



Morphological Structure of Upland Rice Varieties at Different Light Intensities

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Abstract

Increasing food self-sufficiency, especially rice grown as intercrops, requires attention to the development of upland rice varieties that are shade-tolerant and capable of high production. The objective of this research to study about the mechanism of tolerance, morphological characters as characterizing tolerance to shade. The research was carried out in Cengkeh Turi Binjai with an altitude of ± 32 meters above sea level, with soil pH; 4.5, started from May to August 2018. The study used a split plot design with two factors. The first factor was the light intensity, consist of: 100%, 75%, 50%, and 25%. The second factor consisted of 5 rice varieties, namely: Inpago 5, Lipigo 4, Inpago 8, Inpago 10, and Lipigo 2. The result of this study was an increase in the area of the flag leaf with a decrease in sunlight intensity by 75%. The conclusion of this study is that the lower the intensity of sunlight, the lower the angle of the flag leaf and the thickness of the upland rice leaf.

Keywords: light; upland rice; varieties

INTRODUCTION

Rice is a major world food crop (FAOSTAT, 2012). Despite worldwide production increased due to improved varieties and agronomy, it is stagnating since about 10 years in many regions (Ray et al., 2013). Food security, especially rice self-sufficiency, is currently a worrying problem due to several problems that arise, such as crop failure due to weather factors and pest and disease attacks. According to Badan Pusat Statistik (2021) the rice harvested area in 2020 is 10.66 million hectares, a decrease of 20.61 thousand hectares or about 0.19 percent compared to 2019 which was 10.68 million hectares.

Rice production in Indonesia can be increased, one of which is the use of intercropped land under plantation stands. However, the cultivation of plants under plantation stands certainly has several obstacles, such as the low intensity of sunlight. Light is an important factor for plant

growth, because in addition to playing a dominant role in the photosynthesis process, it is also a controller, trigger, and modulator of morphological responses, especially in the early stages of plant growth (Sopandie, 2014). Sunlight affects the growth, reproduction and yield of plants through the process of photosynthesis. The absorption of light by the pigments will affect the division of photosynthate to other parts of the plant through the process of photomorphogenesis (Susilawati, et al., 2016). The main driving force for the growth and biomass production of plants is photosynthesis, which provides the carbon and energy required for the synthesis of organic compounds necessary for development (Nowicka et al., 2018).

According to Chairudin, et al (2015) Plants have the ability to adapt to shade through avoidance and tolerance mechanisms. Avoidance of lack of light is done by increasing the efficiency of light capture. Leaves are plant organs that have a function as a light harvesting tool, so that the efficiency of light absorption by leaves can produce different morphological and physiological changes. Anatomical structure and leaf morphology is one of the adaptation mechanisms that plants do to different light intensities. The goal is for plants to be able to absorb optimal light and carry out the photosynthesis process efficiently (Yustiningsih, 2019). Low light intensity too resulted in changes in the character of agronomy, anatomy, physiology, molecular and biochemical related to photosynthetic efficiency so that it will affect the yield of these plants (Soverda et al., 2013). Therefore, this study aimed to determine changes in the morphological structure of upland rice leaves at different light intensity conditions.

METHOD

The research was carried out at Cengkeh turi, Binjai City 3°38'46.3"N 98°29'22.2"E with an altitude of ± 32 meters above sea level, from May 2018 to August 2018. The study used a split plot design with two factors. The first factor was the light intensity, namely 100%, 75%, 50%, and 25%. The second factor consisted of 5 rice varieties, namely: Inpago 5, Lipigo 4, Inpago 8, Inpago 10, and Lipigo 2. The treatment of shade intensity was using a paranet whose number of paranet layers was adjusted to the intensity of the incoming light using a lux meter. The research data were analyzed using variance analysis, if the analysis of variance showed a significant effect, then further tested with Duncan test at 5% level. Upland rice was first sown, after 20 days of age, transplanting was carried out to the research area. Urea, TSP and KCl fertilization were given twice, namely when the plants were 4 week after planting and 10 week after planting. The morphological characters observed included flag leaf area, flag leaf angle and leaf thickness. Measurement of the area of the flag leaf using the measurement method of length x leaf width x constant (k) with a constant value of 0.75.

RESULT AND DISCUSSION

Upland rice grown under conditions of low light intensity showed some changes in specific morphological characteristics. These characteristics were related to the tolerance and adaptation mechanisms of plants to keep photosynthesizing. Based on statistical tests of different light intensity treatments, varieties and their interactions had a significant effect on flag leaf area, flag leaf angle and leaf thickness.

Flag Leaf Area

Flag leaf area is one of the morphological characters that greatly affects the process of capturing sunlight. One of the adaptation efforts made by plants in conditions of low light intensity was to increase the area of the flag leaf. Table 1 shows the effect of light intensity and variety on flag leaf area.

Table 1. Flag Leaf area of several upland rice varieties at different light intensities

Varieties	Light Intensity				Mean
	100 % (kontrol)	75%	50%	25%	
Inpago 5	76,36abc	89,71a	30,59e-i	23,03ghi	54,92a
Lipigo 4	47,79def	52,69de	33,64e-i	18,21hi	38,08b
Inpago 8	42,21d-g	82,57a	32,29e-i	18,92ghi	44,00ab
Inpago 10	61,89bcd	81,55ab	41,01d-h	13,48i	49,48ab
Lipigo 2	47,14def	58,77cd	21,54ghi	24,84f-i	38,07b
Mean	55,08b	73,06a	31,81c	19,69c	

Flag leaf area increased with decreasing sunlight intensity up to 75% in all varieties. Meanwhile, at 50% and 25% light intensity, the flag leaf area continued to decrease with decreasing sunlight intensity compared to 75% light intensity. Hidayat (2012), explained that the ability of plants to cope with stress of low light intensity generally depends on their ability to continue photosynthesis in conditions of low light intensity. This ability was obtained by increasing leaf area as a way to reduce the use of metabolites and reduce the amount of light transmitted and reflected. Certain varieties were expected to have a high level of efficiency in the use of light so that they can grow and produce optimally in shaded areas. The number and size of leaves determine a plant's photosynthetic potential and play important roles in determining plant yield, stress responses and disease resistance (Yang et al., 2015). Consequently rice yield potential depends on whole plant source-sink relationships that are determined by many traits (Niinemets, 2014). In low light tolerant varieties can retain more efficient rate of photosynthesis and effective antioxidant capacity under low light, because they can maintain higher chlorophyll content and antioxidant enzymes activity level, thereby minimizing grain yield loss (Liu et al, 2012).

Flag Leaf Angle

The intensity of sunlight affects the angle of the upland rice flag leaf, based on Table 2 it can be seen that the lower the intensity of the sun's light, the lower the angle of the flag leaf.

Table 2. Flag Leaf angel of several upland rice varieties at different light intensities

Varieties	Light Intensity				Mean
	100 % (kontrol)	75%	50%	25%	
Inpago 5	79,67b	54,00c	20,00d	16,50d	42,54
Lipigo 4	82,50b	22,67d	17,83d	16,00d	34,75
Inpago 8	103,50a	19,67d	16,83d	15,67d	38,92
Inpago 10	83,83b	24,83d	19,83d	16,50d	36,25
Lipigo 2	84,67b	49,17c	19,17d	16,83d	42,46
Mean	86,83a	34,07b	18,73c	16,30c	

The flag leaf angle gets smaller with decreasing sunlight intensity. There was a decrease of 60.76% at 75% light intensity when compared to 100% light intensity. This was certainly very beneficial for plants in conditions of lack of sunlight as an effort for plants to obtain more sunlight. The criteria for upright leaves are more profitable than the criteria for flat or fallen leaves because in an upright position the plant leaves do not shade each other, so that a lot of light can be captured for a more optimal photosynthesis process, so as to increase the productivity of rice plants. Erect

leaves allow greater penetration and distribution of light and reach the underside of the leaves more evenly, which will increase plant photosynthesis. The solar radiation that was intercepted by plants depends on the incoming solar radiation that reaches the surface of the plant crown, leaf area index, leaf position or angle and leaf distribution in the canopy (Sitompul, 2016).

Leaf Thickness

The intensity of sunlight can affect the thickness of the leaves on each variety. In Table 3 it can be seen that the lower the intensity of sunlight, the lower the thickness of the rice leaves.

Table 3. Leaf thickness of several upland rice varieties at different light intensities

Varieties	Light Intensity				Mean
	100 % (kontrol)	75%	50%	25%	
Inpago 5	3289,45b	2794,19d	2742,98de	1392,31k	2554,73b
Lipigo 4	4423,05a	2747,80de	2245,64f	2688,60e	3026,27a
Inpago 8	3248,71b	2075,75g	1595,18j	1573,59j	2123,30d
Inpago 10	2699,09e	1993,01h	1568,02j	79,33l	1584,86e
Lipigo 2	2892,22c	2129,66g	2307,48f	1888,51i	2304,47c
Mean	3310,50a	2348,08b	2091,86c	1524,47d	

Each of upland rice variety has a different response. The highest average was found in the Lipigo 4 variety while the lowest average leaf thickness was found in the Inpago 10 variety. The difference in plant response was thought to be due to the adaptability of plants to different light intensities. A single genotype of a plant can produce different phenotypes in different environments.

Leaf structure and physiology are affected by light level (Baldi et al., 2012). Leaf thickness was also affected by solar radiation, where the palisade layer of the leaves gets thicker with increasing sunlight received by the leaves. Adaptation of plant anatomy and morphology. From this angle, the characteristics of plants are acclimatized to low light intensity. The leaves of shaded plants will be thinner and wider than leaves grown in open areas due to the reduction of the palisade layer and mesophyll cells. Light intensity also affects leaf shape and anatomy, including epidermal cells and mesophyll cell types. This change is a mechanism for controlling the quality and amount of light that can be utilized by leaf chloroplasts. In addition, leaf anatomy such as palisade size, chlorophyll and stomata greatly determines the efficiency of photosynthesis (Hidayat, 2012). Sunlit leaves are generally smaller and thicker, with more developed palisade tissue and greater stomatal density compared to shaded leaves. They have less chlorophyll but more electron transfer carriers and RuBP carboxylase/oxygenase (Rubisco) per unit leaf area (Marchiori et al., 2014).

CONCLUSION

Flag leaf area increased by 24.60% at 75% light intensity. The decrease in sunlight intensity will reduce the angle of the flag leaf at a light intensity of 75%, 50% and 25%, respectively, by 60.76%, 78.42% and 81.22% compared to the 100% light intensity treatment. Upland rice leaf thickness continued to decrease with decreasing sunlight intensity at 75%, 50% and 25%, respectively, by 29.07%, 36.81% and 53.95%.

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