height of 122.39 cm was found in the treatment with daily irrigation + 2 purple nutsedge weeds (Table 3). This was because water plays a crucial role during the vegetative growth phase of rice and it can suppress weed growth. According Ayyobi *et al.*, (2014), flooded conditions in rice fields provide better weed control and offer other benefits such as nutrient availability to the plants. On the other hand, the treatment with irrigation every 8 days + 3 purple nutsedge weeds had the shortest plant height at 108.25 cm (Table 3). This indicates that water deficiency during the vegetative phase of rice can hinder growth and the increased density of purple nutsedge further reduces rice growth. According to Verma *et al.* (2014), water deficit can reduce plant growth by decreasing cell division and cell elongation due to the loss of turgor pressure.

The dry weight is an important indicator of the amount of biomass produced by a plant. The greater the dry weight of a plant, the more biomass it has produced. This can indicate that the plant has either more cells or larger cells. On the other hand, dry weight represents the net accumulation of photosynthesis results during the plant's growth. It reflects the number of organic substances stored by the plant for growth and reproduction during its life cycle. Both of these are crucial parameters for measuring plants. Treatment with irrigation every 4 days without any purple nutsedge produced the highest dry weight of 29.70 g (Table 3). Whereas, the

treatment with irrigation every 8 days and the presence of 3 purple nutsedges resulted in the lowest dry weight, which was 12.25 g. Based on this explanation, irrigation every 4 days, as well as the absence of biotic disturbances in purple bean plants, provides optimal conditions for plants, including sufficient water supply, availability of nutrients and sufficient light intensity for photosynthesis (Jahn *et al.*, 2011). Previous research has also indicated that weeds in rice fields can hinder plant growth because they absorb nutrients and block the sunlight needed by rice plants. Therefore, the optimal conditions provided by the irrigation every 4 days without the presence of purple nutsedge support better plant growth and crop yields (Vishwakarma *et al.*, 2023).

The number of panicles is one of the components of rice plant yield that significantly affects grain seed production. The treatment showed that once a day irrigation with the presence of 2 purple nutsedge weeds produced the highest number of panicles, which was 7.78 (Table 3). These results are supported by research conducted by Arouna *et al.* (2023) which states that waterlogging in rice fields, whether due to rain or irrigation, can significantly increase the formation of tillers and the early stage of panicle development in rice. Waterlogging can inhibit weed germination and control weed. but, irrigation every 8 days with the presence of 3 purple nutsedge weeds resulted in the lowest number of panicles namely 3.89. This indicates that the number of panicles has a significant correlation with the number of tillers, consistent with the findings of Mallareddy *et al.* (2023) this research suggests that a decrease in soil moisture content during the tillering stage

Table 2: Temperature (°C) and relative humidity (%) at the research location.

Month	Month				Average
	December	January	February	March	
Air temperature	28.45	28.98	29.24	29.38	29.01
Humidity	69.12	68.62	77.50	75.80	72.76

Source: Primary data.

Table 3: Interaction effect of irrigation intensity and weed density on rice growth parameters.

Irrigation intensity	Purple nutsedge density	Plant height (cm)	Number of panicles	Dry weight (g)
Irrigation once a day	without weeds	114.87±10.5 ^{abc}	4.78±0.84 ^{de}	22.39±1.77 ^{abcd}
	1	113.70±3.8 ^{abc}	5.44±1.39 ^{dce}	18.57±1.42 ^{abcd}
	2	122.39±5.3 ^a	7.78±0.84 ^a	28.26±0.83 ^{ab}
	3	119.11±5.5 ^{ab}	4.44±1.02 ^{de}	17.31±7.83 ^{bcd}
Irrigation every 4 days	without weeds	121.44±3.9 ^a	7.22±0.69 ^{ab}	29.70±11.93 ^a
	1	121.40±5.3 ^a	6.67±0.96 ^{abc}	28.93±0.99 ^{ab}
	2	109.74±4.5 ^{bc}	4.56±1.24 ^{de}	13.74±1.29 ^d
	3	110.44±5.5 ^{bc}	4.00±0.88 ^e	15.07±3.67 ^{cd}
Irrigation every 8 days	without weeds	116.72±4.9 ^{abc}	5.56±1.64 ^{bcd}	22.90±9.06 ^{abcd}
	1	113.04±1.9 ^{abc}	5.89±0.77 ^{bcd}	23.25±7.99 ^{abcd}
	2	114.37±4.7 ^{abc}	4.78±0.77 ^{de}	25.69±8.94 ^{abc}
	3	108.25±1.3 ^c	3.89±0.38 ^e	12.25±0.43 ^d

Note: Numbers followed by the same letter in the same column indicate no significant difference in the DMRT at a 5% level.

can lead to a reduction in the number of productive tillers, which in turn can reduce the number of panicles produced per hill.

Tillers are stems that emerge from the main stem of rice plants. The number of tillers is one of the growth parameters and is related to the yield parameter of rice. The more tillers a rice plant produces, the greater the potential for the plant to produce a higher number of panicles. Dry grain weight per hill refers to the total weight of filled and unfilled grain in one hill. This parameter can determine the rice yield per hectare. A greater amount of filled grain can contribute to an increase in grain weight per hill. The number of tillers resulting from interactions between treatments was not significantly different. This could be because all treatments provided sufficient water to the plants. In a study conducted by Nayak *et al.* (2020) explained that the highest grain yield occurred at an irrigation interval of 9 days.

The application of different irrigation intensity treatments did not have a significant effect on the number of rice tillers (Table 4). This was irrigation at intervals of once a day, every 4 days and every 8 days still provides sufficient water for the plants. This was different from the findings of Saidi *et al.* (2021), where water management significantly influenced the number of panicles per cluster. Additionally, continuous water management resulted in fewer tillers per cluster compared to intermittent irrigation. Table 4 shows that the different treatments of purple nutsedge density had significant effects. The treatment without nutsedge weeds had the highest number of rice tillers, namely 8.11. However, the treatments with 2 nutsedge weeds and 3 nutsedge weeds significantly reduced rice tiller numbers by 18.25 and 45.26%, respectively, compared to without nutsedge weeds. This

was is because the presence of weeds in the field inhibits the growth of rice plants during the vegetative phase. According to Thura (2010) Emerging weeds compete with rice during the effective tillering stage, reducing the number of panicles, which can lead to a decrease in grain yield.

Irrigation intensity treatment had no significant effect on grain weight per panicle (Table 4). However, treatment with 3 purple nutsedge weeds was able to reduce dry grain weight per hill significantly by 34.98% compared to treatment without purple nutsedge weeds. This indicates that a higher density of purple nutsedge weeds has a greater impact on rice plant yields. This shows that a higher density of purple bean weeds has a greater impact on rice yields. According to Tian *et al.* (2020) weed density affects rice yields, so that if weed density is high, it can increase competition for water and light intensity with rice plants. This is similar to research conducted by Meena *et al.* (2022) among the various weed management treatments, the number of panicle hills, panicle length and number of grains per panicle showed significantly higher yields in the weed-free treatment. The weight of 100 grains is one of the yield components that affects the weight of rice grains produced by the rice plant. The weight of 100 grains can be influenced by the shape, size and content of the seeds. Seed weighing is only done on filled or plump seeds. The results show that the treatment of irrigation intensity and purple nutsedge density did not have an effect on the weight of 100 grains (Fig 1). This may be because during the grain-filling phase, it was not only influenced by the water availability for rice plants. According to Sasmita *et al.* (2022) Grain filling is influenced by many factors, such as the assimilate supply generated from the photosynthesis process, which provides energy for grain filling, as well as the availability

Table 4: Growth of rice under under irrigation intensity and purple nutsedge density.

Purple nutsedge density (plant)	Numbers of rice tillers	Grain dry weight per hill (g)
Without	8.11±2.07 ^a	25.42±9.78 ^a
1 weed	6.89±2.07 ^{ab}	21.53±6.30 ^{ab}
2 weeds	6.63±2.03 ^{ab}	20.64±7.97 ^{ab}
3 weeds	4.44±1.61 ^c	16.53±4.37 ^b

Note: Numbers followed by the same letter in the same column indicate no significant difference in the DMRT at a 5% level.

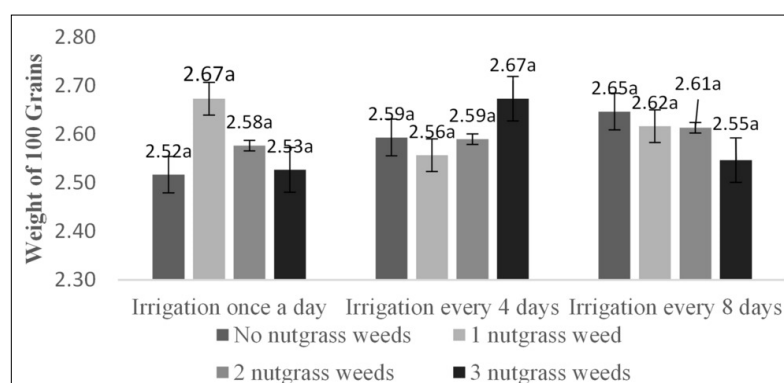


Fig 1: The 100-grain weight under irrigation intensity and purple nutsedge density.

of substances in photosynthesis, including sufficient water during the flowering and maturation phases, carbon dioxide (CO₂) and sunlight intensity. Furthermore, following weed management, biomass was distributed among the reproductive parts and nutrients remained available. The greater number of grains per panicle raises the possibility that the sound filling of grains was brought about by efficient assimilate translocation to the sink. Grain test weight did not significantly change as a result of weed control (Meena *et al.*, 2022). Moreover, according to Hussain *et al.* (2018), the absence of water stress and the ideal input during the early growth stage may have contributed to the non-significant variation in the number of tillers. The average comparison showed that, in contrast to 100% Field Capacity (FC), the period for flowering and maturity grew gradually at 70% and 50% FC, but the performance of agronomic parameters declined.

On the other hand, in aerobic rice research which were looking into the situation of weed infestation and the extent of yield loss in aerobic rice, grassy weeds make up roughly 78-96% of the total weed flora infesting aerobic rice fields and yield loss from weed infestation can reach 38-92%. Therefore, the biggest obstacle to aerobic rice production is weeds and prompt weed control is essential to raising yield (Midya, 2025).

Correlation test

Correlation is a statistical analysis technique used to determine the degree of linear relationship between two variables. It is an analysis of plant characteristics that typically does not consider cause-and-effect factors. Correlation analysis is used to understand the direction and strength of the relationship between two variables. Rice height has a highly significant positive correlation with the number of leaves, number of tillers, straw weight and number of panicles. This is in line with the findings of Chandra *et al.* (2009), which shows that an increase in the number of panicles was positively associated with increased plant height. The number of tillers has a very significant positive correlation with straw weight, number of panicles and the weight of paddy grains per hill. According to (Li *et al.*, 2019). The number of rice panicles is greatly determined by the number of tillers. Transplanted rice generally produces more tillers compared to directly sown rice. The number of panicles in rice plants has a significant correlation with the weight of dry paddy grains per hill. The more panicles produced, the greater the weight of paddy grains per hill. According to (García *et al.*, 2015). The number of panicles plays a crucial role in determining the weight of paddy grains per hill and it's found that this key yield component is strongly influenced by environmental conditions and management practices.

CONCLUSION

The once-a-day irrigation intensity and a purple nutsedge density of 2 plants have increased the height of rice plants

and the number of rice panicles. This suggests that irrigation intensity and purple nutsedge density can simultaneously affect the growth and yield of rice plants. The irrigation intensity did not provide a significant increase in the growth and yield of rice plants. This indicates that in the context of this study, variations in irrigation intensity did not have a clear impact on rice plants. Purple nutsedge density with 1 or 2 plants was able to significantly reduce the number of tillers by 18.2% in rice plants. Purple nutsedge density with 3 plants was able to reduce even more in the number of tillers (45.96%) and the dry weight of rice per hill (34.97%). This indicates that the higher the purple nutsedge density, the greater its impact on the growth and yield of rice plants.

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Disclaimers

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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