



Tolerance of Some Rice Varieties to Drough Based on Drone-Vegetation Index

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Abstract

The utilization of phenotype technology in breeding is directed to see and select plants based on the appearance of the targeted phenotype. One is modern technology based on geographic information systems and remote sensing. The unmanned aerial drone (UAV) uses computing and machine learning in image processing and information extraction. This research focuses on developing tolerance screening of several varieties to drought based on the drone-vegetation index. This study used nine rice varieties in the rice fields of Kab. Bone-SulSel in the dry season. This research aims to identify the best selection character as a measure of tolerance of rice varieties to drought based on image and morphophysiology, which will be used to develop image-based phenotype-based selection methods. This research was conducted with Randomized Block Design (RAK) consisting of 3 replications. The morpho-physiological parameters of several rice varieties showed a significant effect, including the Inpago 15 variety, which gave the best results on NDVI characters and was followed by other characters. The vegetation index, or the greenness of the vegetation value obtained from digital signal processing of several channels of satellite sensor data, can provide information that a plant has good vegetation. The varieties that gave the best treatment were the Inpago 15 and Jeliteng varieties. The results of the correlation analysis showed that the parameter with a significant positive correlation with productivity was the weight parameter of

1000 grain ($r=0.35$).

Keywords: Rice varieties, UAV, drought, drone-vegetation index

A. Introduction

Rice is a staple food for the majority of Indonesia's people. It elevates rice to the status of a commodity critical to the economy and national food security. Indonesia must meet at least 95% of national rice demand by 2025, which is estimated at 65.8 million tonnes of GKG. Meanwhile, production in 2021 is still around 55.3 million tonnes. Efforts to meet the national need for rice can be pursued in two ways: increasing rice productivity with a growth rate of 1.0-1.5% per year; and increasing the rice harvest area through increasing planting intensity and developing new areas.

Efforts to develop and develop the agricultural sector are constantly faced with environmental problems. The main barrier to rice production in Indonesia is drought stress, one of the impacts of climate change due to global warming. Drought stress and groundwater balance are affected by prolonged dry seasons, rainfall, precipitation, and evapotranspiration, so groundwater availability becomes limited (Amalia & Sugiri, 2014).

The impact of extreme climate change ranks first as a cause of crop failure. Apart from directly impacting the level of food crop production, climate change also has an indirect effect which can reduce the productivity of food crops by increasing pests and diseases (Santoso & Budi, 2016). Drought can reduce the growth rate and rice production as reported by Rusmawan, Dede, Ahmadi, & Muzammil (2015), that land that is constantly flooded as deep as 5-10 cm has a production of 5.92 t/ha, while production on land that is not flooded is 4.80 t/ha. Based on these problems, rice development in Indonesia requires an effective solution. One of them is the establishment of varieties that are tolerant to drought stress.

In plant breeding, the formation of varieties requires selection. Selection character development can be done through morphological, biophysical, physiological, and molecular characteristics (Sopandie, 2014). However, these characteristics are highly influenced by the environment, require detailed observations, require a long time, require stable conditions, and are expensive in determining tolerant genotypes (Anshori 2019; Ali, yeasmin, Gantait, Goswami, & Chakraborty, 2014; Rasel, Tahjib-Ul-Arif, Hossain, Sayed, & Hassan, 2019). This becomes less efficient in practice. Therefore, the development of other selection characters that are efficient and effective in the selection of tolerant rice genotypes is urgently needed. One of them is through imaged-based phenotyping. Chawade, Van-Ham, Blomquist, Bagge, Alexandersson, & Ortiz (2019) suggested that the use of phenotyping technology in breeding was more directed at seeing the appearance of the targeted phenotype. Imaging techniques have increased the accuracy and yield of plant phenotyping and have become novelties in the measurement of phenotypic traits (Asaari, & Mohd, 2019).

One of the developments of high-tech imaging and computational systems in imaged phenotyping is modern technology based on geographic information systems and remote sensing, drone unmanned aerial vehicles (UAV) (Siddiqui & Zamin, 2014). Drone UAVs for water and N status can have implications on detecting physiological levels to establish decisions and immediately adopt measures for correctly applying irrigation and N fertilizers (Yi, Bao, Wang, & Zhao, 2013; Li, Shi, Veeranampalayam-Sivakumar, & Schachtman, 2018). Previously, UAV-based multispectral and RGB images have been validated to detect biomass, plant density, leaf area, aging rate, and photosynthetic activity in wheat, barley, and sorghum (Bendig, Bendig, Bolten, Bennertz, Broscheit, Eichfuss, & Bareth, 2014; Sankaran, Khot, & Carter, 2015; Potgieter, George-Jaeggli, Chapman, Laws, Cadavid, Wixted, Watson, Eldridge, Jordan, & Hammer, 2017; Hassan, Hassan, Yang, Rasheed, Jin, Xia, & Xiao, 2018). Physiological properties such as chlorophyll content, nitrogen concentration, and water status are often challenging to assess by the human eye but can be detected through variations in the reflected light spectrum (Haboudane, Miller, Tremblay, Zarco-Tejada, & Dextraze, 2002; Zhang & Zhou, 2019).

Image-based phenotyping has provided an excellent opportunity to assess plant growth by capturing different light spectra (Blue, NIR, Red, Green, and Rededge). At optimum conditions, healthy plants look green because they absorb the red bands and reflect the green bands of the light spectrum (Hatfield, Boote, Fay, Hahn, Izauralde, Kimball, Mader, Morgan, Ort, Polley, Thomson, & Wolfe, 2008). For example, the normalized difference vegetation index (NDVI), red-edge chlorophyll index (CIRededge), and normalized difference red-edge (NDRE) have been used to differentiate genotypes for greenery, water stress, growth under N fertilizer and

chlorophyll levels (Potgieter et al., 2017; Li et al., 2018; Zheng, Cheng, Li, Yao, Tian, & Cao, 2018; Zhang and Zhou, 2019). Therefore, multispectral vegetation indices can be used to assess water and nitrogen status and their fluctuations under various environmental conditions.

The vegetation index can provide information that a plant is well vegetated based on the greenness of the vegetation and is one of the factors that affect the health of a rice plant (Vitasari, Daniel, & Munir, 2017). It is also related to the estimation of production resulting in drought stress. Therefore, this research focuses on developing tolerance screening of several rice varieties to drought based on the drone-vegetation index.

B. Methodology and Method

The experiment evaluated the tolerance of 9 rice varieties to drought during the dry season by providing intermittent irrigation. This research was conducted in Kab. Bone - South Sulawesi is planned to take place in May-December 2022.

Research Design and Procedures

The research uses a randomized block design with a variety of factors (V): V1= Inpari 34, V2= Inpari 29, V3= Inpago 15, V4= Ciherang, V5= IR20, V6= Mekongga, V7= Inpari 42, V8= Way Apo Buru, V9= Jeliteng. All varieties were repeated three times. Each treatment unit has five samples, so there are 135 samples of observations.

The research was carried out using the 2:1 legowo planting system, 2 tons/ha compost, moles of cow urine, urea fertilization, SP36, and NPK phosnka. Drought stress will be given at 20 DAP. Then at 40 DAP, irrigation will be provided so that land conditions are expected. After that, at 60 DAP, it will be again given drought stress. Maintenance includes fertilization, pest and disease control, water checking, and weeding. Plant growth was observed until harvest. Plants are harvested when the seeds have entered the physiological ripe phase with the criteria that 80% of the plants have turned yellow and the rice grains at the base of the panicle have hardened. After treatment, the quantitative and qualitative parameters were maintained and observed, then the data were processed statistically and descriptively.

Pictures were taken every 15 days after stress treatment, namely 35 DAP and 75 DAP. Crop shooting is done directly in the field using the Inspire 2 UAV (Unmanned Aerial Vehicle) Drone, which will be equipped with an RGB camera with a resolution of 20 megapixels with a 4/3 in sensor, 20 mm focal length, a capture speed of 1/16 second. Each flight will contain about 1000 or 3000-4000 images for mapping an area of 100 ha. Flight planning will be carried out from 12.00-14.00 in sunny weather conditions. Then, the image results were analyzed using ArcGIS software.

Normalized Difference Vegetation Index (NDVI) is an index that describes the greenness of a plant. NDVI is a mathematical combination between the red band and the NIR band, which is used as an indicator of the presence and condition of vegetation, so it is commonly used as an indicator of biomass and relative greenness.

Table 1. Classification of Plant Health Based on NDVI Value.

Plant health	NDVI Value
Very good	0,721 - 0,92
Good	0,421 - 0,72
Normal	0,221 - 0,42
Poor	0,11 - 0,22

(Source : <http://endeleo.vgt.vito.be/dataproducts.html>).

Data Analysis

Data analysis to determine the effect of treatment on changes measured was carried out statistically with the help of STAR 2.1 software. Data analysis was performed using the ANOVA method (Analysis of Variance) according to a randomized block design. Parameters that show a natural effect, then proceed with the BNT test. All approaches to morphological, biophysical, and physiological characters were analyzed independently to determine the best selection characteristics for each method. The best selection character for each approach in each selection method was explored together with the Image-based Phenotyping character. It aims to determine the character of the best selection in that approach. The software used in in-depth analysis related to Image-based Phenotyping is ArcGIS.

C. Result

Table 2. Results of correlation analysis between observation parameters on tolerance screening of several rice varieties to drought based on a drone-vegetation index

Note: numbers followed by a sign mean that they are significantly different from the table $r 0.05 = 0.32$ (*); $r 0.01 = 0.44$ (**), PH: plant height, NT: number of tillers, NPT: number of productive tillers, PL: panicle length, Cl a: chlorophyll a, Cl b: chlorophyll b, Cl Tot: total chlorophyll, NDVI: normalized difference vegetation index, %FG: % filled grain, %VG: %vacuum grain, FW: fresh weight, B1000G: 1000 grain weight, and Prod:

	PH	NT	NPT	PL	Cl a	Cl b	Cl Tot	NDVI	% FG	% VG	FW	B1000G	Prod
PH	1.00	0.12	-0.03	-0.10	0.40*	0.22	0.49**	0.47**	-0.02	0.35*	0.07	-0.60**	-0.15
NT		1.00	0.89**	-0.38*	-0.10	-0.36*	-0.12	-0.05	-0.36*	0.28	0.93**	0.08	-0.31
NPT			1.00	-0.31	-0.13	-0.29	-0.08	0.02	-0.28	0.28	0.86**	0.18	-0.26
PL				1.00	0.08	0.21	0.07	0.20	0.14	-0.30	-0.35*	0.01	0.23
Cl a					1.00	0.55**	0.60**	0.22	0.03	0.38*	-0.16	-0.46**	0.00
Cl b						1.00	0.72**	0.22	-0.01	0.27	-0.23	-0.17	0.01
Cl Tot							1.00	0.29	-0.15	0.56**	-0.07	-0.39*	-0.15
NDVI								1.00	0.36*	0.06	-0.04	-0.08	0.15
% FG									1.00	-0.57**	-0.32*	0.09	-0.07
% VG										1.00	0.27	-0.41*	-0.20
FW											1.00	0.11	-0.33*
B1000G												1.00	0.35*
Prod													1.00

productivity.

Table 3. Average plant height (cm), number of tillers (stems), number of productive tillers (stems), panicle length (cm), on drought tolerance screening of several rice varieties based on a drone-vegetation index

Variety	Observation Parameters			
	PH	NT	NPT	PL
INPARI 34	105.00bc	28.22b	22.00bc	25.28ab
INPARI 29	107.67b	20.33d	16.56de	25.66ab
MEKONGGA	107.22b	28.67b	22.56b	24.90ab
INPARI 42	94.00d	21.55cd	18.11d	24.55b
INPAGO 15	116.44a	16.78d	14.00e	25.53ab
WAI APO BURU	103.78bc	27.56b	23.67b	26.70a
CIHERANG	106.78b	25.67bc	23.00b	26.17ab
JELITENG	100.22c	19.67d	19.00cd	24.70b
IR20	109.89b	36.11a	29.89a	22.62c
NP BNT 0.05%	6.32	4.83	3.40	1.68

Note: Numbers followed by the same letters in columns (a,b,c,d,e) mean significantly different in the BNT test $\alpha = 0.05\%$. PH: plant height, NT: number of tillers, NPT: number of productive tillers, PL: panicle length.

Correlation states the magnitude of the relationship that occurs between the parameters observed. The results of the correlation coefficient analysis in table 2 show the relationship between productivity characters and other characters. The results showed that the wet weight and 1000 grain weight characters were significantly correlated with productivity. A correlation analysis was carried out based on the index value to see the relationship between a character and productivity. The research results of Laraswati, Padjung, Farid, Nasaruddin, Anshori, Nur, & Sakinah (2021) and Arifuddin (2021) show that characters with significant positive correlation values can be used as selection parameters.

In contrast, parameters with negative correlation coefficient values are not recommended to be used as selection characters. The results of the correlation analysis are shown in table 2. The analysis indicates that the parameter that has a significant positive correlation to productivity is the parameter weight of 1000 grain ($r=0.35$).

The results of the 0.05 level BNT test in Table 3 show that the characters with the highest average plant height in the Inpago variety with a value of (116.44 cm) are significantly different

from the jeliteng variety and are not substantially different from other rice varieties. The character with the lowest average plant height is the jeliteng varietal (100.22 cm). The character with the highest average number of tillers was the IR20 variety, with a value of (36.11 stems), which was significantly different from the inpari 29, inpago 15, and jeliteng varieties and not substantially different from other rice varieties. The character with the lowest average number of tillers was Inpago 15 (16.78 stems). The character with the highest average number of productive tillers was the IR20 variety, with a value (of 29.89 stems), which was significantly different from the Inpago 15 variety and not substantially different from other rice varieties. The character with the lowest average number of productive tillers was the Inpago 15 variety (14.00 stems). At the same time, the characters have the highest average panicle length on the wai apo buru variety with a value (of 26.70 cm), which is significantly different from the IR20 variety and is not substantially different from other rice varieties. The character with the lowest average panicle length was the IR20 variety (22.62 cm).

Table 4. Average chlorophyll a ($\mu\text{mol.m}^{-2}$), chlorophyll b ($\mu\text{mol.m}^{-2}$), and total chlorophyll ($\mu\text{mol.m}^{-2}$) in screening for tolerance of several rice varieties to drought based on a drone-vegetation index

Variety	Observation Parameters		
	Cl a	Cl b	Cl Tot
INPARI 34	109.74c	59.09c	169.88c
INPARI 29	167.75a	72.62a	245.57a
MEKONGGA	130.87bc	63.42bc	197.02bc
INPARI 42	111.18c	60.74c	172.95c
INPAGO 15	147.78ab	67.15b	218.95ab
WAI APO BURU	139.20ab	65.28bc	207.84bc
CIHERANG	147.76ab	68.06ab	219.93ab
JELITENG	139.98bc	66.79b	183.13c
IR20	142.87ab	63.25bc	212.94bc
NP BNT 0.05%	25.91	4.84	29.95

Note: Numbers followed by the same letter in columns (a, b, c) mean significantly different in the BNT test = 0.05%. Cl a: Chlorophyll a, Cl b: Chlorophyll b, Cl Tot: Chlorophyll Total.

The results of the BNT test level 0.05 in Table 4 show that the character with the highest average chlorophyll a was in the Inpari 29 variety with a value (167.75 $\mu\text{mol.m}^{-2}$), which was significantly different from the Inpari 34 and Inpari 42 varieties, and not substantially different from other rice varieties. The character with the lowest average chlorophyll a was Inpari 34 (109.74 $\mu\text{mol.m}^{-2}$). The character with the highest intermediate chlorophyll b was in the Inpari 29 variety with a value (of 72.62 $\mu\text{mol.m}^{-2}$), which was significantly different from the Inpari 34 and Inpari 42 varieties and not substantially different from other rice varieties. The character with the lowest average chlorophyll b was the Inpari 34 variety (59.09 $\mu\text{mol.m}^{-2}$). Meanwhile, the surface with the highest average total chlorophyll was in the Inpari 29 variety with a value (of 245.57 $\mu\text{mol.m}^{-2}$), which was significantly different from the Inpari 34, Inpari 42, and Jeliteng varieties and not substantially different from other rice varieties. The character with the lowest average total chlorophyll was the Inpari 34 variety (169.88 $\mu\text{mol.m}^{-2}$).

The results of the BNT test level of 0.05 in Table 5 show that the character with the highest average wet weight is the IR20 variety with a value of (36.11 Kg), which is significantly different from the Inpari 29 and Inpago 15. Jeliteng varieties are not substantially different from other rice varieties. The character with the lowest average wet weight is the inpago 15 variety (16.78 Kg). The symbols with the highest average percentage of empty grain were in the Inpari 29 and IR20 varieties with their respective values (29.41% and 32.20%), which were significantly different from the Mekongga, Inpari 42, Ciherang, and Jeliteng varieties, and not substantially different from the other rice. The character with the lowest average percentage of empty grain was inpari 29 (80.54%). Meanwhile, the character with the highest average rate of filled grain was the Inpago 15 variety with a value (of 90.09%), which was significantly different from the Inpari 34, Inpari 29, and IR20 varieties and not substantially different from the other rice varieties. The character with the lowest average percentage of filled grain was inpari 29 (80.54%).

Table 5. Average wet weight (Kg), % empty grain (%), and % full grain (%), on the screening of tolerance of several rice varieties to drought based on a drone-vegetation index

Variety	Obsevation Parameters		
	FW	%FG	%VW
INPARI 34	28.22b	17.77cd	81.12c
INPARI 29	20.33d	29.41a	80.54c
MEKONGGA	28.33b	14.91d	88.13b
INPARI 42	21.56cd	16.01d	86.08b
INPAGO 15	16.78d	19.86bc	90.09a
WAI APO BURU	27.22b	21.90b	86.59ab
CIHERANG	26.33bc	14.80d	86.98ab
JELITENG	19.67d	15.59d	87.18ab
IR20	36.11a	32.20a	81.69c
NP BNT 0.05%	5.59	3.26	3.77

Note: Numbers followed by the same letters in columns (a,b,c,d) mean significantly different in the BNT test $\alpha = 0.05\%$. FW: fresh weight, %FG: % filled grain, %VG: %vacuum grain.

Table 6. The average weight of 1000 grain (gram), productivity (ton ha-1), and NDVI on the tolerance screening of several rice varieties to drought based on the drone-vegetation index

Variety	Observation Parameters		
	B 1000 G	Prod	NDVI
INPARI 34	26.17ab	7.96ab	0.50bc
INPARI 29	23.63bc	6.94b	0.51bc
MEKONGGA	28.23a	6.76b	0.58ab
INPARI 42	27.03ab	6.48b	0.44c
INPAGO 15	21.57c	7.22ab	0.62a
WAI APO BURU	27.00ab	6.67b	0.60ab
CIHERANG	24.43bc	6.48b	0.53b
JELITENG	28.90a	8.24a	0.58ab
IR20	25.50bc	6.20b	0.54b
NP BNT 0.05%	2.98	1.24	0.08

Note: Numbers followed by the same letters in columns (a,b,c) mean significantly different in the BNT test $\alpha = 0.05\%$. B1000G: 1000 grain weight, and Prod: productivity, NDVI: normalized difference vegetation index

The results of the BNT test at the 0.05 level in Table 6 show that the characters with the highest average weight of 1000 grains were in the mekongga and jeliteng varieties with their respective values (28.23 grams and 28.90 grams), which were significantly different from the inpago 15 variety, and not significantly different with other rice varieties. The character with the lowest average weight of 1000 grains is the inpago 15 variety (21.57 grams). The character that has the highest average productivity is the jeliteng variety with a value of (8.24 tons ha-1), which is significantly different from the varieties Inpari 29, Mekongga, Inpari 42, Wai Apo Buru, Ciherang, and IR20, and not substantially different from other rice varieties. . The character that has the lowest average productivity is the IR20 variety (6.20 tons ha-1). Meanwhile, the character with the highest average NDVI was the inpago 15 variety with a value of (0.62), which was significantly different from the inpari 42 variety and not substantially different from other rice varieties. The character that has the lowest average NDVI is the Inpari 42 variety (0.44).

D. Discussion

The development of morphological characters is the most common in determining tolerant genotypes. Biophysical, physiological, and molecular observations are the best approaches to determining susceptible genotypes. However, this approach requires a long time and stable conditions for determining tolerant genotypes (Ali et al., 2014). Therefore, the development of other selection characters that are efficient and effective in the selection of tolerant rice genotypes is urgently needed, one of which is through image-based phenotyping.

Several rice varieties showed a significant effect in morphophysiological parameters, including the inpagu 15 variety, which gave the best results on the NDVI (normalized difference vegetation index) character, followed by other characters. The vegetation index, or the amount of greenness obtained from digital signal processing of several channels of satellite sensor data, can provide information that a plant is well-vegetated. A good vegetation index is one factor that affects the condition of a healthy rice plant and the resulting production (Hunt, Doraiswamy, McMurtrey, Daughtry, Perry, & Akhmedov, 2013). The vegetation index is a value formed from a combination of several spectral wavelength values for leaf reflections which are processed using a variety of mathematical operations designed to produce a single value indicating the level of greenness or the strength of vegetation in pixels.

The response of rice to various levels of salt stress was quantified over time based on the total shoot area and old shoot area, calculated from the visible red-green-blue (RGB) image. Tolerant plants have a high green color index compared to plants that experience stress. Green represents healthy leaves, and red indicates aging areas. According to Anshori, Farid, Nasaruddin, Musa, Iswoyo, Sakinah, Arifuddin, & Laraswati (2021), relatively adapted plants have above-average growth characteristics, even though these plants have a relatively high decline.

The character of the percentage of empty grain showed a significant effect, including varieties inpari 29 and IR20 had the highest percentage of empty grain. Several studies on the impact of drought on rice plants have been carried out. They have proven that drought can reduce the rate of growth and production of rice, as reported by Kadir, Syfar, Jahuddin, & Lestar (2016) that the ratio of land with inundation and stress can reduce up to 61.3% of dry grain weight per hectare and increase the number of empty grains per panicle to 57.6%.

Productivity is the main goal in the development of a plant. The results indicate that the jeliteng varietal produces the best productivity characters. The results of the variance showed that the treatment had a very significant effect on productivity. Plant tolerance to drought can be expressed in terms of plant productivity by comparing yields under stress conditions with optimal conditions.

E. Conclusion

From the study results, it can be concluded that the morphophysiological parameters of several rice varieties showed a significant influence, including the Inpagu 15 variety giving the best results on the NDVI (normalized difference vegetation index) character and followed by other characters. The vegetation index, or the greenness of the vegetation value obtained from digital signal processing of several channels of satellite sensor data, can provide information that a plant has good vegetation. The varieties that gave the best treatment were the inpagu 15 and jeliteng varieties. The results of the correlation analysis showed that the parameter with a significant positive correlation with productivity was the weight parameter of 1000 grain ($r=0.35$).

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