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Growth pattern of fifteen upland rice varieties in shading stress

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Abstract. Shading stress will affecton varieties growth of upland rice especially in the vegetative phase. The objective of this research to study the growth pattern of fifteen upland rice varieties in shading stress treatment. The research was carried out in Cengkeh turi Binjai started from May to August 2018. The research used a split plot design with two factors. The first factor was the shading stress, consist of; control, 25%, 50% and 75%. The second factor was 15 upland rice varieties, consist of: Inpago 5, Lipigo 4, Inpago 8, Inpago 10, Towuti, Kalimutu, Limboto, Black rice, Red rice, IPB 8G, IPB 9G, Lipigo 1, Lipigo 2, Situ patenggang, and Situ bagendit. Decreased of light intensity caused of increase plant length on shading stress treatment 25% were 4.24%. Shading stress treatment in 25%, 50% and 75% will decreasing the number of tillers. Similarly, the parameter of dry weight was decreased in accordance with the increasing in the shading stress treatment that given. Chlorophyll a content was higher than chlorophyll b at all shading stress and varieties. Different from black and red rice which have higher chlorophyll b content at 50% and 75% and Lipigo 1 at 75% shading stress treatment.

1. Introduction

In the 2000-2006 periods, Indonesia's population increased at a growth rate of 1.36% per year while rice consumption was estimated at 137 kg per capita. Assumption the population growth rate increase by 0.03% per year, accordingly the rice consumption in 2010, 2015 and 2020 is projected to be 32.13 million tons, 34.12 million tons and 35.97 million tons respectively. The population in the three periods is estimated to be 235 million, 249 million and 263 million. The need for rice each year is higher along with the increase in population, the pressure of rice needs will decrease if diversification, intensification and extensification of food is successfully implemented [1].

The problem of food security, especially rice self-sufficiency, is currently at a worrying level due to several problems that arise, such as crop failure due to floods and pest attacks. This decline in production can be seen from the amount of rice imports each year which increases by 2 million tons.

One effort to increase paddy production in Indonesia is by utilizing land under the stands of plantation crops. But in its utilization, the cultivation of plants under the stands of plantation crops experienced several obstacles including the low intensity of sunlight. Light is an important factor for plant growth, because in addition to being dominant in the photosynthesis process, it is also a



controller, trigger, and modulator of morphogenesis response, especially in the early stages of plant growth [2].

Plants that grow under the shade show a different growing character with plants without shade. Plants capable of adapting to shade stress have several mechanisms including increasing the efficiency of radiation capture, reducing the transmitted and reflected radiation and reducing the rate of use of metabolites [3]. In shade, low radiation intensity tolerant plants have longer leaves, wider and thinner than the leaves of plants that grow in open areas.

Low light stress will affect every aspect of vegetative growth (plant height, number of tillers, root growth, stomatal regulation and chlorophyll development), photosynthesis, accumulation of dry matter and partitions, also yield and quality of rice [4]. Therefore this research was conducted to study the morphological characteristics of upland rice varieties in shading stress.

2. Methods

The research was carried out in Cengkeh Turi Binjai with altitude ± 32 m above sea level, from May to August 2018. The experiment used a split plot design with three replications. The first factor was the shading stress which consists of 4 shade levels, namely; 0%, 25%, 50%, and 75%. The second factors was upland rice varieties, consist of; Inpago 5, Lipigo 4, Inpago 8, Inpago 10, Towuti, Kalimutu, Limboto, Black rice, Red rice, IPB 8G, IPB 9G, Lipigo 1, Lipigo 2, Situ patenggang, and Situ bagendit. The shade intensity treatment was using paranet, the number of paranet layers was adjusted to the intensity of light entering using lux meters. The research results data were analyzed using analysis of variance, if the analysis of variance showed a significant effect, then it was tested further by Duncan Multiple Range Test at the level of 5%. First, seedling the upland rice, after being planted for 20 days, it was transplanted to the research area. Fertilization of Urea, TSP and KCl was given twice, when the plants are 4 weeks after planting and 10 weeks after planting. Morphological characters observed included plant length, the number of tillers, plant dry weight and chlorophyll a and b content. Observations were made when the plant was 13 weeks after planting, the chlorophyll content was observed at the end of the vegetative period using the formula:

$$\text{Chlorophyll a: } 13.7 D - 665 - 5.76 D - 649 / 10 \text{ (mg/l)} \quad (1)$$

$$\text{Chlorophyll b: } 25.8 D - 649 - 7.60 D - 665 / 10 \text{ (mg/l)} \quad (2)$$

3. Results and Discussion

Upland rice which grew under the conditions of low light intensity showed some changes in specific morphological characteristics. These characteristics were related to the mechanism of tolerance and adaptation of plants to keep photosynthesis. Based on statistical tests the shading stress and variety treatment were significant affected on plant length (Table 1), number of tillers (Table 2) and plant dry weight (Table 3). Meanwhile the interaction between varieties and shading stress treatment significantly affected the number of tillers based on Table 2 and the plant dry weight (Table 3) also the chlorophyll a and b content can be seen in Table 4.

3.1. Plant length

Plant length was one of the morphological characters that had an early response to change. One of the adaptation efforts carried out by plants in shaded conditions is indicated by an increase in plant length. Table 1 shows the effect plant length on shading stress treatment at 13 weeks after planting.

Table 1. Plant lengths of fifteen upland rice varieties on shading stress treatment

Varieties	Shade level				Mean
	0 % (Control)	25%	50%	75%	
(cm).....				
Inpago 5	123.60	127.80	106.37	111.50	117.32ab
Lipigo 4	109.25	105.37	93.65	79.15	96.85cd
Inpago 8	115.22	113.27	96.00	64.22	97.18cd
Inpago 10	99.17	112.17	86.17	76.30	93.45de
Towuti	88.02	96.17	76.63	52.48	78.33f
Kalimutu	134.05	127.65	72.07	81.45	103.80cd
Limboto	109.03	108.07	75.32	74.97	91.85de
Black rice	92.15	99.38	84.40	54.45	82.60ef
Red rice	87.82	101.07	88.43	57.47	83.70ef
IPB 8G	123.35	125.68	97.78	84.25	107.77bc
IPB 9G	124.97	120.50	75.07	70.83	97.84cd
Lipigo 1	114.48	120.65	84.07	89.18	102.10cd
Lipigo 2	128.67	146.23	102.17	113.05	122.53a
Situ patenggang	109.55	111.95	85.37	65.52	93.10de
Situ bagendit	88.58	101.87	79.10	62.53	83.02ef
Mean	109.86a	114.52a	86.84b	75.82c	

Note: numbers followed by different notations in the same row or column show a significant difference in the DMRT level of 5%.

Generally, the decrease of light intensity from 100% to 75% will increase the length of plants in ten rice varieties, except Lipigo 4, Inpago 8, Kalimutu, Limboto and IPB 9G. The different in the response plants were thought due to different plant adaptation capabilities to shade stresses. Single genotype can generate the different phenotypes in different environments [5].

The increase in plant height was thought due to the efforts of plants to get sunlight, caused by the production and distribution of high auxin so as to stimulate cell elongation. Increasing the shading stress treatment into 50% and 75% will reduce the plant length of all rice varieties. Decreasing the intensity of sunlight can reduce the rate of photosynthesis and yield of plants, because the light was an important factor in photosynthesis.

Each variety had a different response to low light intensity. Lipigo 2 and Inpago had the highest average compared to other varieties, Lipigo 4, Inpago 8, Kalimutu, IPB 8G and IPB 9G had the same length of crop response. Inpago 10, Limboto, and Situ Patenggang varieties relatively gave the same response to plant length, while Towuti, Red rice, Black rice and Situ Bagendit had the lowest plant length compared to other varieties.

3.2. Number of Tillers

The number of tillers from fifteen upland rice varieties on shading stress treatment at 13 weeks after planting can be seen in Table 2.

Table 2. The number of tillers of fifteen upland rice varieties on shading stress treatment

Varieties	Shade level				Mean
	0 % (Control)	25%	50%	75%	
.....(Tillers).....					
Inpago 5	18.50bc	1.17j	0.50j	0.50j	5.17abc
Lipigo 4	13.33de	2.17ij	0.83j	0.33j	4.17cd
Inpago 8	14.17cd	1.83ij	0.50j	0.00j	4.13cd
Inpago 10	11.83def	1.50j	0.33j	0.50j	3.54cde
Towuti	24.17a	3.00ij	1.67j	0.00j	7.21a
Kalimutu	6.50gh	1.00j	0.00j	0.83j	2.08ef
Limboto	8.50fgh	1.00j	0.17j	0.50j	2.54def
Black rice	22.50ab	3.83hij	0.83j	0.00j	6.79a
Red rice	21.83ab	3.50ij	1.50j	0.00j	6.71a
IPB 8G	3.67ij	1.50j	0.00j	0.00j	1.29f
IPB 9G	9.33efg	1.17j	0.00j	0.17j	2.67def
Lipigo 1	10.00defg	2.83ij	0.67j	0.17j	3.42cde
Lipigo 2	10.50defg	0.83j	0.00j	0.17j	2.88def
Situ patenggang	14.67cd	2.17ij	0.00j	0.17j	4.25bcd
Situ bagendit	19.83ab	3.17ij	1.33j	0.67j	6.25ab
Mean	13.96a	2.04a	0.56c	0.27c	

Note: numbers followed by different notations in the same row and column show a significant difference in the DMRT level of 5%.

The number of upland rice tillers had decreased in accordance with the increasing shading stress treatment which given. There was a decrease in the number of tillers in of 25%, 50% and 75% shading stress treatment, respectively 85.38%, 95.98% and 98.06% compared to 0% shading stress treatment. This was in accordance with the source-sink concept that photosynthate produced by plants will be distributed to all parts of the organ and each variety had the same capacity so that if the distribution of many saplings will be followed by low plant height, and vice versa. The low number of tillers as a result of shading stress was thought to be caused by plants cannot sharing enough energy for the formation of tillers, this can due to the low ability of leaves or reduced leaf capacity [6].

The number of tillers that showed the highest average were found in Towuti, Black rice and Red rice variety, all of which had the same response to the number of tillers. While the lowest number of tillers was found in Kalimutu and IPB 8G varieties.

3.3. Plant dry weight

Dry weight depicts all biomass produced by plants per specific time period. The effect of shading stress treatment of fifteen upland rice varieties on plant dry weight can be seen in Table 3.

Table 3. Dry weight of fifteen upland rice varieties on shading stress treatment

Varieties	Shade level				Mean
	0 % (Control)	25%	50%	75%	
Inpago 5	14.90ab	2.03gh	2.55fgh	0.73h	5.05ab
Lipigo 4	5.10e-h	1.50gh	1.30gh	0.63h	2.13c
Inpago 8	8.60cde	1.50gh	0.20h	0.27h	2.64c
Inpago 10	10.97bcd	2.07gh	0.95gh	0.84h	3.71abc
Towuti	9.47b-e	2.33fgh	1.25gh	0.33h	3.35abc
Kalimutu	4.97e-h	1.00gh	0.30h	0.47h	1.68c
Limboto	8.31cde	1.73gh	0.65h	0.86h	2.89bc
Black rice	13.63abc	1.40gh	0.40h	0.23h	3.92abc
Red rice	8.60cde	1.57gh	0.70h	0.22h	2.77bc
IPB 8G	7.53def	2.57fgh	0.85h	0.41h	2.84bc
IPB 9G	17.67a	2.33fgh	0.60h	0.50h	5.28a
Lipigo 1	6.23d-g	2.93fgh	0.70h	1.20gh	2.77bc
Lipigo 2	9.17cde	1.77gh	1.00gh	0.83h	3.19abc
Situ patenggang	10.03b-e	2.20fgh	1.45gh	0.57h	3.56abc
Situ bagendit	9.53b-e	2.00gh	0.95gh	0.53h	3.25abc
Mean	9.65a	1.93b	0.92b	0.58b	

Note: numbers followed by different notations in the same row and column show a significant difference in the DMRT level of 5%.

Dry weight decreased in accordance with the decreasing intensity of the light which given. The decrease in the dry weight was thought due to plants that had shade stress having decreased sink strength [7].

Light was an important factor in photosynthesis, the dry weight was a build-up of photosynthetic products whose formation was strongly influenced by nutrients, water, carbon dioxide, and sunlight. Inpago and IPB 9G varieties had the highest average dry weight and showed the same response to dry weight, Inpago 10, Towuti, Limboto, Black rice, Red rice, IPB 8G, Lipigo 2, Lipigo 1, Situ Patenggang and Situ Bagendit varieties showed the same response to the dry weight. While the varieties of Lipigo 4, Lipigo 8, and Kalimutu had the lowest average of dry weight and showed the same response.

3.4. Chlorophyll a and b content

Plants must be able to acclimate to changes in light, among others, was by regulating the chlorophyll content of leaves. Table 4 shows the chlorophyll a and b content of fifteen upland rice varieties on shading stress treatment.

Table 4. Chlorophyll a and b content of fifteen upland rice varieties on shading stress treatment

Varieties	Chlorophyll a				Chlorophyll b			
	0 % (Control)	25%	50%	75%	0 % (Control)	25%	50%	75%
	(mg/l)				(mg/l)			
Inpago 5	29.13	26.33	29.00	29.43	16.38	12.50	15.38	27.10
Lipigo 4	31.02	30.77	30.61	30.55	23.05	22.49	17.74	28.29
Inpago 8	30.33	28.17	30.37	31.08	18.85	13.71	26.19	24.67
Inpago 10	29.52	27.59	26.94	26.49	15.43	12.86	13.92	10.94
Towuti	30.64	30.61	27.66	29.41	19.13	27.73	13.57	14.65
Kalimutu	29.92	29.92	30.30	27.68	28.68	18.23	27.41	11.30
Limboto	30.47	30.61	28.78	30.59	18.70	24.25	14.21	24.40
Black rice	28.00	29.98	29.56	28.95	13.87	29.12	31.01	36.83
Red rice	30.35	29.21	28.02	28.93	21.66	15.78	39.81	33.79
IPB 8G	29.96	27.87	26.43	30.53	18.51	14.13	12.19	20.14
IPB 9G	30.66	29.80	24.34	30.92	20.83	18.46	9.73	19.11
Lipigo 1	30.39	30.00	30.44	27.86	24.60	26.56	22.58	40.31
Lipigo 2	30.41	31.04	30.77	30.89	23.48	26.79	22.29	19.60
Situ patenggang	29.76	30.27	29.03	27.92	16.31	30.02	14.91	13.58
Situ bagendit	29.37	29.00	29.73	30.58	31.56	15.90	29.70	19.20

From the table above it can be seen that in shaded conditions of 25%, 50% and 75% the chlorophyll a is higher than the chlorophyll b in all varieties, except for Black rice and Red rice varieties which had lower chlorophyll a than chlorophyll b at 50% and 75% shading stress treatment and Lipigo 1 at 75% shading stress treatment. This shows that the varieties of Black rice, Red rice and Lipigo 1 were less able to adapt to low light intensity conditions. In shading condition, upland rice continues to maintain chlorophyll a and suppresses the formation of chlorophyll b as a mechanism of plants in low sunlight conditions so that the chlorophyll a / b ratio will increase [8].

The low of leaf chlorophyll content in Black rice and Red also affects some other growths, such as the number of tillers, plant length, and plant dry weight at 75% shading stress treatment. This was because the chlorophyll content affects plant photosynthesis so that it will affect dry weight, number of tillers and plant length.

4. Conclusion

Plant length was increase 4.24% at 25% shading stress treatment. The increase shading stress treatment will reduce the number of tillers at 25%, 50% and 75% respectively 85.38%, 95.98%, and 98.06% compared to 0% shading stress treatment. The plant dry weight was continued to decrease at light intensity 75%, 50% and 25% respectively by 80%, 90.46% and 93.98%. Chlorophyll content will affect other parameters such as the number of tillers and dry weight. Chlorophyll a was generally higher than chlorophyll b, except for Black and Red rice at 50% and 75% and Lipigo 1 at 75% shading stress treatment.

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