The Effect of water level and cow manure fertilizer application method on rice yield and *Cyperus rotundus* weed

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Abstract. Climate change is a global issue that affects rice production. Rice production in Indonesia experiences fluctuations due to several factors, such as water availability, nutrients, and weeds. The study aims to examine the effect of high water levels and organic fertilizer application methods on rice growth and yield and the growth of *Cyperus rotundus* weeds. The research used a completely randomized design of two factors arranged factorially and three replications. The first factor was the high water level with three levels, namely 0-1, 1-2, and 2-3cm. The second factor was applying organic fertilizer with three levels: immersing it 5 cm, spreading it on the surface of the ground, and mixing it evenly with the soil. The combination of water level and organic fertilizer application method affects the number of productive rice tillers. The lower the water level (0-1 cm), the higher the amount of organic fertilizer mixed with soil, which shows the highest number of rice tillers. he higher the water level, the higher the plant, but the weight of dry rice grains decreases. Applying manure mixed with soil can increase the number of productive panicles per plant and reduce rice grains' dry weight but reduce *Cyperus rotundus* weeds' growth.

1 Introduction

Climate change is a threat to food security and agricultural output. Increased extreme temperatures, changes in the distribution, and amount of rainfall contribute to farming activities and production [1]. Increased temperatures cause compaction, acidification, decreased organic matter, and soil biodiversity [2,3]. Rice (*Oryza sativa* L.) is an essential staple food for more than half of the world's population [4]. Climate change affects rice production [5]. According to the Central Statistics Agency, Indonesia's rice production 2024 was 52,659,237.12 tons. Rice production in 2024 decreased from 2023, which was 53,980,993.19 tons. The decrease in rice production is negatively correlated with the rice needs of the Indonesian people. Based on Central Statistics Data, Indonesia's per capita rice consumption in 2023 was 81.23 kilograms/capita/year and increased yearly. The need for rice is growing along with the increasing population because it is to meet food needs [6].

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Intensification in rice cultivation is needed to increase rice production. Factors that affect rice production are water, nutrients, and weeds.

Water is a basic need in the metabolism of rice plants [7]. According to Dossou-Yovo et al. [8] state that the problem of lack or excess water can also cause rice not to grow and produce optimally. During drought, plants face the consequences of closing the entry of CO_2 gas into the leaves, thereby reducing the rate of photosynthesis [9]. This is because when plants open their stomata, which results in transpiration, at the same time, plants also bind CO_2 from the air for photosynthesis needs so that the release of water and the entry of CO_2 gas is like a non-negotiable exchange (trade-off). Therefore, it is essential to ensure the availability of the proper water by knowing the optimal height of irrigation water to support rice productivity[10]. Farmers usually irrigate rice fields until the inundation height exceeds 2.5 cm. The use of irrigation water by farmers can be more economical by reducing the height of the water puddles [11,12].

In addition, fertilization is also an effort to fulfill nutrients for plant growth. Organic fertilizers increase soil organic carbon and increase the soil's capacity to retain water, which is needed for plant growth and development [13]. Better soil structure and capacity to maintain water from organic fertilizers result in better root health and overall plant performance [14]. Organic fertilizers are essential in mitigating climate change by reducing greenhouse gas emissions compared to inorganic fertilizers. Emissions from organic fertilizers mostly come from production and storage, while emissions from chemical fertilizers mostly come from production [15]. The method and dose of fertilization can affect crop yields. Applying fertilizer by spreading and covering it is better than dissolving it and mixing it with the soil [16]. This is because it can cause leaching and evaporation of nutrients. Weeds are also a factor inhibiting the growth and yield of rice. Weeds cause a significant decrease in yield and quality and threaten food security and safety [17]. Weeds are aggressive, invasive, and unwanted plants [18]. Weeds or wild plants can compete with rice plants to obtain soil nutrients. Weeds that are often found in rice fields, for example, from the sedge group, namely *Cyperus rotundus* L. Sedge or *Cyperus rotundus* L., cause yield losses of 20-90% in various agronomic and horticultural crops worldwide [19]. Previous studies conducted by Mboyerwa et al. [20] with continuous flooding and alternating wetting and drying treatments combined with nitrogen fertilizer levels affected water productivity, water use, and irrigation volume. Less water with optimum nitrogen levels can result in rice growth and yield. Research by Abdou et al. [21] showed that deficit irrigation practices and higher nitrogen fertilizers effectively saved irrigation water input by 50–60% when compared to the continuous flooding system method. The novelty of this study combines the treatment of high water levels with organic fertilization in rice cultivation and the growth of Cyperus rotundus weeds. The study aims to examine the effect of high water levels and organic fertilizer application methods on rice growth and yield and the growth of *Cyperus rotundus* weeds.

2 Material and methods

The research was conducted at the Greenhouse, Faculty of Agriculture, Sebelas Maret University, Indonesia. The astronomical location of the research site was 70 33' 39.5" LS and 1100 51' 31.4' BT at 131 meters above sea level (masl). The research used a completely randomized design of two factors arranged factorially and three replications. The first factor was the high water levels consisting of 3 levels, namely 0-1, 1-2, and 2-3 cm. The second factor was the the method of applying organic fertilizer, which consisted of 3 levels: immersing it 5 cm, spread on the surface of the ground, and mixing it evenly with the soil. The research used materials from Inpari 32 variety rice seeds, cow manure, and *Cyperus rotundus* seed; the planting medium was alfisol soil. The measuring instruments used were

meters, digital scales, ovens, envelopes for wrapping stoves, lux meters, thermo hygrometers, rulers, and plant cultivation tools.

Basic fertilizer with 80g of cow dung fertilizer was applied during planting according to the treatment. Rice planting was done by moving ready-to-plant seeds aged 21 days after sowing to an 8-liter bucket. Rice ready to be sown has three leaves and is 15-18 cm high. Alfisol soil that will be used as a planting medium is filtered and then put into each bucket, 6 kg plus 80g of cow manure, given according to the treatment. Cyperus rotundus that have grown shoots less than 1 cm were planted after 2 days of planting rice. The age of nutsedge is about ten days after sowing. Irrigation is carried out according to the treatment, namely 0-1 cm, 1-2 cm, and 2-3 cm. This water level was monitored every 2 days by watering to the specified height. The observation variables observed for rice growth and yield are plant height, number of productive rice tillers, weight of dry harvested, Number of panicles per plant, and plant rice biomass. Observation variables of *Cyperus rotundus* growth were plant height, number of leaves. Data were analyzed using an analysis of variance of 5%. If it was significant, the test of significant differences between treatments was continued with the 5% Duncan Multiple Range Test.

3 Results and discussion

The combination of 0-1 cm water level treatment with 5 cm of immersed fertilizer and mixed with soil will increase the number of productive tillers compared to 2-3 cm water level (Table 1). Fertilizer mixed with soil will increase the number of productive tillers at 0-1 cm and 1-2 cm highwater levels. The results of this study indicate that the higher the water levels, the more likely the growth of rice tillers will be inhibited. Waterlogging can inhibit gas exchange between plant roots and the atmosphere [22]. Oxygen in waterlogged soil is quickly depleted, causing the roots to change from aerobic respiration to anaerobic fermentation while CO_2 and ethylene concentrations accumulate [23]. This causes a severe decrease in root cell ATP synthesis and affects various plant metabolic processes [24,25]. The results of this study by [26] showed that the number of rice tillers could be more optimal at a water height of 4-8 cm. The height of the 0-1 cm interval puddle supports the growth of soil microbes because it creates air space to get oxygen input and improves soil aeration. This non-flooded condition supports the development of soil microorganisms, thus encouraging the growth of rice roots [27]. In addition, the growth of seedlings is influenced by the photosynthesis process, which runs optimally and encourages vegetative and generative growth [28]. The nutrient content of fertilizers can be lost due to several factors, including evaporation, absorption, decomposition, and storage. The evaporation and absorption processes can cause the loss of half of the nitrogen and potassium nutrient content and one-third of phosphate.

Table 1. Effect of combination high water levels and method of applying organic fertilizer on the number of productive rice tillers.

High water levels (cm)	**Method of applying organic fertilizer**			**Average**
	Immersed	Distributed	Mixed with soil	
0-1	3.56 b	3.00 a	3.89 b	3.48 b
1-2	3.11 a	3.22 a	3.67 b	3.33 a
2-3	3.00 a	3.11 a	3.11 a	3.07 a
Average	3.22 a	3.11 a	3.56 b	(+)

Note: Numbers followed by the same letter in the same column/row group show no significant difference at the 5% DMRT level. The (+) sign indicates an interaction between inundation and fertilization methods.

The results showed that the high water levels affected the plant height and dry grain weight (Table 2). The higher the waterlevels, the higher the plant height, but the weight of the harvested dry grain decreased. The 0-1 cm high watertreatment gave the most significant dry grain weight, while the 2-3 cm water treatment showed the most minor dry grain weight. Waterlogging causes continuous water accumulation on the soil surface [29]. Increasing high water causes low soil temperatures, few soil aggregates, underdeveloped plow layers, reduced available nutrients, especially phosphate elements, and accumulation of soil-reducing substances [12]. Waterlogging is a major obstacle in increasing rice production [30]. This is due to a decrease in the number of grains per panicle and the level of seed formation. Waterlogging stress during the booting stage of the rice development cycle significantly increases plant height but decreases stem quality [29]. In the System of Rice Intensification, the minimum inundation height of 1-2 cm can save water use without reducing rice production [31].

Table 2. Effect of high water levels on rice growth and yield

High water levels (cm)	Plant Height (cm)	Dry grain weight (g)
0-1	93.48 a	5.01 b
1-2	96.11 ab	4.89 b
2-3	97.72 b	4.00 a

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

The results showed that the height of the water levels did not affect the number of panicles per plant, riceplant biomassand the height and number of leaves of *Cyperus rotundus* weeds . However, the fertilization method treatment affected the number of panicles per plant, rice plant biomass and the height and number of leaves of *Cyperus rotundus* weeds (Table 3). Fertilizer mixed with soil was able to increase the number of productive panicles per plant compared to fertilization spread and immersed 5 cm into the soil. The spread of nutrient uptake by the plant root system depends on the speed of the plant roots reaching the nutrients [32]. Fertilizer mixed with soil allows the roots to get nutrients faster because of their presence in the root zone. The highest rice plant biomass was in the fertilizer mixed with soil treatment. Plant biomass indicates plant biomass which means the amount of assimilates produced through the process of photosynthesis [33]. Fertilization mixed with soil was able to reduce the growth of height and number of leaves of *Cyperus rotundus* weeds compared to fertilization spread. Weeds compete with plants in utilizing nutrients and water, become hosts for pests or diseases, and will increase production costs for maintenance and control [34]. Therefore, suppressing weed growth will help increase rice dominance in meeting life factors such as nutrients, water, and sunlight [35]. Tall weeds and the number of leaves are generally included in the C4 group which has a high light saturation point [36].

Table 3. Effect of method of applying organic fertilizer on rice yields and *Cyperus rotundus* weed growth

How to fertilize	Number of panicles per plant	Rice plant biomass	*Cyperus rotundus height*	Number of leaves of *Cyperus rotundus*
Immersed	3.30 a	9.05 a	47.85 a	9.52 a
Spread	3.19 a	10.03 a	57.16 b	13.00 b

Mixed with soil	3.47 b	11.84 b	47.78 a	8.93 a

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

4 Conclusion

The combination of water level and organic fertilizer application method affects the number of productive rice tillers. The lower the water level (0-1 cm) with the application of organic fertilizer mixed with soil shows the highest number of rice tillers, which is 3.89. Water level affects the height and weight of dry rice grains. The higher the water level, the higher the plant, but the weight of dry rice grains decreases. The method of organic fertilizer application affects the number of panicles per plant, rice plant biomass, height and number of leaves of *Cyperus rotundus*. Application of manure mixed with soil can increase the number of productive panicles per plant, dry weight of rice grains, but reduces the growth of *Cyperus rotundus* weeds.

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