

Growth and production of new superior rice varieties in the shade intensity

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Abstract. Shade intensity is one of the most important requirements for plant growth, affecting growth, development, survival, and crop productivity. This study aims to evaluate the growth and production of New Superior Rice Varieties In The shade Intensity. This study was conducted in BalaiPengkajianTeknologiPertanian, Pagar Merbau, Deli Serdang, North Sumatra. The research used completely randomized design with twofactors. The shade intensity (N) were 25%, 50% and no shade intensity as a control. Whereas new superior rice varieties were V₁: Inpara 2, V₂: Suluttan Unsrat 2, V₃: Inpari Mugibat, V₄: Inpari Sidenuk, V₅: Mekongga, V₆: Ciherang, V₇:Inpari 10, V₈: Inpari 3, V₉: Inpari 4, V₁₀: Inpari 30, dan V₁₁: Cibogo. The result indicated that new superior rice varieties showed significant effect on the growth and production variables such as leaf area, where Inpari Sidenuk variety was the highest among the varieties. Total chlorophyll, the highest was found on Inpari variety. Number of tillers and plant height where the highest was found on Ciherang variety. The shade intensity showed significant effect on leaf area, where 25% shade intensity was the highest. Total chlorophyll, the highest was found on 50% shade intensity, number of tillers, the highest was found on no shade intensity.

1. Introduction

Rice is an important staple food in Asian populations. World's major rice producing countries are Thailand, China and Vietnam, while Indonesia is the main consumer of rice. Future rice demand is expected to increase, in line with the population growth. Therefore there is a need to increase rice production by at least the rate of the increase in population growth, in order to achieve a sustainable rice production for local consumption. Rice compliance challenges ahead, especially in Indonesia, will be more difficult due to the conversion of agricultural land, especially irrigated land to non-agricultural interests [1]. Rice (*Oryza sativa* L.) is the world's second most important cereal crop, belonging to the family Gramineae. Rice provides 75% calories and 55% proteins to the average daily diet of consumers and contributes tremendously to the economies of many nations [2]. It is estimated that demand for rice in 2025 will be increased by 60% compared to today in order to meet the food needs. Indonesia, which has a population of 237 million people (2010 census) with main meals majority (95%) of the population is rice. Rice consumption is about 137 kg / capita / year, the predicted demand for rice in 2020 to the people of Indonesia reached 35.97 million tons / year. Where the vast rice fields in Indonesia reached 8.061 million hectares consisted of 4.896 million hectares of



irrigated rice and non-irrigated rice fields reached 3.16 million hectares has the potential to increase rice yields [3].

The role of environmental factors in rice production cannot be overemphasized. There are diverse environmental factors that affect rice production; growth and yield, among them are sunlight, drought, and temperature. Growth of autotrophic plants is directly and dramatically influenced by light intensity (i.e. quantum flux density) which is the driving force of photosynthesis and provides nearly all of the carbon and chemical energy needed for plant growth. In addition, it is opined that increased light intensity improved rice yield till plant reaches its light saturation. Furthermore, light intensity is among important requirements for plant growth, development, survival, and crop productivity. Because of the difficulty of controlling light intensity, researchers have evaluated the effects of variation in light regimes on morphological characteristics, physiological characteristics, yield, and quality of agricultural crops [2].

Wang *et al.* [4] examined that the effects of shading on starch content and starch pasting viscosity in rice genotypes. The research results may lay a theoretical foundation for the selection of shade-tolerant varieties of rice and the improvement of cultivation technologies. Therefore, the development of rice varieties are required to test rice variety productivity. In plant photosynthesis, chlorophyll is the most important photosynthetic pigment, and shading also affected the chlorophyll content of plants. Shading altered light-use efficiency by increasing leaf chlorophyll a, chlorophyll b, and chlorophyll a+b, and decreasing chlorophyll a/b ratios [5].

Effect of shade on upland rice varieties decreases the number of tillers, number of panicle, number of productive grains, production of grains per hill of plants and total sugar content of plants [6]. Light intensity is one of the most important requirements for plant growth, affecting growth, development, survival, and crop productivity. Because of the difficulty of controlling light intensity [4], researchers have evaluated the effects of shading on morphological characteristics, physiological characteristics, yield, and quality of agricultural crops. Multiple studies [5] have shown that the morphological changes resulting from shading included increases in leaf width, length, and area index, and decreases in leaf thickness due to the reduction of palisade layer number, palisade cells, and spongy parenchyma length. On the rice plant, shade can reduce the number of tillers, dry weight of the canopy, leaf area index, grain yield and the efficiency of solar radiation use [7].

There are many new superior rice varieties produced by such research institutes as Agricultural Research and Development Agency, universities, and private research institutions, and BATAN. Those varieties, however, are unknown by local farmers regarding their superiority. In addition, fertilization conducted by farmers is not in accordance with recommendation of location specific. Thus, identification of new superior rice varieties will be essential in developing high-yielding varieties that can survive in the shade intensity. Therefore, this present study was carried out in order to examine growth and production of new superior rice varieties in the shade intensity.

2. Materials and Methods

In order to study productivity test of new superior rice varieties in the shade intensity an experiment was conducted in Balai Pengkajian Teknologi Pertanian, Pagar Merbau, Deli Serdang, North Sumatra. The experiment was conducted from November 2014 until March 2015. The experiment was designed as a completely randomized design with two factors. The shade intensity (N) were 25%, 50% and no shade intensity as a control. Whereas new superior rice varieties were V₁: Inpara 2, V₂: Suluttan Unsrat 2, V₃: Inpari Mugibat, V₄: Inpari Sidenuk, V₅: Mekongga, V₆: Ciherang, V₇: Inpari 10, V₈: Inpari 3, V₉: Inpari 4, V₁₀: Inpari 30, dan V₁₁: Cibogo. If the effect of different treatments on the real variance, then tested further by Duncan's multiple range test.

Land preparation, Tillage was done by using a tractor plow and harrow. Plowed soil until conditions crumb processed layer 15-25 cm deep. Experimental Plots, Created with a length of 200 cm and width of 100 cm by the number of beds 45 plot. The experiments were replicates three times. The distance between replications of 200 cm, 50 cm distance between plots. Shade Manufactures, Shade was made of bamboo poles and the roof put on paranet 25% and 50%. Appropriate treatment shade 10

m long and 4.5 m wide shade. Tall bamboo from the ground level was 2 m. Seed preparation, Seeds cleaned then soaked for 24 hours in saltwater. Washed with clean water and then drained and ripened for 24 hours. Cultivation, Seedlings planted at 18 days after sowed. Row spacing 25 cm x 25 cm ,1 seed per hole.Regulate Irrigation,Seeds are planted in water-saturated soil conditions and mapped fields in circulated again after 3-4 days. Water rotation must be checked every 3 days. Fertilization,Fertilizer used was 14.49 kg urea fertilizer with 3 times applications when the plant was 10 days, 30 days and 45 days, 9.66 TSP twice applications when the plant was 30 days and 45 days, and KCL 9.66 kg with once application at age of plant 30 days. Pest and Disease Control, Pests controlled by kenfas 100 EC (Alfa sipermethria 100 g/l), walang sangit pest controlled by baycarb (BPMC (2-Ci-methyl propy) Phenyl Methyl carbamate), snails pest controlled mechanically (citations) and spraying molluscicides debestan (besnoid 400 gr), and stem rot disease was controlled byfungicides (Difenokonazol 250 g/l).Harvest, Rice was harvested when 95% of panicles have yellowed.

Parameters observed: 1)leaf Area (cm²), which the measurement was done before harvest calculated using the leaf area meter. The leaves were observed which leaves the largest, medium and smallest unfolded. 2) Number of tillers. The number of tillers was calculated starting from 30 days after planting. Puppies were calculated by counting the number of tillers that grow from the main stem, once in 15 days until 60 days after planting. If the clump of rice plants was 20 stems, then the number of tillers was 19 straws, because the rod rest was rice plant stem [8]. 3) Plant height (cm). Plant height measurements started when the plant was 10 days after planting until flowering, once every two weeks. 4) Total of Chlorophyll (mg/g), Chlorophyll content was calculated by spektrofotometerUvis following the method proposed by Henry and Grime [9]. The extraction of chlorophyll done with acetone 80%, weighed 0.1 g leaves, crushed in a mortar, plus 10 ml acetone. Then filtered with Whatman filter paper. The filtrate was measured absorbance at 645nm and 663nm. The calculation of the levels of chlorophyll as follows:

$$\begin{aligned} \text{Chlorophyll a mg/g weight of leaf} &= (12,7 \times A_{663} - 2,69 \times A_{645})10^{-1} \\ \text{Chlorophyll b mg/g weight of leaf} &= (22,9 \times A_{645} - 4,68 \times A_{663}) \times 10^{-1} \\ \text{Chlorophyll total mg/g weight of leaf} &= (8,02 \times A_{663} + 20,2 \times A_{645}) \times 10^{-1} \end{aligned}$$

3. Results and Discussion

In this research, New superior rice varieties showed significant effect on the growth and production variable such as leaf area, where Inpari Sidenuk variety was the highest among the varieties. Total chorophyll, the highest was found on Inpari variety. Number of tillers and plant height where the highest was found on Ciherang variety. The shade intensity showed significant effect on leaf area, where 25% shade intensity was the highest. Total chlorophyll, the highest was found on 50% shade intensity, number of tillers, the highest was found on no shade intensity.

There were significant effect on leaf area amongnew superior rice varieties (Table), where Inpari Sidenuk variety was the highest among the varieties, followed by Inpara and Inpari as the lowest. The shade intensity showed significant effect on leaf area, where 25% shade intensity was the highest then followed by 50% shade intensity and no shade intensity was the lowest. The rice plants respond and adapt to various types, timing and duration of flooding in different ways which include elongation for deepwater rice varieties and submergence tolerance for lowland varieties exposed to transient flash floods.[15] stated that the contribution of superior varieties on the increase in national production is 56%. Research and Development Agency has produced 233 superior varieties consist of 144 Inbrida superior rice varieties, 35 hybrid superior rice varieties, 30 superior upland rice varieties, and 24 wet rice varieties. [4] reported that shading at different growth stages and in different rice varieties all affected the starch pasting characteristics of rice. The effects of shading on starch pasting viscosity at middle and later growth stages were greater than those at earlier stages. Shading enhanced breakdown

but reduced hold viscosity and setback at tillering-elongation stage. Most pasting parameters changed significantly with shading after elongation stage. Furthermore, the responses of different varieties to shading differed markedly. The change scope of starch pasting viscosity in Dexiang 4103 was rather small after heading, while that in Ilyou 498 and Gangyou 906 was small before heading. We observed clear tendencies in peak viscosity, breakdown, and pasting temperature of the five rice varieties with shading in 2010 and 2011. Correlation analysis indicated that the rice amylose content was negatively correlated with breakdown, but was positively correlated with setback. Based on our results, Ilyou 498, Gangyou 906, and Dexiang 4103 had higher shade endurance, making these varieties most suitable for high-quality rice cultivation in low-light regions. That's why in their research reported that to be successful staple crops, crops need to be resistant to varying growing conditions, providing consistent yield and quality under a range of environmental conditions. While many previous studies focused on shading effects on rice morphology, physiology, and yield, the responses of starch quality to shading in indica hybrid rice are unclear. Therefore, they examined the effects of shading on starch content and starch pasting viscosity in rice genotypes. Their research results may lay a theoretical foundation for the selection of shade-tolerant varieties of rice and the improvement of cultivation technologies.

New superior rice varieties showed significant effect on number of tillers 4 weeks after planting where the highest was found on Ciherang variety then followed by inpari variety and Suluttan Unsrat was the lowest. The shade intensity showed significant effect on number of tillers 4 weeks after planting, where no shade intensity was the highest followed by shade intensity (25%) then shade intensity (50%) was the lowest (Table). It was caused by factor of shade is one of the issues that need to be addressed in the development of lowland rice cultivation as intercrops. Rice productivity comes under some influencing indices which are often interdependent. The present study revealed that total number of tillers; and more importantly, number of effective tillers increased with increasing light intensity; this agreed with the findings of [10], who reported that the numbers of tiller increased in parallel with increases in the level of light intensity. In the same vein, the quantity of harvest is directly related to the number of tillers that produced panicles provided there were no disease or pest incidence. Effect of shade on upland rice varieties decreases the number of tillers, number of panicle, number of productive grains, production of grains per hill of plants and total sugar content of plants [6]. There are varieties of red rice that can adapt to low and high light intensities [11]. Wang *et al.* [4] examined the effects of shading on starch content and starch pasting viscosity in rice genotypes. The research results may lay a theoretical foundation for the selection of shade-tolerant varieties of rice and the improvement of cultivation technologies. Therefore, the development of rice varieties are required to test rice variety productivity. However, this factor can interfere with the development of plant morphological characteristics and metabolic processes resulting in the ability of the plant. Light availability is the main constraint to grow upland red rice in shading trees. Vacant land between crops and forestry tree that is not utilized is the potential for the development of upland rice. The land area in Indonesia is estimated at 11.5 million hectares every year and 3-4% of them rejuvenated. Deficit light on upland rice caused disruption of metabolic processes that have implications for decreasing the rate of photosynthetic and carbohydrate synthesis. The main ecological constraint in the utilization of land under plantation crops and forest stands is the low intensity of solar radiation, so that the plant will light stress, which will result in the decrease of growth and production. On the rice plant, shade can reduce the number of tillers as reported earlier by Cruz [7] and shade can reduce dry weight of the canopy, leaf area index, grain yield and the efficiency of solar radiation use.

There were significant differences in plant height among the new superior rice varieties at 14 weeks after planting, the highest was obtained in Ciherang variety followed by Inpari Sidenuk and the lowest was obtained in Suluttan Unsrat. The result of this study indicated there are several indices in the cultivation and management of the new superior rice varieties that could be improved. Emmanuel and Mary [2] reported that plant height decreased with increasing light intensity; this is encouraging because tall rice stems make them susceptible to lodging consequently heavy harvest losses. Also, plants grown in the dark or in very weak light have delicate, soft and slender stem since they continue

in rapid growth and elongate, looking for light until they reach their maximum dimension and bend toward light direction. A condition generally referred to as etiolation. Short erect plant type is also an impetus for direct seeding which is often cheaper than transplanting using machines.

Table 1. Average plant height, number of tillers, leaf area, total chlorophyll on new superior rice varieties and shade intensity

Treatment	Leaf Area	Number of Tillers 4 WAP	Plant Height 14 WAP	Total Chlorophyll
New Superior Rice Variety				
V ₁	47.74 ab	7.97 cd	115.30 bc	4.43 c
V ₂	41.51 c	6.08 d	103.99 c	5.30 abc
V ₃	42.49 bc	10.14 b	111.26 bc	6.30 a
V ₄	49.05 a	10.31 ab	119.98 ab	5.96 ab
V ₅	45.42 abc	10.24 ab	112.37 bc	5.20 abc
V ₆	41.33 c	12.31 a	128.87 a	5.64 ab
V ₇	43.07 bc	10.30 ab	112.97 bc	5.60 abc
V ₈	41.81 c	6.90 d	107.48 bc	5.23 abc
V ₉	40.40 c	10.36 ab	111.98 bc	5.49 abc
V ₁₀	45.34 abc	9.60 bc	113.47 bc	5.59 abc
V ₁₁	45.79 abc	6.23 d	108.12 bc	5.04 bc
Shade Intensity				
N ₀	40.91 b	13.35 a	110.85	4.83 b
N ₁	46.97 a	7.63 b	115.88	5.59 a
N ₂	44.11 a	6.42 c	113.03	5.88 a
New Superior Rice Variety and Shade Intensity				
V ₁ N ₀	46.10	12.97 bc	121.43	3.15
V ₁ N ₁	47.87	7.23 defghi	113.73	5.31
V ₁ N ₂	49.25	3.70 i	110.73	4.84
V ₂ N ₀	37.67	7.23 defghi	105.06	4.27
V ₂ N ₁	44.59	5.70 efghi	101.16	6.20
V ₂ N ₂	42.28	5.30 fghi	105.73	5.43
V ₃ N ₀	38.07	16.10 ab	107.9	5.31
V ₃ N ₁	48.17	6.90 defghi	110.56	6.02
V ₃ N ₂	41.24	7.43 defghi	115.3	7.58
V ₄ N ₀	45.84	14.40 ab	115.86	5.86
V ₄ N ₁	48.83	8.50 defgh	122.6	5.82
V ₄ N ₂	52.49	8.03 defgh	121.46	6.19
V ₅ N ₀	41.48	15.03 ab	112.3	4.51
V ₅ N ₁	51.16	8.67 defg	111.63	5.49
V ₅ N ₂	43.63	7.03 defghi	113.16	5.61
V ₆ N ₀	40.85	17.33 a	109.76	5.32
V ₆ N ₁	43.39	10.17 cd	155.8	5.20
V ₆ N ₂	39.76	9.43 de	121.03	6.39
V ₇ N ₀	39.61	16.17 ab	165.33	5.17
V ₇ N ₁	50.20	6.67 defghi	158.86	5.76
V ₇ N ₂	39.40	8.07 defgh	170.76	5.88
V ₈ N ₀	38.64	9.17 def	108.5	5.09
V ₈ N ₁	41.16	6.93 defghi	115.16	4.27
V ₈ N ₂	45.64	4.60 hi	115.23	6.34
V ₉ N ₀	38.99	14.50 ab	109.53	5.07
V ₉ N ₁	43.68	8.93 defg	105.03	5.84
V ₉ N ₂	38.54	7.63 defghi	107.86	5.56
V ₁₀ N ₀	36.47	15.53 ab	111.7	4.60
V ₁₀ N ₁	50.85	8.33 defgh	113.26	5.88
V ₁₀ N ₂	48.69	4.93 ghi	110.96	6.30
V ₁₁ N ₀	46.28	8.37 defgh	108.26	4.74
V ₁₁ N ₁	46.77	5.87 efghi	114.9	5.77
V ₁₁ N ₂	44.32	4.47 hi	117.23	4.61

Means followed by the same letters in the same columns and rows are not significantly different at 5% level of probability by DMRT

Some research indicates that the level of shade more than 50%, can decline production. The rate of decline rice production by shade is depending on the level of tolerance and growth phase of each variety. A process in plants that may be affected by shade is photosynthesis, transpiration, respiration, nitrate reduction, protein synthesis, hormone production and photosynthate translocation, root growth and mineral absorption [12]. Rice leaf responds to different levels of light received. For high light intensity, the ratio of a/b chlorophyll will be the highest from plants that can adapt to high light. Whereas in low-light conditions, the a/b chlorophyll ratio was highest in plants that was adapted to the low light, $\pm 20\%$ of light in [11].

In this research, the new superior rice variety showed significant effect on total chlorophyll, where the highest was found on Inpari Mugibat then followed by Inpari Sidenuk variety and Inpara variety was the lowest (Table). Rice leaf responds to different levels of light received. There are varieties of red rice that can adapt to low and high light intensities. For high light intensity, the ratio of a/b chlorophyll will be the highest from plants that can adapt to high light. Whereas in low-light conditions, the a/b chlorophyll ratio was highest in plants that was adapted to the low light, $\pm 20\%$ of light in. Watanabe *et al.* [11] reported that leaf morphology and anatomy indicate changes in correlated with shaded conditions. Research to determine the morphological characteristics of plants that are good for full light have been carried out. While knowledge of the morphological characteristics of plants that are good at low light intensity is still limited. Based on the pattern of assimilation rate and the linear erect leaves to changes in light intensity and pattern of flat leaf assimilation rate reaches a maximum at low light intensity which can be presumed that the arrangement of the leaves is good for low-light leaf leaves are erect leaves on top and flat leave on bottom.

Furthermore, shade will affect plant morphology changes will also affect the quality of upland rice grain obtained. Leaf morphology and anatomy indicate changes in correlated with shaded conditions. The leaves tend to be thinner and wider [13]. In 2014, Agricultural Research and Development Agency has launched new superior varieties (VUB) in irrigated land (Inpari 1 – Inpari 33), superior upland rice varieties (Inpago 4-10), and for marsh ecosystem of Inpara 1-7 varieties [14], continues to play a key role in rice farming in many parts of Asia.

Wang *et al.* [4] examined the effects of shading on starch content and starch pasting viscosity in rice genotypes. The research results may lay a theoretical foundation for the selection of shade-tolerant varieties of rice and the improvement of cultivation technologies. Therefore, the development of rice varieties are required to test rice variety productivity. In plant photosynthesis, chlorophyll is the most important photosynthetic pigment, and shading also affected the chlorophyll content of plants. Shading altered light-use efficiency by increasing leaf chlorophyll a, chlorophyll b, and chlorophyll a+b, and decreasing chlorophyll a/b ratios [5].

4. Conclusions

New superior rice varieties showed significant effect on the growth and production variable such as leaf area, where Inpari Sidenuk variety was the highest among the varieties. Total chlorophyll, the highest was found on Inpari variety. Number of tillers and plant height where the highest was found on Cihorang variety. The shade intensity showed significant effect on leaf area, where 25% shade intensity was the highest. Total chlorophyll, the highest was found on 50% shade intensity, number of tillers, the highest was found on no shade intensity. New superior rice varieties should be recommended. Thus, enhancing the yield of new superior variety like Cihorang variety which performs better in the shade intensity.

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