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Enhancing Food Security: Chlorophyll B Content in Several Rice Genotypes as an Indicator of Drought Stress Tolerance

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Abstract

Drought stress poses a major challenge in rice cultivation, particularly in dryland areas, as it inhibits plant growth and significantly reduces yield. Rice plants that are not drought-tolerant often suffer damage during critical growth phases, necessitating the development of rice varieties that possess resilience to drought stress to ensure food security. This study aimed to identify rice genotypes with the highest chlorophyll B content, which may be more resistant to drought conditions, allowing them to be developed as superior varieties in water-scarce areas. The experiment involved measuring the highest chlorophyll B content in each test plant with three replications. Subsequently, the data were correlated with physiological traits such as leaf length, leaf count, and root length. We found that the highest chlorophyll B content was observed in the Inpago 5 rice variety, which positively correlated with leaf length, leaf width, and plant height. Therefore, chlorophyll B content can be used as an indicator of drought stress resistance in rice.

Keywords: *Chlorophyll B; Correlation; Drought Stress; Inpago 5; Physiological Traits; Resistance Indicator*

Introduction

Drought stress is one of the major challenges faced by agriculture, particularly in rice cultivation (*Oryza sativa L.*), which serves as one of the primary food sources in Indonesia. Drought can occur as a result of climate change, leading to extreme weather fluctuations, including prolonged dry seasons that negatively impact water availability for crops. According to the Central Bureau of Statistics, rice production in Indonesia experienced a significant decline in 2019, with total production decreasing by 7.76% compared to the previous year, largely due to drought conditions affecting various regions across the country [1].

Rice productivity is severely threatened under drought conditions. The morphophysiological damage and biochemical dysfunction caused by drought are evident in rice plants, hindering active plant growth and development. It has been reported that drought stress can reduce rice yields by up to 90%, depending on the intensity, duration, and growth stage of the plant (whether vegetative or reproductive) [2]. Several rice varieties have been developed to improve tolerance to drought stress. For instance, the Jeliteng variety has been shown to be more resistant to dry conditions compared to other varieties. Research indicates that proline accumulation in plants is one of the adaptive mechanisms that helps mitigate cell damage caused by water deficiency [1]. Furthermore, plant breeding aims to develop new genotypes capable of surviving and producing yields even under drought conditions.

The importance of research on drought stress in rice lies not only in improving agricultural productivity but also in securing national food security. By understanding the plant's response mechanisms to drought stress and developing more tolerant varieties, it is expected that the negative impacts of climate change can be minimized, ensuring the sustainability of rice production in Indonesia [3]. Therefore, this study aimed to identify rice genotypes with the highest chlorophyll B content, which may be more resistant to drought conditions, allowing them to be developed as superior varieties in water-scarce areas.

Materials and Methods

Materials

The study utilized a mortar and pestle, digital scale, micropipette, centrifuge, and UV-Vis spectrophotometer. The materials included rice leaf samples from Inpago cultivars 5, 7, and 10, along with nitrogen, absolute alcohol, and distilled water. This study was carried out in September 2024 at the Biology Laboratory of the Indonesian Defense University.

Methods

Three rice varieties (Inpago 5, Inpago 7, and Inpago 10) were analyzed for their chlorophyll and carotenoid content. Leaf chlorophyll and carotenoid content were assessed based on the procedure of Fendiyanto et al. (2019) with slight modifications. A total of 0.002 g of rice leaves was ground using a mortar and homogenized with the addition of 1 ml of 100% ethanol. The mixture was then centrifuged at 11000 rpm for one minute. The absorbance of the supernatant was measured using a spectrophotometer at wavelengths of 470, 646, and 662 nm. The experiment was performed with three biological and three technical replicates. After data collection, correlation tests were conducted to analyze the relationship between chlorophyll content and rice plant morphology, including leaf length, leaf area, number of leaves, number of roots, and root length.

Data analysis

The correlation between chlorophyll B content were processed using Microsoft Excel. Further the physiological data was processed using ImageJ software and then visualized using correlation tests (t-test).

Results and Discussion

Plants under drought stress significantly reduce the rate of photosynthesis at all growth stages. Drought during the panicle initiation phase reduces photosynthesis by 30.69%, and by 28% during the anthesis phase. Drought causes physiological changes such as a decrease in photosynthetically active radiation (PAR), photosynthesis rate, transpiration rate, stomatal conductance, and pigment degradation. The panicle initiation phase is the most critical stage for these physiological changes [4]. Drought at this phase disrupts biochemical and physiological processes, reduces enzymatic activity, and leads to chlorophyll pigment degradation. Physiological characteristics related to plant drought resistance include reduced transpiration through fewer stomata and increased photosynthesis via higher chlorophyll content [5].

Table 1. Chlorophyll B Test

Genotype	klorofil B	Stdev	SE
Inpago 10	2,34	0,61155049	0,26067231
Inpago 7	2,04	0,98811879	0,33134722
Inpago 5	4,99	5,0220000	0,7470000

Based on the data, Inpago 5 appears to have the greatest potential for chlorophyll B production, but the variability in its chlorophyll B content is also the highest. Inpago 10 has a more consistent chlorophyll B content but at a lower level compared to Inpago 5. Further investigation is needed to understand the reasons for these differences and to determine the optimal conditions for chlorophyll B production in these varieties.

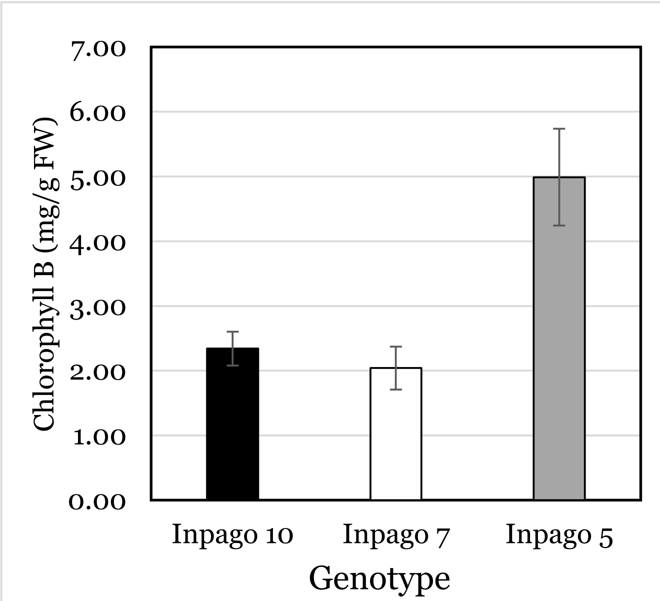

Figure 1. Chlorophyll B Results Diagram

Based on the graph (Figure 1), the Inpago 5 rice variety exhibited the highest chlorophyll b content at 5 mg/g FW, significantly different from Inpago 7 and 10, which had chlorophyll b levels below 3 mg/g FW. Accordingly, the higher chlorophyll b content in Inpago 5 indicates a greater tolerance to drought stress.

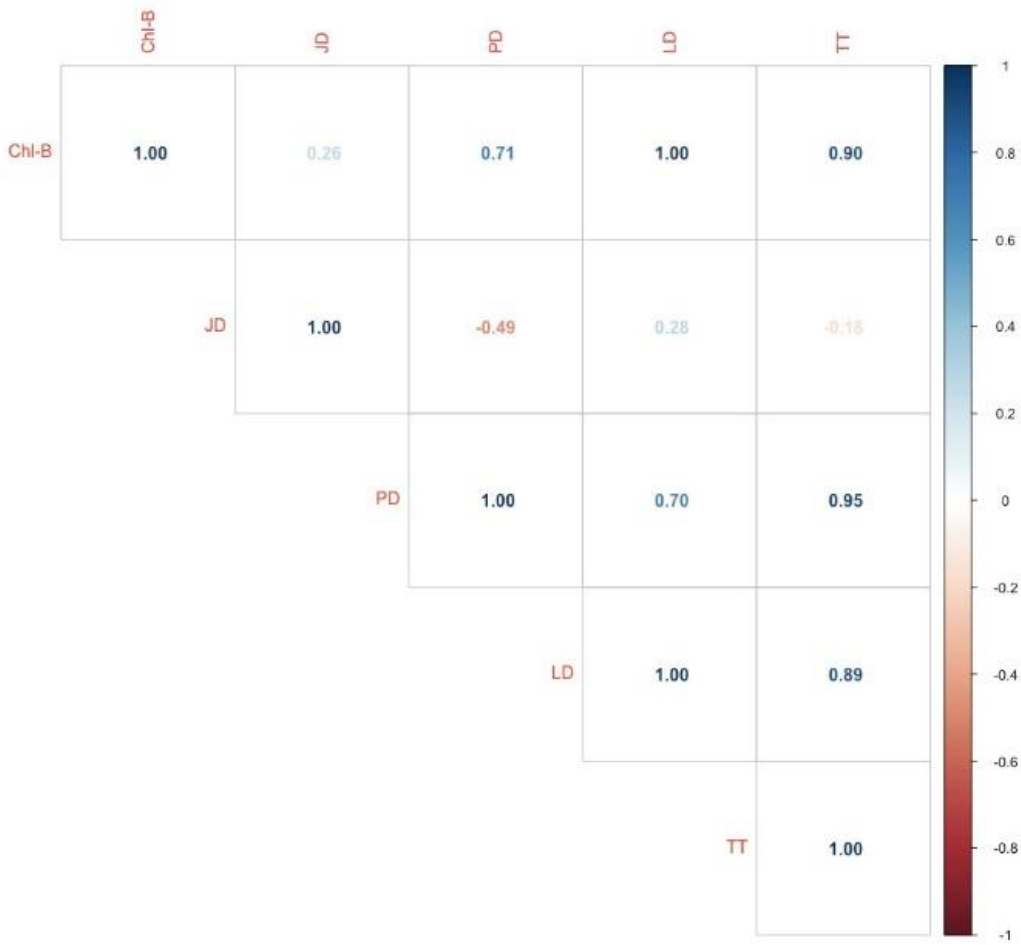

Figure 2. The Correlation of Chlorophyll B content with the number of leaves, leaf length, leaf width, and plant height.

The result of the correlation analysis shows that there is a significant positive correlation was found between chlorophyll b content and both leaf length and width, suggesting a pivotal role of chlorophyll b in leaf growth and development. Chlorophyll b also demonstrated a positive correlation with plant height, albeit less pronounced than its correlation with leaf dimensions.Leaf number did not exhibit a strong correlation with chlorophyll b content, indicating that other factors are likely more influential in determining leaf number.

Conclusion

This study highlights the critical correlation between chlorophyll b as a parameter for rice drought tolerance. Drought stress affects all growth factors in rice, including physiological and morphological changes, growth patterns, and ultimately yield. Morphological and physiological responses can be utilized as indicators for selecting water stress-tolerant varieties. Chlorophyll b content in rice can serve as a parameter for assessing drought resistance, positively correlating with leaf count, leaf length, root count, and root length.

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