DOI :https://doi.org/10.36378/juatika.v5i1.2838
JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL.5 NO. 1 January 2023
eissn 2656-1727
pissn 2684-785X
Hal : 145 – 160

Tolerance of Upland Rice Genotypes from Deli Serdang North Sumatra to Drought Stress Condition

Noverina Chaniago*, Rahmad Setia Budi, Nurhayati, Indra Gunawan
Department of Agrotechnology, Faculty of Agriculture,
Universitas Islam Sumatera Utara, Jl. Sisingamangaraja
191, Medan 20217, North Sumatra, Indonesia
*email: noverinachaniago40515@gmail.com

ABSTRACT

Usually, drought is the main problem faced in upland rice cultivation in the dry land. Therefore, drought-tolerant rice varieties are needed, but until now, it is very rare. It is crucial to produce drought-tolerant rice because Indonesia has a relatively sizeable dry land of 148 million ha. This study aimed to obtain a genotype of drought-tolerant upland rice with high productivity that can be developed in dry ground. This research was then continued with drought tolerance testing by distributing water below field capacity in a greenhouse. This study was in a factorial form using a Split Plot Design, with the main plot of drought stress treatment consisting of three levels: water availability, one-third field capacity water, two-thirds field capacity water, and three-third field capacity water. The sub-plots were four genotypes of upland rice from Deli Serdang North Sumatra consisting of Sialus, Arias, Silayur, and Sirabut, and one drought-tolerant variety for comparison is Inpago11. The observed variables included plant height, chlorophyll content, number of tillers, number of productive tillers, age of flowering, harvest period, grain weight per clump, and weight of 100 grains. The heaviest drought stress one-third field capacity water caused a significant decrease in plant height, number of tillers per clump, number of productive tillers, and grain weight per clump, extending the flowering and harvesting ages. Based on the tolerance index criteria, it was found that the Silayur genotype was more tolerant to drought stress than the other upland rice genotypes.

Keywords: *Deli Serdang, drought stress, field capacity water, tolerant, upland rice*

1. INTRODUCTION

Upland rice farming is one of the essential supports for national food security. However, upland rice farming contribution is still meager to national rice production. It was considering that Indonesia has a relatively large dry land where about 148 million ha (78%) of the approximate total land area of 188.20 million ha, and dry land that can be used for agriculture reaches approximately 76.22 million ha (52%) (Alavan et al., 2015). In fact, the development of upland rice cultivation in dry land is still very low. The contribution of dry land to national rice production is only around 10-12% (Saleh et al., 2015).

Based on the BPS-Deli Serdang (2020), there is a significant difference between the harvested area of upland rice and lowland rice production. The harvested area of field rice is only around 691 Ha, while for lowland rice, it is 86,014.80 Ha. Upland rice production is ± 3,331.31 tons, while lowland rice production is ± 501,208.24 tons. The main factor causing the low harvested area and rice production in dryland is that rice plants require plenty of water. Still, groundwater availability is very limited in drylands, especially during the dry season, so plants often experience drought stress (Hairmansis et al., 2015).

Drought stress can occur in plants due to a lack of water supply in the root area due to the evapotranspiration rate that exceeds the plant roots' water absorption rateBray, 2007; Nio & Torey, 2013). This drought seriously impacts the quantity and quality of plant growth, especially in the generative phase, reducing rice grain quantity and quality produced (Guo et al., 2013; Sujinah & Jamil, 2016).

Plants can meet water requirements by root absorption. Usually, the water absorbed by plant roots depends on the soil moisture content that can be held by soil particles and the roots' ability to absorb it. The soil's ability to hold water is considered equivalent to the water content capacity of the field. In general, the water content capacity of the area is defined as the soil water content in the field when the drainage water has stopped or almost stopped flowing due to the gravitational force after the soil was completely saturated (Gardner et al., 1991; Jury et al., 1991).

Drought is one of the main obstacles that must be faced to support the sustainability of agricultural production, especially upland rice. The adverse effects of drought stress due to prolonged drought need to be anticipated. Drought stress with a 70% moisture content and 60% field capacity reduced plant height (20-21%) and the number of tillers (54-60%) of upland rice of the Jambu cultivar. The tillers that appeared did not release the panicles, so the weight of the grain/clump was not obtained (Supriyanto, 2013). This opinion aligns with Akram et al. (2013) research, which stated that drought could cause the rate of photosynthesis to decrease significantly in the panicle initiation phase, where the photosynthesis volume reduces by 30.69% and in the anthesis phase by 28%.

Therefore, appropriate strategies for rice cultivation techniques and adaptive varieties to dry land environmental conditions were required. It can be done by utilizing seeds from local rice, especially upland rice with high yield potential and drought resistance(Hairmansis et al., 2015;

Husnain et al., 2016).

Deli Serdang is one of the North Sumatra districts with a fairly high diversity of upland rice and can adapt to drought conditions. This condition showed upland rice grows in diverse habitats with varying topography, land slope (contour), and climate. The results of previous research on Deli Serdang local rice with drought stress treatment induced through Polyethylene Glycol (PEG) found five genotypes of local upland rice tolerant to drought according to the tolerance index. The genotypes were Ramos Merah, Arias, Sialus, Silayur, and Sirabut. These five local rice genotypes will be used for further experiments searching drought-resistant rice genotypes (Chaniago et al., 2021). Therefore, it is essential to test the ability of upland rice genotypes in Deli Serdang, which has high yield potential and is tolerant to drought stress, by testing the growth and productivity of upland rice with water treatment below field capacity.

This study aimed to obtain upland rice genotypes that are resistant to drought stress and have high productivity, and have the potential to be developed in drylands, especially in Deli Serdang, North Sumatra.

2. MATERIALS AND METHODS

This research was carried out in the greenhouse of the Faculty of Agriculture, Islamic University of North Sumatra, Medan. The duration of the study is from July to December 2021, with an altitude of 25 m above sea level (asl). The average intensity of sunlight during the study was ± 43500 lux, air temperature 30° C and 29% RH.

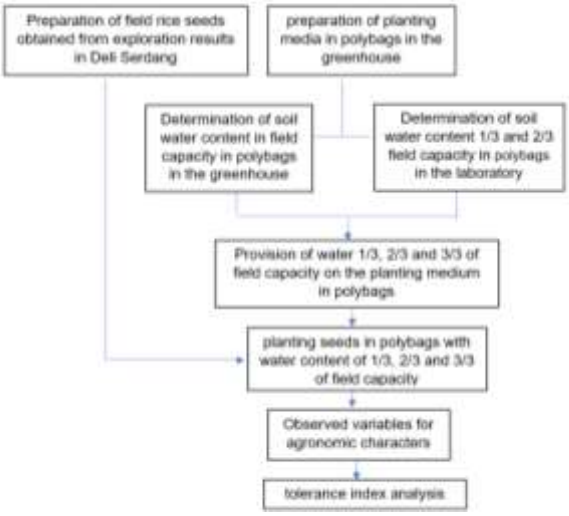

Figure 1. The research flowchart

The materials used include four genotypes of upland rice. These genotypes were obtained from exploration results in Deli Serdang, North Sumatra. Other materials are one variety of drought-tolerant rice as a comparison, topsoil soil, black polybag measuring 50 x 40 cm, Urea fertilizer, SP36, KCl, insecticide Decis 50 EC, fungicide Antracol 70 WP.

The tools used include digital scales, soil sieve, weighing cup, oven, measuring cup, soil moisture sensor measuring instrument, lux meter LX 1330B, hygrothermometer, meter, and SPAD 502 chlorophyll meter.

This study is a factorial experiment arranged using a Split Plot Design (SPD) model and repeated three times. The main plots are drought stress consisting of $\frac{1}{3}$ field capacity water (K_1), $\frac{2}{3}$ field capacity water (K_2), and $\frac{3}{3}$ field capacity water (K_3). The subplots are four genotypes of upland rice in the Deli Serdang consisting of Sialus (G_1), Arias (G_2), Silayur (G_3), Sirabut (G_4), and Inpago 11 (G_5) drought-tolerant rice varieties for comparison.

Soil water content can be determined indirectly by measuring other properties closely related to groundwater and can be resolved directly, using the gravimetric method, by measuring differences in soil weight carried out in the laboratory. Its application takes a lot of time and effort to get one value of soil moisture content, but it has very high accuracy (Hermawan, 2004).

Soil moisture content is expressed as a ratio between the mass/weight of water in the sample after drying until it reaches a constant mass/weight at a temperature of 105˚C (Abdurachman et al., 2006).

According to Saputra et al. (2015), determining the water content of the field capacity is carried out by weighing 10 kg of soil from the land that has been selected homogeneously and the soil has been previously air-dried. The soil is put into a black polybag measuring 50 x 40 cm and then watered slowly until the first drops of water come out. The volume of water sprinkled on the ground until the first drop of water comes out is field capacity water **(FCW)**. In this experiment, the FCW volume was 3,4 liters.

Then proceed by determining the soil water content in the laboratory using the gravimetric method (Saputra et al., 2015; Siregar et al., 2013) by taking 10 g of soil samples from polybags that were doused with 3.4 liters of water and were left for 24 hours, then placed in a weighing dish. The soil was dried in an oven at a 105˚C temperature for 24 hours. This activity was repeated three times. The average yield of soil weight after it was dried in the oven was 6.46 g. The formula determines soil water content:

$$\textbf{SWC}\ (\%) = \frac{\mathbf{A-B}}{\mathbf{A}}\ \mathbf{x\ 100}\%$$

SWC = percentage of soil moisture content), A= Weight of the initial soil sample before being baked (g), the B=weight of the final soil sample after being baked (g). Thus the percentage SWC = $\frac{10-6,46}{10}$ x 100% = 35,4%.

Application of giving water to the treatment $\frac{1}{3}$FCW, $\frac{2}{3}$FCW is made by weighing 10 kg of dried soil (Abdurachman et al., 2006), putting the soil into polybags, and then being given water stress according to the prescribed treatment. Which are $\frac{1}{3}$ FCW and $\frac{2}{3}$ FCW, with the calculation formula according to Saputra et al. (2015):

$\frac{1}{3}$FCW = $\frac{1}{3}$ x [(FCW - (FCW x SWC)]

= $\frac{1}{3}$ x [3,4 liters – (3,4 liters x 35,4%)]

= 0,732 liters = 732 ml

$\frac{2}{3}$FCW = $\frac{2}{3}$ x (FCW- (FCW x SCW)]

= $\frac{2}{3}$ X [3,4 liters – (3,4 liters x 35,4%)]

= 1,464 liters = 1464 ml

$\frac{3}{3}$FCW = $\frac{3}{3}$ x (FCW- (FCW x SCW)]

= $\frac{3}{3}$ X [3,4 liters – (3,4 liters x 35,4%)]

= 2,196 liters = 2196 ml.

To simplify adjusting the water level $\frac{1}{3}$FCW (K_1), $\frac{2}{3}$FCW (K_2), and $\frac{3}{3}$FCW (K_3). To remain constant during the experiment, a soil moisture sensor is needed, a device that can measure soil moisture with a measuring probe rod length of 8 inches, which is plugged into the soil in a polybag as deep as 15-20 cm. The results of measuring soil moisture at the water content $\frac{1}{3}$FCW obtained a scale of 3 for water content treatment $\frac{2}{3}$FCW scale 5 and $\frac{3}{3}$FCW scale water content 8 (Figure 1).

Figure 2. Sensors for measuring soil moisture

Therefore, for polybag moisture content to remain constant according to treatment, the planting media in polybags must be measured again with a soil moisture sensor every morning. Suppose there is a change or decrease in the scale number on the moisture sensor where the soil moisture rate is no longer following what was set at the beginning according to the treatment. This process is due to the reduced soil water content in polybags because plants are used for the growth and development process or due to the evapotranspiration process. In that case, water can be added back into the planting medium slowly so that the scale on the moisture sensor returns to the initial determination according to the treatment.

Observed variables for agronomic characters included plant height (cm) and chlorophyll content reading using SPAD 502 with Chlorophyll Content Index (CCI) units. The number of tillers and productive tillers (stems), flowering age (days after planting), and harvest age (days after planting). After planting), the weight of grain per clump (g) and weight of 100 grains of grain (g).

The tolerance index (TI) was obtained using the following equation:

$$\textbf{Tolerance index} = \frac{Yd}{Yn} \times \frac{Yd}{Hyd}$$

Yd and Yn represent observed variables under drought and normal conditions. Hyd is the highest observed variable under drought conditions. TI > 0.5 = tolerant and TI < 0.5 = susceptible (Iriany et al., 2005). The data obtained were then analyzed for variance at the 5% level, and if the calculated F was more significant than the F table, then continued with DNMRT at the 5% level.

3. RESULTS AND DISCUSSION

The results of the variance of drought stress and upland rice genotype significantly affected all observed variables, plant height (PH), chlorophyll content (CC), number of tillers (NT), number of productive tillers (NP), flowering age (FA), harvest age (HA), grain weight per clump (WC) and weight of 100 grains of grain (WG). The interaction of the two treatments significantly affected all observed variables except for chlorophyll and the weight of 100 grains of grain (Table 1).

Table 1. Results of the variance of drought stress treatment and rice genotype in Deli Serdang on Plant Height (PH) chlorophyll content (CC), number of tillers (NT), number of productive tillers (NP), flowering age (FA), harvest age (HA), grain weight per clump (WC) and weight of 100 grains (WG)

Source of Diversity	**PH**	**CC**	**NT**	**NP**	**FA**	**HA**	**WC**	**WG**
Block	3.87 tn	0.11tn	0.18 tn	0.09 tn	2.00 tn	0.44 tn	0.11tn	0.30 tn
Drought (K)	1404.59*	32.11*	17.19*	37.15*	2466.67*	72.06*	145.11*	46.03*
Genotype (G)	43.58*	4.30*	40.06*	234.87*	1288.65*	76.03*	135.37*	36.16*
K x G	3.42*	1.76tn	3.55*	6.21*	117.21*	5.73*	10.01*	1.56 tn

Description: * (significant impact); tn (not significant impact)

Water is the main component needed in every phase of rice plant growth, from germination to production. Although the needs are different for each step, none of the metabolic processes in each stage can be passed without water. Fulfilling water requirements for plants is obtained through the absorption of soil water by plant roots. Water that plant roots can absorb is called available water, which is the difference between the amount of water in the soil at field capacity and the amount of water in the soil, the percentage of permanent withering (Gardner et al., 1991; Jury et al., 1991). Drought limits the available water supply, which results in the disruption of metabolic processes in plant cells. It affects the physiological and morphological aspects, then continues on the growth rate and productivity. This is clearly seen in Table 1, where the drought stress treatment with water availability $\frac{1}{3}$ FCW, $\frac{2}{3}$ FCW and without drought stress($\frac{3}{3}$FCW) significant effect on all observed variables PH, CC, NT, NP, FA, HA, and WG.

Plant height

The results of Duncan's 5% average difference test (Table 2) against plant heights aged 16 weeks after planting, four genotypes of upland rice in Deli Serdang, and one drought-tolerant variety with drought stress treatment showed significant differences. Drought stress causes a decrease in plant height (Figure 2).

Based on the tolerance index for plant height, all upland rice genotypes were tolerant to drought stress conditions, as seen in Table 2.

Table 2. Average plant height (cm) of four genotypes of upland rice in Deli Serdang and one drought-tolerant variety aged 16 weeks after planting with drought stress treatment

Upland Rice Genotype (G)	Drought Stress (K)			Average (G)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	104.67 b	124.00 e	137.33 g	122.00 d	0.73	tolerant
Arias (G_2)	108.67 c	125.33 f	137.00 g	123.67 d	0.79	tolerant
Silayur (G_3)	103.00 b	121.67 e	127.33 f	117.33 c	0.77	tolerant
Sirabut (G_4)	102.33 b	114.00 d	127.33 f	114.55 b	0.76	tolerant
Inpago 11 (G_5)*	95.33 a	116.00 d	123.33 e	111.56 a	0.68	tolerant
Average K	102.80 a	120.20 b	130.40 c	CV= 1.95%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance. Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S)

Figure 3. Plant height due to drought stress $\frac{1}{3}$ FCW, $\frac{2}{3}$ FCW and without drought stress ($\frac{3}{3}$ FCW)

When viewed from the four genotypes of upland rice that received the heaviest stress ($\frac{1}{3}$ FCW), the highest plant was found in the Arias genotype (108.67 cm), which was significantly different from Sialus, Silayur, Sirabut, and the comparison variety Inpago 11, the lowest plant was found in the Inpago 11 variety (95.33 cm), can be seen in Figure 3.

Average plant height of the four genotypes of upland rice (Sialus, Arias, Silayur and Sirabut) and the Inpago 11 variety in drought stress conditions ($\frac{1}{3}$ and $\frac{2}{3}$ FCW) decreased plant height by 8-21%.

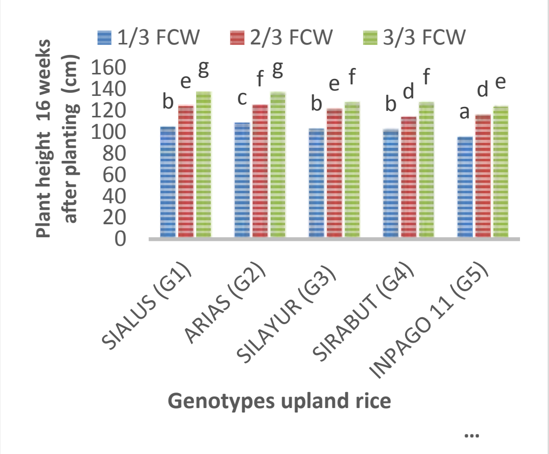

Figure 4. Histogram of plant height of four genotypes of upland rice and one variety drought-tolerant with $\frac{1}{3}$FCW, $\frac{2}{3}$ FCW and without drought stress ($\frac{3}{3}$ FCW) at 16 weeks after planting.

Drought stress studies significantly reduced 1-56 % of several rice cultivars' fresh and dry plant weights (Larkunthod et al., 2018). The decrease in fresh and dry weight is related to a reduction in plant height.

The water limitation in the growing media is a severe environmental constraint, affecting the physiology and biochemistry at the cellular level and throughout the plant organs, making it a complex phenomenon. It is known that plant growth occurs due to the activity of cell division, enlargement, and differentiation, where water is a significant factor in supporting the activity of these cells (Bray, 2007). Water scarcity results in a low rate of water absorption by plant roots.

In this experiment, these four genotypes of upland rice that experienced drought stress showed more extended plant heights when compared to the drought-tolerant Inpago 11 variety. Genetic and environmental factors determine the adaptability of a genotype or type. Upland rice genotypes generally have high adaptability to drought conditions. Besides that, they have a plant length character that exceeds the existing upland rice varieties (Suryanugraha et al., 2017). This is in line with a study by Chaniago et al. (2021), which stated, "drought stress during the vegetative growth phase in the greenhouse did not affect the plant height of 23 local upland rice genotypes from Deli Serdang. Almost all of the rice genotypes tested were drought tolerant, with Plant height ranging from 27-41 cm; when compared to the plant height of the Inpago 11 variety (24.83 cm), the local upland rice genotypes were still more tolerant to drought. The characteristics of 23 genotypes of local rice from Deli

Serdang on plant height showed that local rice cultivated in fields with low water availability generally had a longer plant height when compared to local rice cultivated in fields with sufficient water availability (Chaniago et al., 2022).

Leaf Chlorophyll Level with SPAD 502 Chlorophyll meter

The results of DMRT 5% on leaf chlorophyll content of four genotypes of upland rice and one drought-tolerant variety with drought stress treatment showed no significant differences. Still, drought stress causes a decrease in chlorophyll content. Based on the tolerance index for chlorophyll content, all upland rice genotypes were tolerant to drought stress conditions except for the Arias genotype (Table 3).

Table 3. The average leaf chlorophyll content (CCI) of four genotypes of upland rice in Deli Serdang and one drought-tolerant variety with drought stress treatment

Upland Rice Genotype (G)	Drought Stress (K)			Average (G)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	15.10	18.89	23.30	19.09 a	0.51	tolerant
Arias (G_2)	13.40	19.83	22.31	18.51 a	0.42	susceptible
Silayur (G_3)	17.51	18.27	24.95	20.24 ab	0.64	tolerant
Sirabut (G_4)	18.69	20.07	25.03	21.26 b	0.73	tolerant
Inpago 11 (G_5)*	19.06	21.73	23.42	21.40 b	0.81	tolerant
Average (K)	16.75 a	19.76 b	23.80 c	CV= 12.28%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance. Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S).

A decrease in leaf chlorophyll content of 29.62% in drought stress $\frac{1}{3}$ FCW and 16.97 % in the treatment $\frac{2}{3}$ FCW. This decrease in chlorophyll levels is closely related to the disruption of plant metabolic processes in cells. Morphological changes in rice plants that experience drought stress begin with plant responses to physiological processes reducing the transpiration rate to save water by closing stomata. Then morphological changes occur as indicated by reducing leaf surface area by leaf rolling (Anggraini et al., 2016).

This symptom indicates that the leaves cannot perform normal metabolic activities due to the limited roots absorbing water and dissolved mineral nutrients, inhibiting chlorophyll formation (Banyo et al., 2013). Several rice varieties that experienced drought stress reduced chlorophyll a's content by 19.35% and chlorophyll a/w by 34.35% (Maisura et al., 2014). In line with the study of seven traditional rice varieties of Assam, India, physiological drought conditions through simulation at three levels of osmotic stress 0.15 bar, 0.25 bar, and 0.56 can reduce the chlorophyll content in leaves compared to controls (Chutia & Borah, 2012). According to Farooq et al. (2009), drought in several plant species can cause changes in the ratio of chlorophyll a/b and carotenoid content. The content of chlorophyll a/b, which experienced drought stress was lower than without drought stress. Osmotic pressure induces oxidative stress caused by the activity of ROS (Reactive Oxygen Species). ROS are very dangerous free radicals. Increased ROS causes oxidative damage to lipids, proteins, and DNA (Sharma et al., 2012). This causes a decrease in chlorophyll in the leaves.

Number of tillers and productive tillers

The results of DMRT 5%, four upland rice genotypes, and one drought-tolerant variety with drought stress treatment were significantly different from the number of tillers (NT) shown in Table 4, and productive tillers (NP) can be seen in Table 5.

The number of tillers based on the tolerance index was only Sialus and Silayur genotypes tolerant to drought stress (Table 4). Of the number of productive tillers, only Silayur is tolerant to drought stress; and the others are susceptible (Table 5).

Table 4. The average number of tillers per clump (stem) of four genotypes of Deli Serdang upland rice and one drought-tolerant variety under drought stress treatment

Upland Rice Genotype (G)	Drought Stress (K)			Average (G)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	7.00 a	7.67 ab	7.83 ab	7.50 a	0.58	tolerant
Arias (G_2)	5.17 a	8.50 b	7.50 a	7.06 a	0.33	susceptible
Silayur (G_3)	10.83 bc	12.67 c	16.17 d	13.22 b	0.67	tolerant
Sirabut (G_4)	8.17 b	14.17 c	15.33 cd	12.56 b	0.40	susceptible
Inpago 11 (G_5)*	6.00 a	9.67 b	8.83 b	8.17 a	0.38	susceptible
Average (K)	7.43 a	10.53 b	11.13 b	CV=14.40%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance. Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S)

Table 5. The average number of productive tillers per clump (stem) of four genotypes of Deli Serdang upland rice and one drought-tolerant variety with drought stress treatment

Upland Rice Genotype (G)	Drought Stress (K)			Average (G)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	2.33 a	4.50 b	6.33 c	4.39 a	0.08	susceptible
Arias (G_2)	2.17 a	4.50 b	5.33 b	4.00 a	0.09	susceptible
Silayur (G_3)	10.30 e	11.33 ef	15.17 g	12.28 d	0.68	tolerant
Sirabut (G_4)	6.67 c	12.33 f	12.83 f	10.61 c	0.34	susceptible
Inpago 11 (G_5)*	5.00 b	8.00 d	8.50 d	7.17 b	0.29	susceptible
Average (K)	5.30 a	8.13 b	9.63 c	CV= 9.39%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance. Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S)

Drought stress $\frac{1}{3}$ FCW can reduce NT by 33.24% and NP by 44.94% (Tables 4 and 5). This study is in line with the research results (Sulistyono et al., 2012), which reported that the decrease in rice yield due to drought stress of five lowland rice lines varied between 32.4 - 48.87%. Reduced water supply around plant roots, resulting in decreased water content and leaf potential, causes low turgor pressure and stomatal closure, thereby inhibiting photosynthesis (Amini et al., 2020). The inhibition of the photosynthesis process will decrease assimilated compounds, ultimately affecting the formation of the number of productive tillers or tillers that produce filled panicles. This is to the statement of Audebert et al. (2002), the character of rice plants due to drought stress is indicated by the reduced number of tillers (NT) and the number of productive tillers (NP). The decrease in NT and NP due to drought stress begins with a reduction in the rate of transpiration followed by closing stomata due to loss of cell turgidity. Closing of stomata inhibits the exchange of gases such as CO_2 and O_2 between plants and the atmosphere (Liu et al., 2004; Sujinah & Jamil, 2016). This result inhibits the process of photosynthesis and results in a decrease in the assimilation of compounds. Of the four upland rice genotypes tested, the Silayur genotype had a higher tolerance to drought stress. This is shown by the decrease in NT and NP, which is lower than the other genotypes. Tables 4 and 5 show that the Silayur genotype was in the highest drought stress condition, producing the highest NT and NP, namely 10.83 and 10.30 stems.

Flowering Age and Harvest Age

Interactions between genotypes of upland rice treated with drought stress gave significantly different responses to flowering age (FA) and harvesting age (HA). Based on the criteria of the tolerant index, all genotypes of upland rice were tolerant to drought stress conditions, as seen in Tables 7 and 8.

The upland rice Silayur genotype that received the heaviest stress was ($\frac{1}{3}$ FCW), showing an earlier flowering response of 119 days after planting (Table 7) and a shorter harvest time of 157.67 days after planting (Table 8). Followed by Sirabut, namely FA 120.33 days after planting and HA 166 days after planting. However, the two genotypes are still older compared to the control variety Inpago 11.

Table 7. The average flowering age (days after planting) of four genotypes of Deli Serdang field rice and one drought-tolerant variety with drought stress treatment

Upland Rice Genotype (G)	Drought Stress (K)			Average (G)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	123.00 f	119.00 d	116.67 cd	119.56 d	0.93	tolerant
Arias (G_2)	126.33 e	121.67 e	119.00 d	122.33 e	0.94	tolerant
Silayur (G_3)	119.00 d	103.67 b	102.33 b	108.33 b	0.74	tolerant
Sirabut (G_4)	120.33 d	114.67 c	103.33 b	112.78 c	0.75	tolerant
Inpago 11 (G_5)*	114.33 c	104.00 b	91.67 a	103.33 a	0.62	tolerant
Average (K)	120.60 c	112.60 b	106.60 a	CV= 6.15%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance. Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S).

Table 8. Average harvesting age (days after planting) of four genotypes of Deli Serdang upland rice and one drought-tolerant variety under drought stress treatment

Upland Rice Genotype (G)	Drought stress (K)			Average (K)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	164.33 e	157.67 d	158.00 d	160.00 c	0.92	tolerant
Arias (G_2)	172.33 f	170.00 f	165.67 e	169.33 d	0.96	tolerant
Silayur (G_3)	157.67 d	157.33 d	140.33 b	151.78 b	0.75	tolerant
Sirabut (G_4)	166.00 e	155.33 cd	152.33 c	157.89 c	0.84	tolerant
Inpago 11 (G_5)*	154.33 c	143.67 bc	130.33 a	142.78 a	0,66	tolerant
Average (K)	162.93 c	156.80 b	149.33 a	CV= 5.20%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance. Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S)

The study results on four tested field rice genotypes showed that drought stress $\frac{1}{3}$ FCW or $\frac{2}{3}$ FCW could extend the flowering period from 6-14 days after planting and harvest time from 8-14 days after planting compared to stress-free plants ($\frac{3}{3}$ FCW). Drought causes photosynthesis to decrease significantly in the panicle initiation phase, where the photosynthetic volume reduces by 30.69% and in the anthesis phase by 28% (Akram et al., 2013). The impact is caused by changes in nature, where the age of the plant is longer, and there is a delay in flowering, which affects the period of the more extended harvest (Audebert et al., 2002; Blum, 2002).

Experts put forward many limitations regarding the mechanism of plant resistance to drought. (Nio & Torey, 2013), stating the response of plants to drought can be done by several mechanisms, they are: (1) drought escape, namely the ability of plants to be able to regulate growth plasticity or complete their life cycle before experiencing drought, (2) dehydration avoidance, namely the ability of plants to maintain high water potential, in line with increasing drought stress, so rolling leaves maintain that cell turgidity to reduce water loss, and (3) drought tolerance, namely the ability of plants to adjust cell osmotic so that in conditions of low cell water potential caused by drought, turgidity remains high (Man et al., 2011) This process begins with changes in osmotic sugars, especially in xylose sugars (Toruan et al., 2016). Osmotic decrease in cells under drought stress and increase sugar accumulation in plant cells. Thus, the plantaintains its turgor so that physiological and biochemical processes are still running even in drought stress conditions (Mostajeran & Rahimi-Eichi, 2009). Cells induce the production and accumulation of amino acids, especially proline, in roots and shoots (Guo et al., 2012). Drought also inhibits protein synthesis and cell walls, but drought can stimulate increased synthesis and release of the hormone abscisic acid from leaf mesophyll cells (Larkunthod et al., 2018).

Grain Weight per Clump and 100 Grain Weight

The results of DMRT 5%, four genotypes of upland rice, and one drought-tolerant variety with drought stress treatment were significantly different on the grain weight per clump (WC), which can be seen in Table 9. The grain weight of 100 grains (WG) showed no significant differences, as seen in Table 10.

Based on the criteria of the tolerant index for average grain weight per clump, all upland rice genotypes were susceptible to drought stress conditions (Table 9). In contrast to the average grain weight of 100 grains, all upland rice genotypes were tolerant to drought stress conditions (Table 10).

Table 9. The Average grain weight per clump (g) of four genotypes of Deli Serdang field rice and one drought-tolerant variety under drought stress

Upland Rice Genotype (G)	Drought Stress (K)			Average (G)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	4.19 a	9.09 b	16.53 d	9.94 a	0.07	susceptible
Arias (G_2)	4.85 a	11.43 bc	18.53 d	11.60 a	0.08	susceptible
Silayur (G_3)	12.77 c	27.55 e	45.50 h	28.61 b	0.23	susceptible
Sirabut (G_4)	15.31 c	32.06 f	39.66 g	29.01 b	0.39	susceptible
Inpago 11 (G_5)*	14.88 c	31.35 f	37.61 g	27.95 b	0.38	susceptible
Average (K)	10.39 a	22.29 b	31.57 c	CV=11.73%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance.
Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S)

Table 10. The average grain weight of 100 grains (g) of four genotypes of Deli Serdang upland rice and one drought-tolerant variety under drought stress

Upland Rice Genotype (G)	Drought Stress (K)			Average (G)	Tolerance Index (TI)	Criteria
	$\frac{1}{3}$ FCW (K_1)	$\frac{2}{3}$ FCW (K_2)	$\frac{3}{3}$ FCW (K_3)			
Sialus (G_1)	1.95	2.32	2.69	2.32 b	0.58	tolerant
Arias (G_2)	1.84	1.94	2.04	1.94 a	0.69	tolerant
Silayur (G_3)	2.02	2.22	2.46	2.23 b	0.69	tolerant
Sirabut (G_4)	2.42	2.72	2.89	2.68 d	0.84	tolerant
Inpago 11 (G_5)*	2.35	2.50	2.70	2.52 c	0.85	tolerant
Average (K)	2.12 a	2.34 b	2.55 c	CV=19.11%		

Remarks: * (Control varieties: drought-tolerant). The mean values within the same column followed by similar small letters are not significantly different at 5% DMRT. CV = Coefficient of Variance.
Criteria of tolerant index: Ti > 0.5 = tolerant (T) and Ti < 0.5 = susceptible (S)

The greater the drought stress, the lower the grain weight produced per clump, whereas the water drought stress $\frac{1}{3}$ and $\frac{2}{3}$ FCW decreased dry grain weight per clump by 29.40% to 67.10% (Table 9). The weight of 100 grains was also reduced by 8.24 to 16.86%. This drought has a serious impact on the growth of rice plants, especially in the generative phase, which can reduce the quantity and quality of the rice grain produced. Sujinah & Jamil (2016) stated that in the productive phase, three steps are very susceptible to drought: panicle formation stage, pollination/fertilization, and seed filling. Lack of water at the flower formation stage reduces the number of grains per panicle. At the pollination/fertilization stage, insufficient water increases the amount of open grain. This process happens because the pollen becomes sterile, so fertilization does not occur. Drought stress at the panicle initiation reduced panicle dry weight and the number of grains per panicle. It decreased the weight of 1,000 seeds because the grain was not filled or the grain size was smaller than average, which ultimately reduced grain yield.

The impact of water supply shortages in the root area starts from a decrease in the transpiration rate in the leaves by closing the stomata. The closing of the stomata on the leaves is caused by the loss of plant cells' turgidity (Taiz & Zeiger, 2006) and loss of osmotic balance (Anjum et al., 2011; Bhardwaj & Yadav, 2012). Closing these stomata will interfere with plants' cellular and tissue function (Bray, 2007). Closure of stomata will also inhibit the exchange of CO_2 and O_2 from plant tissues with the atmosphere (Liu et al., 2004). As a result, there is a decrease in assimilated compounds, ultimately affecting the formation of increasingly narrow leaf areas. The narrowing of the leaf surface area can reduce the capture of solar radiation, thus reducing the photosynthesis volume. As a result, there is a reduction in assimilation production for panicle growth and grain filling (Akram et al., 2013).

4. CONCLUSION

The effect of drought stress on the growth and production of four upland rice genotypes from Deli Serdang, North Sumatra, showed various responses. The heaviest drought stress ($\frac{1}{3}$FCW) caused a significant decrease in plant height, number of tillers per clump, number of productive tillers, and grain weight per clump and extended the flowering and harvesting ages. Based on the tolerance index criteria, it was found that the Silayur genotype was more tolerant to drought stress than the other upland rice genotypes.

ACKNOWLEDGMENT

We thank the Faculty of Agriculture, Islamic University of North Sumatra, Deli Serdang District Agriculture Service, and farmers who have assisted in this research.

REFERENCE

Abdurachman, A., Haryati, U., & Juarsah, I. (2006). Penetaan Kadar Air Tanah Dengan Metode Gravimetrik. In *Sifat Fisik Tanah dan Metode Analisanya* (pp. 131–142). Balai Besar Litbang Sumberdaya Pertanian.

Akram, H. M., Ali, A., Sattar, A., Rehman, H. S. U., & Bibi, A. (2013). Impact of water deficit stress on various physiological and agronomic traits of three Basmati rice (Oryza sativa L.) cultivars. *Journal of Animal and Plant Sciences*, *23*(5), 1415–1423.

Alavan, A., Hayati, R., & Hayati, E. (2015). Pengaruh pemupukan terhadap pertumbuhan beberapa varietas padi gogo. *Jurnal Floratek*, *10*, 61–68.

Amini, S., Rohani, A., Aghkhani, M. H., Abbaspour-Fard, M. H., & Asgharipour, M. R. (2020). Assessment of land suitability and agricultural production sustainability using a combined approach (Fuzzy-AHP-GIS): A case study of Mazandaran province, Iran. *Information Processing in Agriculture*, *7*(3), 384–402. https://doi.org/10.1016/j.inpa.2019.10.001

Anggraini, N., Faridah, E., & Indrioko, S. (2016). Pengaruh Cekaman Kekeringan terhadap Perilaku Fisiologis dan Pertumbuhan Bibit Black Locust (Robinia pseudoacacia). *Jurnal Ilmu Kehutanan*, *9*(1), 40. https://doi.org/10.22146/jik.10183

Anjum, S. A., Xie, X., Wang, L., Saleem, M. F., Man, C., & Lei, W. (2011). Morphological, physiological and biochemical responses of plants to drought stress. *African Journal of Agricultural Research*, *6*(9), 2026–2023. https://doi.org/10.5897/AJAR10.027

Audebert, A., Asch, F., & Dingkuhn, M. (2002). Morpho-Physiological Research on Drought Tolerance in Rice at WARDA. In N. P. Saxena & J. C. O'Toole (Eds.), *Field Screening* *for Drought Tolerance in Corp Plants with Emphasis on Rice* (Vol. 1, Issue 1, pp. 59–60). International Crops Research Institute for the Semi-Arid Tropics, The Rockefeller Foundation. http://dx.doi.org/10.1016/j.cirp.2016.06.001%0Ahttp://dx.doi.org/10.1016/j.powtec.2016.12.055%0Ahttps://doi.org/10.1016/j.ijfatigue.2019.02.006%0Ahttps://doi.org/10.1016/j.matlet.2019.04.024%0Ahttps://doi.org/10.1016/j.matlet.2019.127252%0Ahttp://dx.doi.o

Banyo, Y. E., Nio, A. S., Siahaan, P., & Tangapo, A. M. (2013). Konsentrasi Klorofil Daun Padi Pada Saat Kekurangan Air Yang Diinduksi Dengan Polietilen Glikol. *Jurnal Ilmiah Sains*, *13*(1), 1. https://doi.org/10.35799/jis.13.1.2013.1615

Bhardwaj, J., & Yadav, S. K. (2012). Comparative Study on Biochemical Parameters and Antioxidant Enzymes in a Drought Tolerant and a Sensitive Variety of Horsegram (Macrotyloma uniflorum) under Drought Stress. *American Journal of Plant Physiology*, *7*(1), 17–29. https://doi.org/10.3923/ajpp.2012.17.29

Blum, A. (2002). Drought Resistance – is it a Complex Trait? In N. P. Saxena & J. C. O'Toole (Eds.), *Field Screening for Drought Tolerance in Corp Plants with Emphasis on Rice* (pp. 17–22). International Crops Research Institute for the Semi-Arid Tropics, The Rockefeller Foundation.

BPS-Deli Serdang. (2020). Pertanian. In BPS Deli Serdang (Ed.), *Kabupaten Deli Serdang Dalam Angka 2020* (Vol. 148, pp. 148–162). BPS-Statistics of Deli Serdang Regency.

Bray, E. A. (2007). Plant Response to Water-deficit Stress. *Encyclopedia of Life Sciences*, 1–7. https://doi.org/10.1002/9780470015902.a0001298.pub2

Chaniago, N., Suliansyah, I., Chaniago, I., & Nalwida, R. (2021). Identification Of Local Rice Genotypes From Deli Serdang, North Sumatera, Indonesia, To Drought Stress Condition. *Journal of Applied Agricultural Science and Technology*, *5*(1), 13–27.

Chaniago, N., Suliansyah, I., Chaniago, I., & Rozen, N. (2022). Morphological characteristics of local rice in Deli Serdang District, North Sumatra, Indonesia. *Biodiversitas*, *23*(2), 883–894. https://doi.org/10.13057/biodiv/d230229

Chutia, J., & Borah, S. P. (2012). Water Stress Effects on Leaf Growth and Chlorophyll Content but Not the Grain Yield in Traditional Rice (Oryza sativa Linn.) Genotypes of Assam, India II. Protein and Proline Status in Seedlings under PEG Induced Water Stress. *American Journal of Plant Sciences*, *03*(07), 971–980. https://doi.org/10.4236/ajps.2012.37115

Farooq, M., Wahid, A., Kobayashi, N., & S.M.A. Fujita, D. B. (2009). Plant drought stress : effects , mechanisms and management. *Agronomy for Sustainable Developmen*, *29*(1), 185–212. https://doi.org/10.1051/agro:2008021

Gardner, F., Pearce, R. B., & Mitchell, R. L. (1991). *Fisiologi Tanaman Budidaya* (2nd Editio). Scientific Publishers. website: www.scientificpub.com

Guo, R., Hao, W., & Gong, D. (2012). Effects of Water Stress on Germination and Growth of Linseed Seedlings (Linum usitatissimum L), Photosynthetic Efficiency and Accumulation of Metabolites. *Journal* *of Agricultural Science*, *4*(10), 253–265. https://doi.org/10.5539/jas.v4n10p253

Guo, R., Hao, W. P., Gong, D. Z., Zhong, X. L., & Gu, F. X. (2013). Effects of Water Stress on Germination and Growth of Wheat, Photosynthetic Efficiency and Accumulation of Metabolites. *Intechopen*, *Cell Interaction-Regulation of Immune Responses, Disease Development and Management Strategies*, 1–15. https://www.intechopen.com/books/advanced-biometric-technologies/liveness-detection-in-biometrics

Hairmansis, A., Supartopo, Yullianida, Sunaryo, Warsono, Sukirman, & Suwarno. (2015). Pemanfaatan plasma nutfah padi (Oryza sativa) untuk perbaikan sifat padi gogo. *PROS SEM NAS MASY BIODIV INDON*, *1*, 14–18. https://doi.org/10.13057/psnmbi/m010102

Hermawan, B. (2004). Penetapan Kadar Air Tanah Melalui Pengukuran Sifat Dielektrik Pada Berbagai Tingkat Kepadatan. *Jurnal Ilmu-Ilmu Pertanian Indonesia*, *6*(2), 66–74.

Husnain, Nursyamsi, D., & Syakir, M. (2016). Fertilizer Technology in Supporting Jarwo Super. *Sumberdaya Lahan*, *10*(1), 1–10.

Iriany, R. N. A., Takdir, M. M., Yasin, H. E., & Mejaya, M. J. (2005). Maize Genotype to drought stress. *Journal of Indonesian Cereals Research Institute*, 156–161.

Jury, W. A., Gardner, W. R., & Gardner, W. H. (1991). *Soil physics. 5th ed.* New York, N.Y. : John Wiley & Sons, 1991.

Larkunthod, P., Nounjan, N., Siangliw, J. L., Toojinda, T., Sanitchon, J., Jongdee, B., & Theerakulpisut, P. (2018). Physiological responses under drought stress of improved drought- Tolerant rice lines and their parents. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *46*(2), 679–687. https://doi.org/10.15835/nbha46211188

Liu, F., Jensen, C. R., & Andersen, M. N. (2004). Drought stress effect on carbohydrate concentration in soybean leaves and pods during early reproductive development: Its implication in altering pod set. *Field Crops Research*, *86*(1), 1–13. https://doi.org/10.1016/S0378-4290(03)00165-5

Maisura, Chozin, M. A., Lubis, I., Junaedi, A., & Ehara, H. (2014). Some Physiological Character Responses of Rice Under Drought Conditions In a Paddy System. *ISSAAS Journal*, *20*(1), 104–114.

Man, D., Bao, Y. X., Han, L. B., & Zhang, X. (2011). Drought Tolerance Associated With Proline and Hormone Metabolism In Two Tall Fescue Cultivars. *HortScience*, *46*(7), 1027–1032. https://doi.org/10.21273/hortsci.46.7.1027

Mostajeran, A., & Rahimi-Eichi, V. (2009). Effects of Drought Stress on Growth and Yield of Rice (Oryza sativa L.) Cultivars and Accumulation of Proline and Soluble Sugars in Sheath and Blades of Their Different Ages Leaves. *American-Eurasian J. Agric. Dan Environ. Sci*, *5*(2), 264–272. https://www.semanticscholar.org/paper/Effects-of-Drought-Stress-on-Growth-and-Yield-of-of-Mostajeran-Rahimi-Eichi/f7a4ab6e1f28e57145d32fa9319323032df8772c

Nio, S. A., & Torey, P. (2013a). Karakter morfologi akar sebagai indikator kekurangan air pada tanaman (Root morphological characters as water-deficit indicators in plants). *Jurnal Bios Logos*, *3*(1). https://doi.org/10.35799/jbl.3.1.2013.3466

Nio, S. A., & Torey, P. (2013b). Karakter morfologi akar sebagai indikator kekurangan air pada tanaman (Root morphological characters as water-deficit indicators in plants). *Jurnal Bios Logos*, *3*(1). https://doi.org/10.35799/jbl.3.1.2013.3466

Saleh, E., Irsan, C., Suwandi, & Herlinda, S. (2015). Pengembangan Teknologi untuk Pengelolaan Lahan Suboptimal yang Produktif, Inklusif dan Ekonomis. *Prosiding Rumusan Hasil Seminar Nasional Lahan Suboptimal*, 953–955.

Saputra, D., Timotiwu, P. B., & Ermawati. (2015). Pengaruh Cekaman Kekeringan Terhadap Pertumbuhan dan Produksi Benih Lima Varietas Kedelai. *Jurnal Agrotek Tropika*, *3*(1), 7–13.

Sharma, P., Jha, A. B., Dubey, R. S., & Pessarakli, M. (2012). Reactive Oxygen Species, Oxidative Damage, and Antioxidative Defense Mechanism in Plants under Stressful Conditions. *Journal of Botany*, *2012*, 1–26. https://doi.org/10.1155/2012/217037

Siregar, S. R., Zuraida, & Zuyasna. (2013). Pengaruh kadar air kapasitas lapang terhadap pertumbuhan bebrapa genotipe m3 kedelai. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699.

Sujinah, & Jamil, A. (2016). Mekanisme Respon Tanaman Padi terhadap Cekaman Kekeringan dan Varietas Toleran. *Iptek Tanaman Pangan*, *11*(1), 1–8.

Sulistyono, E., Suwarno, Lubis, I., & Suhendar, D. (2012). Pengaruh frekuensi irigasi terhadap pertumbuhan dan produksi lima galur padi sawah. *Agrovigor*, *5*(1), 1–8.

Supriyanto, B. (2013). Pengaruh Cekaman Kekeringan Terhadap Pertumbuhan dan Hasil Padi Gogo Lokal Kultivar Jambu (Orysa sativa Linn). *Jurnal AGRIFOR*, *XII*(1), 77–82.

Suryanugraha, W. A., Supriyanta, & Kristamtini. (2017). Keragaan Sepuluh Kultivar Padi Lokal (Oryza sativa L.) Daerah Istimewa Yogyakarta. *Vegetalika*, *6*(4), 55–70.

Taiz, L., & Zeiger, E. (2006). *Plant Physiology*. Sunderland, Mass. : Sinauer Associates, 2006.

Toruan Mathius, N., Liwang, T., Danuwikarsa, M. I., Suryatmana, G., H, D., Saodah, D., & Wenten Astika, I. G. P. (2016). Respons biokimia beberapa progeni kelapa sawit (Elaeis guineensis Jacq.) terhadap cekaman kekeringan pada kondisi lapang Biochemical responses of several oil palm (Elaeis guineensis Jacq.) progenies to drought stress in field condition. *E-Journal Menara Perkebunan*, *72*(2), 2271–2280. https://doi.org/10.22302/iribb.jur.mp.v72i2.121