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by Rini Fitri

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Book:

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Abstract:

Assaeed AM. 2007. Seed production and dispersal of Rhazya stricta. 50th annual symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds.) Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

Information from internet: Balagadde FK, Song H, Ozaki J, Collins CH, Barnet M, Arnold FH, Quake SR, You L. 2008. A synthetic Escherichia coli predator-prey ecosystem. Mol Syst Biol 4:187. www.molecularsystembiology.com

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Evaluation of growth and yield of upland rice varieties under various shading levels and organic fertilizer concentrations

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Abstract. *Satriawan H, Nazirah L, Fitri R, Ernawita. 2022. Evaluation of growth and yield of upland rice varieties under various shading levels and organic fertilizer concentrations. Biodiversitas 23: 2655-2662*. The present study aimed to reveal the effect of shading treatments and organic fertilizer dosages on the growth and yield of several upland rice varieties. A split-split plot experimental design with 3 factors was used in this study, consisting of shading levels as the main plot (0%, 30%, 60%), organic fertilizer as a sub-plot (0 g/plant, 25 g/plant, 50 g/plant, and 75 g/plant) and upland rice varieties as sub-sub plot (Ciherang, Situ Bagendit, Kabir 07 and Malaysian upland). Parameters observed were plant height and tiller numbers (expressed as area under the curve), panicle number, dry hay weight, grain weight, flowering time, and chlorophyll number. Results showed that shading treatments significantly affected panicle number, grain weight, and dry hay weight (0% and 30% shade showed the highest result with no significant differences; while 60% shades showed the lowest results); varieties are an important determinant in tiller numbers (Malaysian upland, Ciherang, Situ Bagendit and Kabir 07 with 798.33±7.76 and 792.71±9.4, 764.38±8.75 and 738.33±14.84, consecutively) and panicle numbers (Ciherang, Situ Bagendit, Malaysian upland and Kabir 07 with 46.51±5.97, 45.26±5.68, 44.31±5.09, and 41.08±5.92, consecutively); while organic fertilizer dosages significantly affected tiller numbers in which 26 t ha^{-1} and 8 t.ha^{-1} were the highest and the lowest tiller number observed, respectively. Shade and variety interaction significantly affected plant height and flowering time, while interactions of varieties and organic fertilizer dosages are significant on tiller number, panicle number, grain weight, and dry hay weight. The highest total chlorophyll number was shown by Situ Bagendit variety (144.44 granules mm^{-2}) at 60% shading level, while Kabir 07 (98.8 granules mm^{-2}) at 30% shading level showed the lowest total chlorophyll number. It can be concluded that organic fertilization significantly affected the growth and production of upland rice varieties compared to shading treatments. Thus, upland rice cultivation under shading conditions is the potential to be developed, particularly with appropriate rice varieties and optimum organic fertilization techniques.

Keywords: Organic fertilizer, shading, upland rice, varieties

INTRODUCTION

Rice is widely accepted as a major staple food in Asia; including Indonesia. In Indonesia, total rice production was recorded as much as 5.13 t ha^{-1}, and the average consumption per capita was 111.58 kg per capita in 2017 (BPS 2018). Rice procurement currently stands as one of the fundamental problems in Indonesia as a slow change in community consumption patterns, land-use change from agricultural to non-agricultural use, and extreme climate fluctuation. The change in land use has become the most prominent cause. The agricultural census held in 2017 stated that land conversion in 2012-2015 was reported to be as much as 39.493 annually. Interestingly, the largest land conversion did occur in Aceh, Riau, West Sumatra, and Jambi provinces (PSIP 2017). It is predicted that the paddy field area left in 2045 will be 5.1 million hectares (Mulyani et al. 2016). Actions are needed to surmount this problem; otherwise, Indonesia will continuously be importing rice from other countries.

One of the alternatives to increase national rice production is the cultivation of upland rice varieties in various plantations with the intercropping system. In Indonesia, upland rice production donated significant contributions to cater staple food, particularly to communities that live in marginal dry land (Suwarno et al. 2021). In Indonesia, as many as 1.1 million hectares of upland rice varieties contribute to 5% of national rice production (Puslitbangtan 2014). Upland rice is cultivated in different areas as monoculture or as intercropping with other plants (Sopandie and Trikoesoemaningtyas 2011; Putra et al. 2017).

In Sumatra Island, especially Aceh Province, plantation area is keep growing, including oil palm plantations. Total oil palm plantations area in 2010 were as much as 9 million hectares (Putra et al. 2012), which continually increased to 12.3 million hectares, which comprised 42% community plantation, 7% government-owned, and 51% privately owned. In Aceh province, the total area of oil palm plantations is up to 458,619 hectares, with 50.89% being community-owned and 39.87% privately owned (Direktorat Jenderal Perkebunan 2018). Of total oil palm plantation areas, 2.7 million hectares are immature oil palm plants, while in Aceh province alone, immature oil palm plants are as much as 118,173 hectares. This area is very suitable to be used for intercropping with upland rice.

However, several obstacles are faced in the development of upland rice intercropping in areas of oil palm plantations with immature plants. First, environmental factors, namely low light intensity, especially under the canopy of 2 years old and above oil palm stands; second, relatively low soil organic contents; and third, limited groundwater supply. Sunlight radiation affects plant growth and production through photosynthesis (Kobayashi 2021; Kobayashi et al. 2013). It is known that upland rice needed high light intensity; thus, lack of light due to shaded conditions caused a reduction in photosynthesis rate and low carbohydrate production (Abidin 2015; Asfaruddin and Mulatsih 2017).

Previous research explained the effect of shaded conditions on morphology, physiology, and rice production, but studies revealed different effects depending on the upland rice genotype (Hairmansis et al. 2017; Alridiwirsah et al. 2018; Ahmad and Sija 2020). However, their results provided a theoretical foundation for upland rice varieties that could withstand shaded conditions and improve their cultivation technology. Genotype variation response to low light intensity has been reported previously (Demao and Xia 2001; Sopandie et al. 2003; Wang et al. 2015; Wang et al. 2016). The reduction in photosynthesis rates caused by shaded conditions has been lower than tolerant genotype compared to sensitive genotype (Wang et al. 2015). Physiological disturbances will cause low upland rice production under shaded conditions (Hafni et al. 2019). One way to develop upland rice in oil palm plantations is the examination of upland rice cultivation conditions, especially those linked to the improvement of land conditions utilizing organic matter addition. The introduction of organic fertilizer in upland rice varieties cultivation has become an alternative to sustain soil fertility and reduce the dependency on chemical fertilizer (Six et al. 2014).

Moreover, the presence of organic fertilizer can increase nutrient availability, either directly through nutrient supply or indirectly through the improvement of soil's physical properties (Andriamananjara et al. 2018). For example, Suryanto et al. (2020) reported 91.7% increase in the production of upland rice with the addition of 10 t ha^{-1} organic fertilizer to the agroforestry cultivation system of eucalyptus. Therefore, the study aimed to analyze the growth and production of four upland rice varieties under shaded conditions and organic fertilizer treatments.

MATERIALS AND METHODS

The study was conducted on the experimental site of Almuslim University from Mei to July 2021. A Split-split plot experimental design with 3 factors was used in this study, i.e., shading as the main plot (0, 30, and 60%), organic fertilizer as the sub-plot (0 t ha^{-1}, 8 t ha^{-1}, 16 t ha^{-1}, 24 t ha^{-1}), 3) variety as the sub-sub plot (Ciherang, Situ Bagendit, Kabir 07 and Malaysian upland).

Shading installation

Shading level was set using block woods and lat boards. Dimensions of each installation unit were as follows: length: 4.5 m; height: 2.0 m; and width: 2,4 m. To get the desired level of shading treatments of 0%, 30%, and 60%, the distance between lat board as the roof of the building is set according to the following formula (Ginting et al. 2015): I=n(n+r); where I: desired shading intensity (%); n: distances between lat boards (cm); and r: width of lat boards (cm).

Preparation of media

Topsoil was taken from oil palm plantations in Bukit Sudan area, Peusangan Siblah Krueng district, was air-dried for 15 days, pulverized, and filtered through a 6 mm mesh sieve. The soil was then put into polybags, 10 kg each. As many as 432 polybags were used in this study.

Planting

The soil in polybags was conditioned in field capacity before seed planting. Each polybag was planted with 5 selected seeds at 2.5 cm depth. After 1 week, thinning was conducted with only 3 plants left on each of the polybags.

Fertilization

Two days before planting, basal fertilizers of N, P, K were added to the media. One-third dosage of N fertilizer was obtained by adding 160 kg ha^{-1} urea, P and K were given simultaneously through the addition of TSP (300 kg ha^{-1} g P) and KCl (350 kg ha^{-1} K) one each polybag. Fertilizer was applied evenly to the soil and then covered thinly with soil. Afterward, soil was watered to the field capacity. The second and third dosages of N were given at 30 and 55 days after planting (DAP).

Crop cultivation and harvest

Plant water conditions were cautiously tended. Watering of the plant was conducted if there was no rain on two consecutive days. After that, watering was done each time to field capacity. The watering was discontinued after crops were in the mature stage for harvest. Crop pest controls were conducted using Decis and Marshall 25 EC insecticides every 1-2 weeks. Manual weeding was conducted on each of the polybags every other week. Harvest was conducted when rice grain was 90% yellow.

Parameters observed

Plant height

Plant height measurement (cm) started at 15 DAP until flowering, every 15 days.

Tiller numbers

The number of tillers was counted at 15-45 DAP according to (Alridiwirsah 2018). The tiller number was counted by counting the tiller number of the main stem.

Dry hay weight (g)

Hay was cut into 5 cm strips and sundried for several days, put into yellow envelopes, and dried in the oven at 80^{o}C until constant weight. The measurement was conducted at the end of the observation period.

Panicle numbers

Panicle numbers were counted of sample plant clumps using a hand counter.

Panicle length

Panicle length (cm) was measured from the panicle base to the end of the panicle. Panicle length counted as the average of panicle length to panicle number per clump of sample plant.

Chlorophyll numbers

Leaves chlorophyll numbers were measured using the SPAD (Soil Plant Analysis Development) chlorophyll meter, which was carried out according to the observation points determined in the rice plant clump (Nasution et al. 2019). Data collection on chlorophyll numbers in plants is carried out and collected according to the observation points selected to be used as data samples 70 days after planting (DAP).

Grain weight

Paddy grains from each treatment were dried to ±14% water content using a protimeter. The 1000-grain weight was determined using the analytical balance in triplicate, and the average was then calculated (g) and converted to t ha^{-1} of yield.

Data analysis

The data were analyzed using analysis of variance based on split split-plot design. Mathematical equation is presented as follows (Gomez & Gomez 1995):

$$Y_{ijk} = \mu + K_l + A_i + Y_{il} + B_j + (AB)_{ij} + \delta_{ijl} + C_k + (AC)_{ik} + (BC)_{jk} + (ABC)_{ijk} + \varepsilon_{ijkl}$$

$$i = 1,2...,a;\ j = 1,2..b;\ k = 1,2..c;\ l = 1,2..r$$

In which:

Y_{ijk} : Observations on the 1st experimental unit obtained a combination of treatment at the i-level of factor A, the j-level of factor B, and the k-level of factor C

μ : Population mean value

K_l : Additive effect of the 1st group

A_i : Additive effect of the i-level from factor A (shading) (main plot).

Y_{il} : The main plot's random effect appears at the i-level of factor A in the 1st group (main plot error or an error)

B_j : The additive factor of the j-level of factor B (fertilizer) (subplot)

$(AB)_{ij}$: The additive effect of the i-level of factor A and the j-level of factor B

δ_{ijl} : The random effect of the 1st experimental unit that obtained the treatment combination ij (subplot error or b error)

C_k : Additive effect of the k-level of C factor (variety) (sub subplot)

$(AC)_{ik}$: Additive effect of the-i level of A factor and the-k level of C factor

$(BC)_{jk}$: Additive effect of the j-level of B factor and the k-level of the C factor

ε_{ijkl} : The random effect of the k-experimental unit that obtained combination treatment of ijk (sub subplot error or c error)

Statistical analysis

Data were presented as mean average ± standard deviation (SD). Coefficient of variation (CV) was calculated to measure the relative variability. The data collected on different parameters were statistically analyzed using SPSS software version 16.0. After performing ANOVA, the differences between the treatment means were compared by LSD test at 5% level of significance.

RESULTS AND DISCUSSION

Shading treatment as the main plot and organic fertilizer as a sub-plot affected crop growth and production differently, especially on plant height, tiller numbers, panicle numbers, grain weight, dry hay weight, and total chlorophyll number parameters. Interactions of varieties and organic fertilizer dosages (VD) significantly affected all parameters observed except for plant height and flowering time. While interactions between shading and dosage (ND) and NVS generally showed non-significant effects (Table 1).

Tabel 1. Recapitulation of growth and production of upland rice varieties on different shading treatments and organic fertilizer dosages

Variables	Shade	Varieties	Organic fertilizer dosage	Interactions			
	(S)	(V)	(D)	SV	SD	VD	SVD
Plant height	ns	ns	ns	*	ns	ns	ns
Tiller number	ns	*	*	ns	ns	*	ns
Panicle number	*	*	ns	ns	ns	*	ns
Grain weight	*	ns	ns	ns	ns	*	ns
Dry hay weight	*	ns	ns	ns	ns	*	ns
Flowering time	ns	ns	ns	*	ns	ns	ns

Note: *Significant, ns Not significant

Table 2. Means, standard deviation and coefficient variation of plant height and tiller numbers of observed samples. Values presented as the area under the curve (AUC) of plant height and tiller number at 15, 30, and 45 DAP

	AUC of tiller number			
	Average	±	SD	CV
Varieties				
Ciherang	792.71	±	9.43[c]	1.19
Situ Bagendit	764.38	±	8.75[b]	1.14
Kabir 07	738.33	±	14.84[a]	2.01
Malaysian Upland	798.33	±	7.76[c]	0.97
Organic fertilizer dosages ($t.ha^{-1}$)				
0	766.25	±	0.62[b]	0.08
8	744.90	±	2.26[a]	0.30
16	764.58	±	3.19[b]	0.42
24	818.02	±	0.65[c]	0.08

Note: numbers followed by the same letter notation in the same column are not significantly different based on the 5% LSD test

Table 3. Means, standard deviation and coefficient variation plant height and tiller numbers of samples were observed under interaction of two factors. Values presented as the area under the curve (AUC) of plant height and tiller number at 15, 30, and 45 DAP

AUC of plant height (cm)				
Shade (%)	**Varieties**			
	Average	**±**	**SD**	**CV**
	Ciherang			
0	1,250.16	±	22.92^{b}	1.83
30	1,189.22	±	22.18^{a}	1.87
60	1,188.28	±	37.38^{a}	3.15
	Situ Bagendit			
0	1,180.16	±	14.56^{a}	1.23
30	1,240.00	±	17.68^{b}	1.43
60	1,283.13	±	17.25^{c}	1.34
	Kabir 07			
0	1,202.97	±	38.15^{a}	3.17
30	1,278.28	±	45.85^{b}	3.59
60	1,182.03	±	44.97^{a}	3.80
	Malaysian Upland			
0	1,129.69	±	13.36^{a}	1.18
30	1,238.13	±	15.96^{c}	1.29
60	1,212.50	±	13.58^{b}	1.12

AUC of tiller number				
Varieties	**Organic fertilizer dosages (t ha^{-1})**			
	Average	**±**	**SD**	**CV**
	0			
Ciherang	802.08	±	8.68^{c}	1.08
Situ Bagendit	713.75	±	7.14^{b}	1.00
Kabir 07	686.67	±	14.94^{a}	2.18
Malaysian Upland	862.50	±	6.21^{d}	0.72
	8			
Ciherang	732.50	±	10.80^{ab}	1.47
Situ Bagendit	720.00	±	7.14^{a}	0.99
Kabir 07	785.83	±	11.01^{c}	1.40
Malaysian Upland	741.25	±	6.21^{b}	0.84
	16			
Ciherang	808.75	±	6.21^{d}	0.77
Situ Bagendit	766.25	±	7.14^{cb}	0.93
Kabir 07	710.83	±	11.01^{a}	1.55
Malaysian Upland	772.50	±	6.21^{b}	0.80
	24			
Ciherang	827.50	±	8.35^{b}	1.01
Situ Bagendit	857.50	±	7.14^{c}	0.83
Kabir 07	770.00	±	11.77^{a}	1.53
Malaysian Upland	817.08	±	6.80^{b}	0.83

Note: the numbers followed by the same letter notation in the same column are not significantly different based on the 5% LSD test

Tabel 4. Means, standard deviation and coefficient variation of hay weight (t ha^{-1}), panicle numbers, grain weight (t ha^{-1}) of upland rice varieties under interactions of two factors

Varieties	**Organic fertilizer dosages**							
	0 t ha^{-1}		**8 t ha^{-1}**		**16 t ha^{-1}**		**24 t ha^{-1}**	
	Average ± SD	**CV**	**Average ± SD**	**CV**	**Average ± SD**	**CV**	**Average ± SD**	**CV**
Hay weight								
Ciherang	15.15 ± 15.97^{b}	14.46	13.22 ± 15.97^{a}	16.56	14.50 ± 16.10^{b}	15.22	14.89 ± 16.10^{b}	14.83
Situ Bagendit	16.48 ± 24.87^{c}	20.7	15.41 ± 24.87^{b}	22.14	16.43 ± 24.87^{d}	20.75	16.59 ± 24.87^{c}	20.55
Kabir 07	15.58 ± 15.91^{b}	14	16.21 ± 16.38^{c}	13.87	13.67 ± 16.38^{a}	16.44	14.08 ± 16.38^{a}	15.96
Malaysian Upland	14.24 ± 17.63^{a}	16.98	15.86 ± 15.32^{bc}	13.25	15.56 ± 17.63^{c}	15.53	14.33 ± 17.63^{ab}	16.87
Panicle numbers								
Ciherang	45.72 ± 5.97^{b}	13.05	44.06 ± 5.97^{b}	13.55	47.56 ± 5.97^{c}	12.55	48.72 ± 5.97^{c}	12.25
Situ Bagendit	41.89 ± 5.68^{a}	13.55	45.06 ± 5.68^{b}	12.6	46.72 ± 5.68^{b}	12.15	47.39 ± 5.68^{b}	11.98
Kabir 07	41.5 ± 5.92^{a}	14.26	42.67 ± 5.92^{a}	13.87	38.83 ± 5.92^{a}	15.24	41.33 ± 5.92^{a}	14.32
Malaysian Upland	46.06 ± 5.82^{b}	12.64	44.72 ± 5.82^{b}	13.02	45.89 ± 5.82^{b}	12.69	46.39 ± 5.82^{b}	12.55
Grain weight								
Ciherang	2.82 ± 2.84^{b}	13.78	2.78 ± 2.84^{a}	14	2.67 ± 2.46^{b}	12.59	2.69 ± 2.84^{a}	14.48
Situ Bagendit	2.74 ± 2.52^{b}	12.61	2.82 ± 2.59^{a}	12.6	2.86 ± 2.59^{c}	12.39	2.68 ± 2.59^{a}	13.24
Kabir 07	2.83 ± 3.06^{c}	14.8	2.74 ± 3.06^{a}	15.3	2.58 ± 3.06^{a}	16.25	2.67 ± 2.89^{a}	14.83
Malaysian Upland	2.63 ± 3.35^{a}	17.46	2.93 ± 3.24^{b}	15.21	2.83 ± 3.24^{c}	15.7	2.74 ± 3.24^{a}	16.22

Note: the numbers followed by the same letter notation in the same column and row are not significantly different on the 5% LSD test

Plant height

Plant height during the growth observation period (up to 45 days after planting) was significantly affected by a combination of shading and varieties (SV). In contrast, doses of organic fertilizer did not significantly affect plant height (Table 1, Table 2). Different varieties also exhibited similar growth patterns. The plant's capability strongly regulates the plant growth rate to adapt to the shaded conditions. Ciherang varieties were affected by shade, where growth in height was lower in shaded conditions than without shade. Situ Bagendit varieties are in line with the results of the study, showing adaptation to shaded conditions, this is evidenced by higher plant height growth in shaded conditions (30 and 60%) compared to no shade. While the varieties of Kabir 07 and Malaysian Upland showed good adaptation in 30% shade, while at 60% shade, they tended to inhibit plant height growth, even lower than without shade.

Tiller numbers

The low light intensity did not significantly affect productive tiller numbers compared to unshaded conditions. Results showed that tiller numbers at 0% shading level are higher compared to 30% and 60% shading level (Table 2). It means that the optimal intensity is needed for optimal tiller growth. The result is in line with (Aumunde et al. 2013), who reported that tiller numbers increased with light intensity. However, a conflicted result is reported by Khairunnisa et al. (2019). Our result aligns with the source-sink concept, where photosynthesis products will be distributed to all organs and each variety equipped with equal capacity. Thus, if the plant has a high tiller number, then the plant height wouldn't be optimum, and vice versa. Upland rice varieties that showed the best adaptive response to organic fertilization are Ciherang and Malaysian upland rice varieties (Table 2).

The interaction effect observed in this study revealed that varieties and organic fertilizer dosages (VxD) significantly affected tiller growth at 30 to 45 DAP. Malaysian upland rice variety at 0 t ha^{-1} organic fertilizer and Situ Bagendit variety at 24 t ha^{-1} organic fertilizer dosage (V4D1) and (V2D4) exhibited the most prominent growth. In contrast, Kabir 07 varieties showed the lowest tiller growth at 45 DAP (Table 2).

Chlorophyll content

Shading treatments affected the chlorophyll content of each variety observed, which was displayed by the difference in the chlorophyll content. The difference is assumed to be caused by genetic variability, particularly the adaptability to light stress. Situ Bagendit displayed the highest chlorophyll contents at shading level of 30% (111.11 granule/mm^2) and 60% (144.4 granule/mm^2). While Kabir 07 displayed the lowest chlorophyll contents (98.8 granule/mm^2). It is widely accepted that the greener the leaves, the higher the chlorophyll contents are. The increase of the green intensity in low light depicted the accumulation of chlorophyll on leaf surfaces (Muharia et al. 2006). Shaded conditions resulting in adaptable varieties increased the contents of its chlorophyll a, b, and total chlorophyll).

Flowering time, panicle numbers, panicle length, the weight of pithy grain, dry hay weight

The flowering time of upland rice varieties under shaded and unshaded conditions showed insignificant differences in all studied varieties (Figure 2). Panicle number is influenced by a single factor of shading (main plot), varieties (sub-plot), and interactions between varieties and organic fertilizer dosages given (Tables 4 and 5). A shading level of 60% produced the lowest panicle numbers (37.91/plant), followed by 30% shading and 0% shading. Interactions between varieties and organic fertilizer dosages, which produce the highest panicle number is the Ciherang variety (48.72 per plant) at 50 g/plant organic fertilizer. In contrast, the lowest panicle number is Kabir 07 (40.11 per plant) at 24 t ha^{-1} organic fertilizer. Panicle length is significantly affected by shading and the combination of shading and varieties (Figure 4). 30% shading intensity resulted in the longest panicles (22.6 cm), followed by 0% shading (21.5 cm). The shortest panicle length was reported at 60% shading (20.7 cm). Furthermore, the interaction effect between shading and varieties resulted in optimum panicle length was reported at 30% shading treatments of Situ Bagendit variety and 30% shading treatments and Kabir 07 variety (23.7 cm). While 60% shading treatment of Kabir 07 resulted in the shortest panicle length (18.7 cm). Figure2 depicts the adaptability of Situ Bagendit variety to moderate shading intensity, while the Malaysian upland rice variety is more adaptive to high shading intensity.

Table 5. Means, standard deviation and coefficient variation of panicle numbers, grain weight, and dry hay weight of samples observed

	Observation parameters			
	Average	±	SD	CV
Varieties			Panicle numbers	
Ciherang	46.51	±	5.97^{c}	12.83
Situ Bagendit	45.26	±	5.68^{bc}	12.54
Kabir 07	41.08	±	5.92^{a}	14.41
Malaysian Upland	44.31	±	5.09^{b}	11.5
Shade (%)			Panicle numbers	
0	48.03	±	2.67^{b}	5.55
30	48.03	±	2.77^{b}	5.77
60	37.91	±	2.75^{a}	7.24
			Grain weight	
0	21.48	±	0.70^{b}	3.27
30	21.97	±	0.94^{b}	4.26
60	16.77	±	0.77^{a}	4.57
			Hay weight	
0	122.82	±	14.66^{b}	11.94
30	117.74	±	6.11^{b}	5.19
60	90.58	±	6.83^{a}	7.54

Note: the numbers followed by the same letter notation in the same column are not significantly different on the 5% LSD test

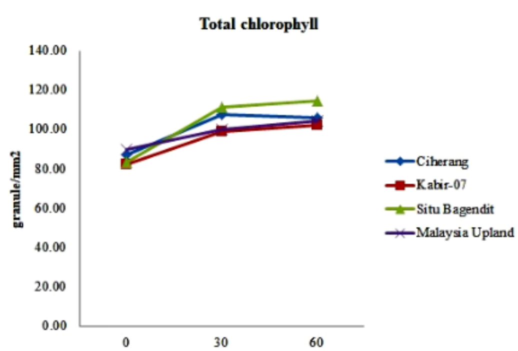

Figure 1. Total chlorophyll due to shading treatments in upland rice varieties

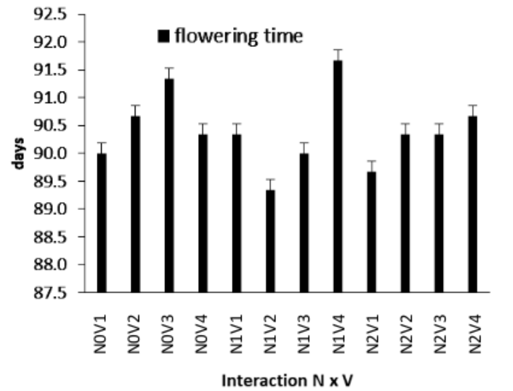

Figure 2. Flowering time of various upland varieties at different shading treatment

Discussion

Plant height

Plant height under shaded conditions indicated plant growth is strongly influenced by light availability. The etiolation process which occurs during stem elongation is suspected as a way for the immature plant to capture light more efficiently. Similar results were also found by Alridiwirsah et al. (2018) in their research, where they reported that the most adaptive rice plant height growth was found in 20% shade conditions, meaning that the shade conditions we tested supported this finding. According to Rizwan et al. (2020), increasing plant height is an effort to increase light absorption because plants cannot lift leaves above the canopy. Therefore, the plant growth rate has been strongly regulated by the plant's ability to adapt to the shaded conditions. This is in line with the report from Soepandi et al. (2003), which stated that the tolerant genotype responds to low light intensity by increasing the length of the stem nodes, which then results in stem length increment. Yang et al. (2019) also stated that plant height increment is one of its adaptation mechanisms to low light conditions. This mechanism imposed that shading treatment could induce cell expansion and rapid cell division, thus resulting in higher plant height.

Tiller number

It is stated that high tiller numbers under shaded conditions would lower the total productivity due to competition of light; hence, the tiller in the inner side of the clump will act as a parasite (Sulistyono et al. 2002). In addition, Sasmita et al. (2008) explained that the tolerant genotype showed a lower drop in tiller numbers than intolerant genotypes. Tiller numbers growth reported in this study was significantly influenced by organic fertilizer dosage and varieties interactions. Malaysian upland rice varieties produced the highest tiller numbers even without organic fertilizer treatment, followed by Ciherang varieties at 16 t ha^{-1}. The effect of the single factors on the tiller number parameter is also found in subplot (varieties) and sub-sub plot (organic fertilizer dosages). At all observation times, the optimum dosages were 24 t ha^{-1}.

The stress in environmental factors such as light intensity and organic fertilizer keeps the growth to normal conditions, particularly on adaptive varieties such as Malaysian upland rice. However, Krismawati et al. (2011) stated that tiller numbers and adaptability of each variety are different. The variety adapted to certain environmental conditions based on the genotypes to gain the optimum growth capability.

Observation of interaction effects indicates that the difference in plant height due to environmental and genetic factors contributed significantly to plant growth. Moreover, it is assumed that each variety has its mechanisms for absorbing and distributing plant nutrients which are assumed to be regulated by genes.

Variety responses to fertilizer, particularly organic fertilizer, mirror plant adaptability to nutrient input from the environment. Fertilizing using organic fertilizer deemed to be better due to its ability to continue providing nutrients according to plant needs (Rizwan et al. 2021; Tuhuteru et al. 2021). Furthermore, raw material sources such as rice straws are abundant.

Chlorophyll contents, flowering time, panicle numbers, panicle length, weight of pithy grain, hay dry weight

The genetic composition of each variety of traits is unique attributes to its quantitative or qualitative traits. For example, it is known that upland rice has higher growth rates at shaded conditions (30% and 60%) compared to without shading (0%) at 15-45 DAP, albeit statistically insignificant. The tendency of shading treatments leads to plant growth increase due to shading treatment affecting the plant's physiological process, which leads to stem etiolation or cell elongation for the plant to get sunlight for its growth. Moreover, plant response to shading largely depends on its adaptability, especially due to the plant's need to obtain sunlight through heightened auxin production and distribution, resulting in cell elongation (Khairunnisa et al. 2019).

Study results showed that the higher the level of shading treatments are, the higher plant height increment, whole leaves chlorophyll, and tiller numbers of the observed varieties. On the contrary, panicles numbers, panicle length, pithy grain numbers and dry hay weight were reduced. The observed growth stress of the three parameters is probably due to lower photosynthesis net production due to shading treatments (30% and 60%). Lower light intensity caused disturbances in plant metabolisms which implicated lower photosynthesis rates and carbohydrate synthesis for the plant growth. Slow growth response due to shading treatments was reported differently in each variety observed. Adaptive variety in this study is Situ Bagendit due to its ability to maintain tiller numbers, high chlorophyll number, panicle length and number, pithy grain number, and high dry hay number. This phenomenon was strictly stated previously by Zhu et al. (2008) and Liu et al. (2014) that low light intensity greatly influenced agronomy and physiology traits of the paddy plants, slowing physiologic metabolism, including photosynthesis hence contributing to carbon and nitrogen distribution. Moreover, Hairmansis et al. (2017), in which

55% shading level caused an increase in plant height, reduced productive tiller number, increased pith grain sterility, and reduced total grain production.

Study results showed that the highest growth response on each variety tested tends to increase with the increase of organic matter on plants. For example, the highest response showed by Kabir 07 at observation times of 30 and 45 DAP. It is known that organic matters improve the quality and quantity of plant growth, including plant biochemical conditions, through the improvement of the physical, chemical, and biology of the soil as the plant growth medium. This is in line with the finding of Schulz and Glaser (2012), which stated that organic fertilizer could improve soil fertility due to its ability to repair soil structure, increase soil permeability, increase the land's capability to provide water to the plant, increase cation exchange capacity, providing nutrients such as N, P, K, Ca, Mg, S as well as micronutrients. An increase in cation exchange capacity will simplify nutrient provision and absorption of the plant for its growth.

Shading treatments did not significantly affect the plant height of all studied rice varieties. In contrast, organic fertilizer dosage treatment showed a significant effect. Shading treatments influenced chlorophyll number in each variety observed. Situ Bagendit variety produced the highest total chlorophyll at 30% and 60% shading level. While Kabir 07 variety showed the lowest response to total chlorophyll number at shaded conditions. Tiller numbers were insignificantly affected by shading treatments instead of organic fertilizer dosage, and Malaysian upland rice varieties showed the highest tiller numbers compared to other observed varieties.

Furthermore, flowering time is not affected by shading treatments. At the same time, the panicle number was affected by the single factors, i.e., shading level, varieties, and interactions between varieties and organic fertilizer dosages given. A shading level of 60% resulted in the lowest panicle number compared to other treatments of all varieties observed. In conclusion, rice cultivation under shaded conditions is plausible, particularly in a country such as Indonesia with vast plantation areas and other tropical regions. However, caution must be taken to use appropriate rice varieties and optimum organic fertilization techniques.

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