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Evaluation of Seedling Tray Selection for the Screening of Saline-Tolerant Rice

AUTHORS INFO

Muhammad Fuad Anshori*
Universitas Hasanuddin
fuad.anshori@unhas.ac.id

Nur Qalbi Zaesar Muharram
Universitas Hasanuddin
zaizarizar@gmail.com

Indrayani Muslim
Universitas Hasanuddin
indahyani@gmail.com

A, Chamsitasari Zulfikarahmi A. Jamil
Universitas Hasanuddin
andichamsitasari@gmail.com

Muh. Fikri Al Qautzar
Universitas Hasanuddin
mammang939@gmail.com

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Abstract

This study aimed to identify the effectiveness of seedling trays in screening rice for salinity tolerance. The study was conducted at the greenhouse, Faculty of Agriculture, Hasanuddin University, from August 2022 to October 2022. The genotypes used consisted of 4 dihaploid lines (F37, F42, F46, and F47), which were tolerant to salinities in nutrient culture screening. The Duncan Multiple Range Test (DMRT) with STAR 2.0.1 software and regression analysis with Microsoft Excel were used to analyze the interaction between genotype and environment. The results showed that the characters of shoot length (SL) and shoot fresh weight (SFW) were significantly influenced by all sources of diversity. In addition, the F37 and F42 genotype had a stable tolerance to salinity stress. The SFW character of F42 was more affected by SL than SL in the screening with soil media in trays. Based on the two evaluation characters (SL and SFW), fixed crown height is recommended as a selection criterion with SFW for the screening of saline-tolerant rice.

Keywords: *Oryza sativa*, salinity screening, seedling trays, shoot fresh weight, shoot length

A. Introduction

Rice is synonymous with national food security in Indonesia. This is corroborated by data on Indonesia's high per capita rice consumption (1.59 kg/week) (Indonesia 2022) so that efforts to increase rice production continue every year. However, dynamic climate change is challenging

for this fulfillment (Rumanti Hairmansis, & Nugraha, 2018). One of the impacts of climate change is salinity stress (Anshori, Purwoko, Dewi, Ardie, & Suwarno, 2020; Rhaman et al. 2021).

Salinity stress is caused by increased salt concentration in the planting area (Gupta & Huang 2014). This stress significantly affects rice productivity (Gerona, Tahjib-Ul-Arif, & Kibria, 2019). According to Linh, Linh, Xuan, Ham, Ismail, & Khanh, (2012), an increase in salinity stress can reduce the productivity potential of rice cultivation by up to 50% at six dS/m and even cause crop failure at 12 dS/m. This is crucial in Indonesia because Indonesia is the largest archipelagic country in the world, with most of the population consuming processed rice (Anshori et al. 2020; Anshori, Purwoko, Dewi, 2021). According to Asian Development Bank (ADP) (2009), coastal areas contribute as much as 15% of Indonesia's total rice production potential, reaching 15%. In addition, according to Nababan, Hadianti, & Natih (2015), sea level rise has reached 5.84 mm/year, so inland seawater intrusion will be more intense, which correlates with an increase in salinity. Therefore, we must solve a solution to rice cultivation in coastal areas. One of them is the development of saline-tolerant varieties.

The development of saline-tolerant rice varieties can be carried out with an accurate screening concept. The accuracy of this screening is highly dependent on the method, critical point phase, selection criteria, and environment (Anshori, Purwoko, & Dewi, 2018). In general, research on salinity tolerance is carried out in the seedling phase. It is a relatively fast and effective initial screening method for large populations (Ali, Yeasmin, Gantait, Goswani, & Chakraborty, 2014; Anshori et al. 2018; Rasel, Tahjib-Ul-Arif, & Hossain, 2021). However, the screening concept is relatively using nutrient culture or hydroponic methods. This concept is considered less adaptive because rice cultivation is carried out on soil media (Ismail, Palten, & Miro, 2013; Kranto, Chankaew, Monkham, Theerakulpisut & Sanitchon, 2016). Water media and soil media have very different physical and biological properties, so it is necessary to have a seedling phase screening method that focuses on soil media. Kakar, Jumaa, Redona, Warbuton, & Reddy (2019) and Anshori et al. (2021) have used the concept of tolerance testing in the seedling phase with soil media up to the generative phase. However, the pots used are still relatively large, so this concept requires ample space in large populations. Accordingly, small containers are necessary for this screening, such as seedling trays. The use of seedling trays as screening containers for salinity tolerance has not been widely reported. The selection tray has a relatively small size. It is somewhat similar to the concept of nutrient culture so that containers can be efficient for screening salinity tolerance with large populations. Therefore, the development of salinity screening using seedling trays needs to be developed. This study aimed to identify the effectiveness of seedling trays in screening rice for salinity tolerance.

B. Methology

1. Experimental Design

The study was conducted at the greenhouse, Faculty of Agriculture, Hasanuddin University, from August 2022 to October 2022. The study was designed using a completely randomized nested design, where the genotypes were nested at NaCl concentration. The concentration of NaCl used consisted of two treatments, namely 0 dS/m and 60 dS/m. Meanwhile, the genotypes used consisted of 4 dihaploid lines (F37, F42, F46, and F47), which were tolerant to salinity stress in nutrient culture screening. In addition, this study used the IR 29 variety as a sensitive control in this study. Then, each combination of genotypes and NaCl concentrations had repetitions of 15 samples, so there were 300 plants.

2. Research procedures

The research used homogenized compost. The compost was put into trays with 60 holes per tray. Then, the seeds for each genotype were soaked for one day using warm water. After that, the seeds are planted as many as two per planting hole. When the seedlings were seven days after sowing (HSS), thinning was carried out by leaving one seed per planting hole. Fertilization is done by fertigation with tray mats every one week, where each tray is given 3 L of Abmix fertilizer solution with a concentration of 5 ml/L. Tray bases volume of water is maintained daily by providing water outside of fertigation. After 28 HSS, the salinity treatment was carried out based on the concentration. Giving NaCl is done gradually to avoid excessive osmotic stress. The stress application is carried out for 30 days or 58 HSS. After that, the salt-treated water was cleaned on the tray base and replaced with normal water. The plants were recovered for 2 or 72

DAS before being observed. Meanwhile, the observations on these plants were adjusted to the recommendations of Anshori et al. (2021). The observational data were analyzed for variance with α of 5% using STAR 2.0.1 software. Then, observational data significantly influence the interaction in the Duncan Multiple Range Test (DMRT) with STAR 2.0.1 software and regression analysis with Microsoft Excel.

C. Result and Discussion

The variance analysis shows that the characteristics of shoot length (SL) and shoot fresh weight (SFW) are significantly influenced by all sources of diversity. On the other hand, the character of the number of tillers (NT) is only affected by variations in salinity levels (Table 1). Based on these results, the maternity environment significantly affects the decline in rice growth characteristics. However, this growth character is considered adequate if nature can distinguish the response between tolerant and sensitive genotypes at different levels of the saline environment. This indicates that the diversity of genotype and environment interactions is the key to determining effective selection criteria for salinity tolerance. This concept has also been reported by Akçura & Çeri, (2011), Mohamadi, Bagheri, Kiani, & Jelodar (2017), Horváth, Gombos, & Széles (2021), and Anshori, Purwoko, Dewi, Sowarno, & Ardie (2022). Therefore, the shoot length and fresh weight shoot characters are more recommended as selection criteria than the number of tillers characters. This result has also been reported by Anshori et al. (2020) and Anshori et al. (2021) on the tolerance of dihaploid rice under salinity stress. DMRT test results on shoot length characters showed that F37 and F42 did not show a significant difference between normal and maternity conditions (Table 2). In addition, under saline conditions, the two genotypes showed significantly different responses to F46, F47, and IR 29. Meanwhile, the largest relative decrease was found in F46, while F37 and F42 had a relative decrease of below 20%.

Table 1. Analysis of variance on the growth characteristics of rice seedling under salinity stress

Kind of Sources	Pr(>F)		
	Shoot Length	Number of Tiller	Shoot Fresh Weight
salinity (S)	0.0000	0.0056	0.0000
variety (V)	0.0057	0.5015	0.0081
SxV	0.0380	0.1657	0.0409
CV (%)	10.93	27.75	26.74

Note: CV = coefficient of variation, Pr (>F) = Probability values

Table 2. DMRT test and relative decrease in rice on shoot length characters

Variety	Normal (NaCl 0 dS/m)		Salinity (NaCl 60 dS/ m)		Relative Decrease (%)
	SL (cm)	not	SL (cm)	not	
F37	80.82	a ^p	70.38	a ^p	12.91
F42	71.25	a ^p	72.00	a ^p	-1.05
F46	75.29	a ^p	43.54	b ^q	42.17
F47	77.95	a ^p	49.60	b ^q	36.37
IR 29	70.67	a ^p	44.44	b ^q	37.13

Note: SL= shoot length; not = notation by the same letter in columns (a, b) and rows (p,q) are not significantly different at DMRT α 5%

DMRT test results on new weight shoot characters showed that F42 was the only genotype with a relatively similar SFW response between normal and delivery conditions (Table 3). In addition, under saline conditions, F42 and F37 showed significantly different responses to F46, F47, and IR 29. Meanwhile, the most significant relative decrease was found in IR29 (95.65), while F37 and F42 had a relative reduction of below 50%.

Table 3. DMRT test and relative decrease in rice on fresh weight shoot characters

Variety	Normal (NaCl 0 dS/m)		Salinity (NaCl 60 dS/ m)		Relative Decrease (%)
	SFW(g)	not	SFW(g)	not	
F37	49.35	a ^p	33.62	a ^q	31.88
F42	38.85	a ^p	35.70	a ^p	8.11

F46	39.23	a ^p	7.85	b ^q	79.98
F47	39.50	a ^p	11.82	b ^q	70.08
IR 29	43.76	a ^p	1.91	b ^q	95.65

Description: SFW= shoot fresh weight , not = notation by the same letter in columns (a, b) and rows (p,q) are not significantly different at DMRT α 5%

Based on the two evaluation characters (SL and SFW), the SFW character is more affected by salinity stress than SL in the salinity tolerance screening with soil media in trays. This difference in impact is reflected in the threshold of the two characters in distinguishing tolerant and sensitive genotypes. This is also in line with the report of Anshori et al. (2020) on nutrient culture-based salinity tolerance screening in the seedling phase. This phenomenon indicates that rice plants will continue to increase their shoot height growth under salinity stress. Although, this genotype experienced a decrease in tissue water content. However, tolerant varieties will reduce the tissue's water content and not exceed 50% capacity of its total SWF (Suplick-Ploense, Qian, & Read, 2002). Therefore, the SWF character is more recommended as a cross-screening criterion than other characters (Mohamadi et al., 2017; Anshori et al., 2020; Anshori et al. 2021). However, canopy height considerations must be included as a correction for this tolerance. This is evidenced by the graphs of the two characters, which reach a determination value of 0.923 (Figure 1). In this figure, F37 and F42 are in quadrant 3 with a shallow error distance to the regression line. In contrast, IR 29, F46 and F47 are united in quadrant one. However, the three genotypes are pretty far from the regression line. This indicates that fixed crown height is recommended as a selection criterion with SFW for salinity screening with soil media in trays.

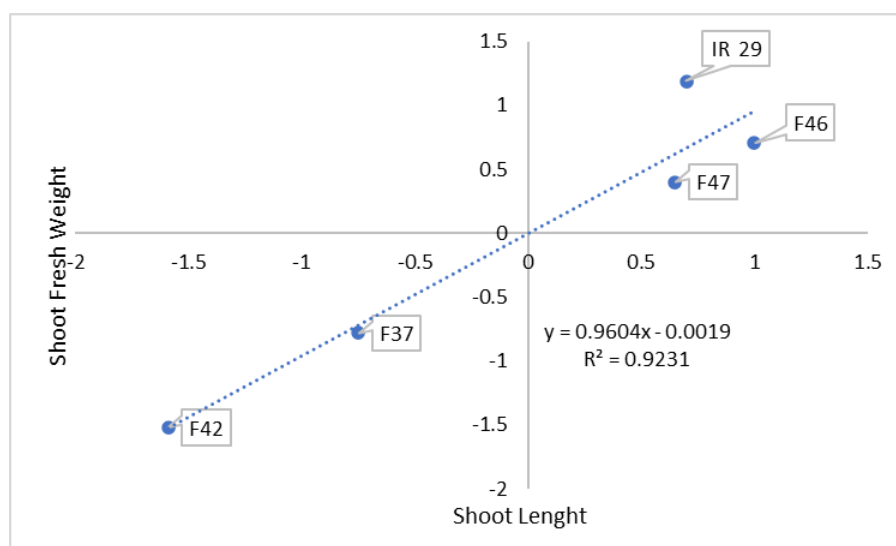


Figure 1. Regression analysis of shoot length and shoot fresh weight

Based on the grouping of genotypes in Figure 1, genotypes F37 and F42 have good tolerance in salinity screening in the tray. In contrast, F46 and F47 were declared as varieties classified as sensitive to salinity stress. This result is not in line with Anshori et al. (2021), where F46 and F47 were categorized as tolerant varieties in nutrient culture salinity screening. However, this result is in line with the research of Anshori et al. (2022) on screening for salinity tolerance in soil media in pots. This indicates that this concept can explain in more detail the possible tolerance of genotypes to salinity stress compared to de-nutrient culture. In addition, this concept is considered relatively fast compared to the idea in the pot. Therefore, screening saline soils in trays can be an early detection indicator of tolerance to the salinity of rice lines. However, this concept needs to be matured with more accurate and precise proofs.

D. Conclusion

The results of this study indicate that the seedling tray is effectively used as a container in screening the seedling phase of rice salinity tolerance with soil media. The characters of shoot length and shoot fresh weight are effectively used as selection criteria in salinity screening with soil media in trays. The F37 and F42 genotypes had stable tolerance to salinity stress. However,

this screening concept still needs to be tested for accuracy with a precise approach before being recommended as a screening method for rice salinity tolerance.

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Growth and Production Responses of Cabbage (*Brassica oleracea* L.) after Various Bat Guano Fertilizer Application Doses in Lowlands

AUTHORS INFO

Rahman Hairuddin
University of Cokroaminoto Palopo
rahmanhairuddin@uncp.ac.id

Andi Safitri Sacita*
University of Cokroaminoto Palopo
andi_safitrisacita@yahoo.co.id

Oktafianus Toricelin
University of Cokroaminoto Palopo
oktafianustoricelin99@gmail.com

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Abstract

Cabbage is a popular horticultural commodity in the community with great potential development in highlands and lowlands. Nutrient fulfillment is a factor that supports optimal cabbage growth and production. This study aimed to determine the effect of different bat guano fertilizer doses on the growth and production of cabbage in lowlands. The cabbage type used was a suitable variety at lowlands called *Grand 22*. This study was performed in the experimental land of the Faculty of Agriculture, UNCP at 2 masl on September – December, 2021, through a randomized group design with six treatments and four replications. The treatments included: P0 = Control (without bat guano treatment), P1 = 30 g of bat guano per crop, P2 = 60 g of bat guano per crop, P3 = 90 g of bat guano per crop, P4 = 120 g of bat guano per crop, and P5 = 150 g of bat guano per crop. The results indicate that bat guano significantly affects all observed parameters. The 150 g of bat guano per crop provides the best effect on the cabbage height (27.75 cm), leaf width (27 cm), crop-forming age (36.5 days), and crop weight (1106.5 g).

Keywords: lowlands, *Grand 22*, bat guano, cabbage

A. Introduction

Cabbage is one of the popular horticultural commodities and is generally cultivated in the highlands. Cabbage plants are usually cultivated at 800-1000 masl (Destiwarni, et al., 2021). Although generally grown in the highlands, cabbage plants can also be cultivated in the lowlands. In the lowlands, cabbage plants have great potential for development and have high enough economic value to become a commodity with promising prospects (Hartono, et al., 2019). Cabbage plants can grow in the lowlands at 0-200 masl (Destiwarni, Sari, Astarina, &

Umar, 2021). Suitable varieties for lowland cultivation are *Grand 22*, *Green Coronet*, *Green Helmet*, *KK-Cross*, *Gloria Osen*, and *Green Autumn 2055* (Hartono, Kartinaty, Sunardi, & Marsusi, 2019).

Cabbage contains many vitamins and minerals required by the human body. Vitamins in cabbage include vitamins A, B, C, and E. In addition, the minerals in cabbage are potassium, phosphorus, sodium, and iron (Akbar, 2015). High Vitamin C content in cabbage can prevent the acute mouth ulcers (Patty, 2012). Cabbage can also deactivate toxicants in the human body by triggering glutathione formation (Destiwarni, et al., 2021).

Cabbage production in Indonesia has fluctuated in 2015-2019. In 2015, cabbage production in Indonesia reached 1,433,227 tons, then increased to 1,513,326 tons in 2016. Cabbage production decreased to 1,442,624 tons in 2017, then continued to decrease in 2018 (1,407,932 tons) and in 2019 (1,413,060 tons) (BPS, 2020). The Central Bureau of Statistics recorded that cabbage production in Indonesia was 1.40 million tons in 2022. This number decreased by 2.08%, compared to the previous year, which reached 1.43 million tons (BPS, 2022).

Many factors can cause decreased production in a cultivation business. Planting media is an important component for optimal plant growth and production. The planting media has a role in supplying nutrients to plants. Fertilization is an effort to fulfill the nutrient requirements in plants to support their growth and production (Dewanto, Londok, Tuturoong, & Kaunang, 2013). Organic fertilizer is a widely-recommended fertilizer that can be applied to plants. Besides supplying nutrients, organic fertilizer can also improve the soil structure, thus supporting the development of plant roots. Organic fertilizers are also rich in microorganisms, which can increase soil nutrients and organic matter (Hartatik, Husnain, & Widowati, 2015); (Siswanto, Sugiyanta & Melati, 2015); (Haryadi, Yetti, & Yosefa., 2015).

Bat guano is an under-utilized organic fertilizer widely, although containing abundant nutrient contents for soil nutrient requirements. Bat guano fertilizer has macronutrients, such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur (Tangguda, Valentine, Hariyadi, & Sadiarsa, 2022). The bat guano fertilizer can also improve the soil structure and act as a biological fungicide due to containing organic material, bacteria, and microflora (Hariyadi, 2014).

Based on Hayanti, Yuliani & Fitrihidayati (2014), applying bat guano at 3.96 g per polybag could increase the growth of peanut plants. In addition, the combination of bat guano and urea could increase the growth and production of green bean plants (Taofiq, Setiati, & Purnama, 2018). Based on the description above, organic fertilizer from bat guano can be applied as a source of nutrients for cabbage cultivation in lowlands. This study aimed to determine the effect of various bat guano doses on the growth and production of cabbage plants at lowlands.

B. Methodology

1. Experimental Design

This study was performed in the experimental land of Faculty of Agriculture, University of Cokroaminoto Palopo, Palopo at 2 masl on September – December, 2021. The materials used in this study were *Grand 22* cabbage seeds, bat guano, bamboo, raffia fiber, board, and water. The equipment included hoes, shovels, machetes, a camera, stationery, books, rulers, and scales.

This study used a randomized group design with six treatments and four replications, thus, the total treatment units were 24 units with 2 plant samples, so there were 48 observed plants. The dose treatments included: P0 = Control (without bat guano), P1 = 30 g of bat guano per crop, P2 = 60 g of bat guano per crop, P3 = 90 g of bat guano per crop, P4 = 120 g of bat guano per crop, and P5 = 150 g of bat guano per crop.

2. Research procedures

The experiment was started by processing and cleaning the land from weeds or remnants of previous plantings with hoes and machetes. Then, the soil tillage was performed by 30 cm depth. After processing, beds were made with 80 cm x 50 cm size, a distance of 30 cm and a height of 30 cm. This design was aimed as a walking path and drainage.

Furthermore, a nursery was conducted to prepare the seeds for planting, reducing the mortality risk. In this process, the seeds were sown in the prepared containers, with a 1:1 planting medium, namely 1 kg of compost and 1 kg of soil. The nursery was carried out for 2 weeks until the seedlings were ready to be transferred to the field. Seedlings with 3-4 leaves were soon transferred to the experimental land for planting. Seedlings were planted in the afternoon by inserting them into the holes of the prepared beds. Each planting hole was filled

with one seedling and covered with soil to support growth. The bat guano was applied only once, namely before planting and by hole immersion, based on the doses applied in each treatment. The parameters observed in this study were plant height, leaf width, crop-forming age, and crop weight.

Data from the observation results were analyzed using an analysis of variance (F-test) at 1% and 5% confidence levels. The analysis results with a significant difference were further tested with an Honest significance test (HST) at 5% for a significantly different value and 1% for a very significantly different value.

C. Result

Plant Height (cm)

Based on the analysis of variance results, different bat guano doses showed a very significant effect on the average cabbage plant height cultivated in lowlands. The average cabbage plant height at 8 Week After Planting (WAP) can be shown in Figure 1.

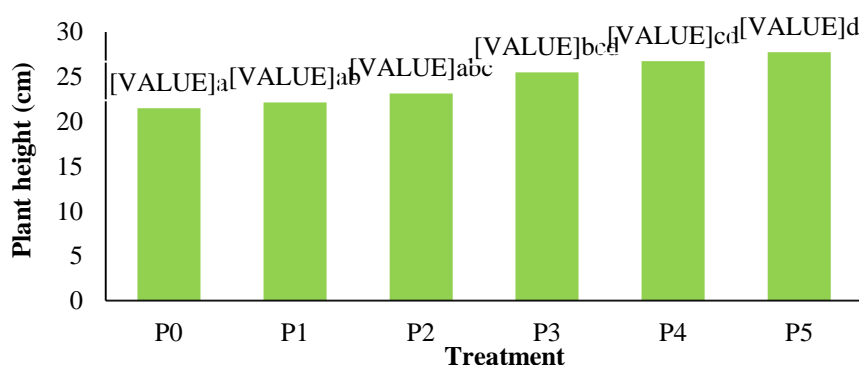


Figure 1. Average of cabbage plant height after different bat guano doses at 8 WAP. Notations behind numbers are the results of HST at a 1% confidence value. Numbers followed by the same notation have no significant difference.

Based on Figure 1, the P0 (control) treatment was insignificantly different from the P1 (30 g of bat guano per crop) and P2 (60 g of bat guano per crop) treatments, but showing a significant difference with the P3 (90 g of bat guano per crop), P4 (120 g of bat guano per crop), and P5 (150 g of bat guano per crop) treatments. The best treatment was obtained from the P5 with the cabbage plant height of 27.75 cm. The P0 treatment obtained the lowest plant height compared to other treatments.

Leaf Width (cm)

Based on the analysis of variance results, various bat guano doses significantly affected the average cabbage leaf width in lowlands. The average leaf width of cabbage plants at 8 WAP can be seen in Figure 2.

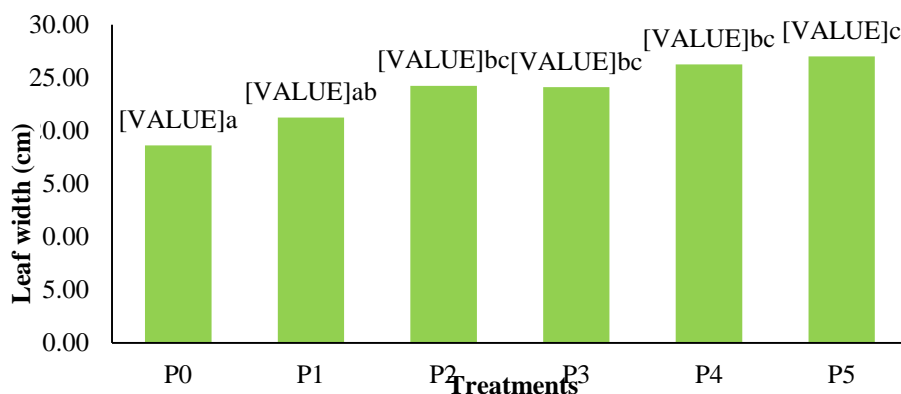


Figure 2. Average of cabbage leaf width after different bat guano doses at 8 WAP. Notations behind numbers are the results of HST at a 1% confidence value. Numbers followed by the same notation have no significant difference.

Based on Figure 2, the P0 (control) treatment was insignificantly different from the P1 (30 g of bat guano per crop) treatment but significantly different from the P2 (60 g of bat guano per crop), P3 (90 g of bat guano per crop), P4 (120 g of bat guano per crop), and P5 (150 g of bat guano per crop) treatments. The P1 treatment was insignificantly different from the P2, P3, and P4 treatments but significantly different from the P5 treatment. The best treatment was shown in the P5 treatment with an average cabbage leaf width of 27 cm. The P0 treatment showed the lowest average leaf width, compared to other treatments.

Crop forming-age

Based on the analysis of variance results, different bat guano doses had a significantly different effect on the average crop-forming age of cabbage cultivated at lowlands. The average crop-forming age in cabbage can be seen in Figure 3.

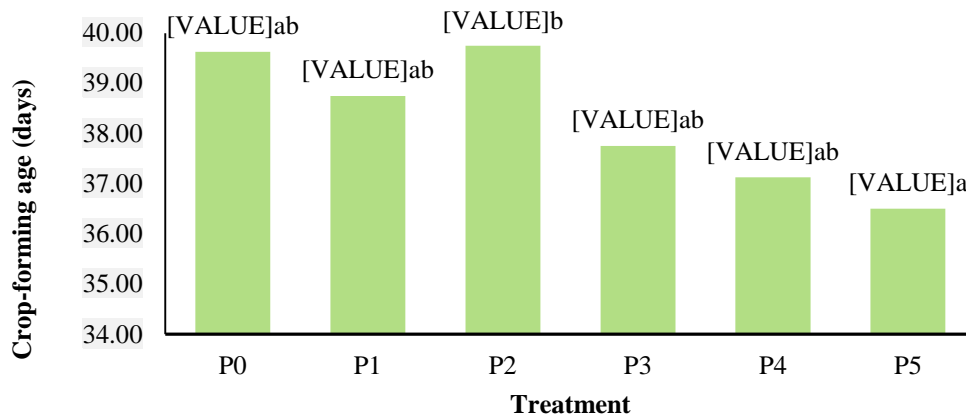


Figure 3. Average crop-forming age in cabbage after different bat guano doses at 8 WAP. Notations behind numbers are the results of HST at a 1% confidence value. Numbers followed by the same notation have no significant difference.

Based on Figure 3, the P0 (control) treatment was insignificantly different from the P1 (30 g of bat guano per crop), P3 (90 g of bat guano per crop), P4 (120 g of bat guano per crop), and P5 (150 g of bat guano per crop) treatments, but significantly different from the P2 (60 g of bat guano per crop) treatment. The P1 treatment was insignificantly different from the P2, P3, and P4 treatments but significantly different from the P5 treatment. The best treatment was obtained from the P5 treatment with an average crop-forming age in cabbage at 36.5 days. Cabbage plants administered with 150 g of bat guano formed crops faster than other treatments. The P2 treatment showed the longest crop-forming age compared to other treatments.

Crop Weight

Based on the analysis of variance results, different bat guano doses had a significantly different effect on the average crop weight of cabbage cultivated in lowlands. The average crop weight of cabbage can be seen in Figure 4.

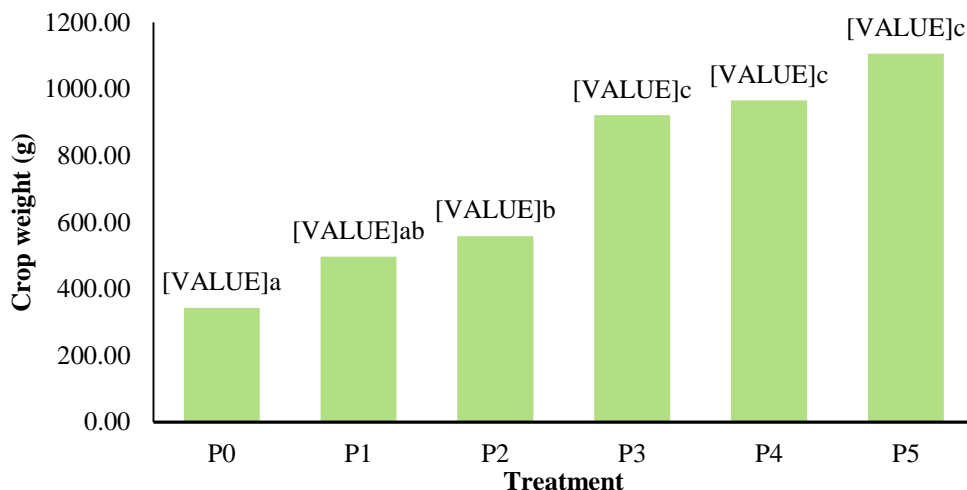


Figure 4. Average of cabbage crop weight after different bat guano doses at 8 WAP. Notations behind numbers are the results of HST at a 1% confidence value. Numbers followed by the same notation have no significant difference.

Based on Figure 4, the P0 (control) treatment was insignificantly different from the P1 (30 g of bat guano per crop) treatment but significantly different from the P2 (60 g of bat guano per crop), P3 (90 g of bat guano per crop), P4 (120 g of bat guano per crop), and P5 (150 g of bat guano per crop) treatment. The P1 treatment was insignificantly different from the P2 treatment but significantly different from the P3, P4, and P5 treatments. The P3, P4, and P5 treatments were insignificantly different. The best treatment was obtained from the P5 treatment with an average crop weight of 1106.50 g. The P0 treatment showed the lowest average crop weight compared to other treatments.

D. Discussion

Based on the study results, the application of bat guano at 150 g per crop obtained the best effect compared to other treatments for all observation parameters, including plant height (cm), leaf width (cm), crop-forming age (days), and crop weight (grams). The unfertilized cabbage plants showed the lowest growth and production responses among all treatments. This indicates that applying bat guano can increase the growth and production of cabbage plants in lowlands. The nutrient contents in the bat guano were thought to meet the nutrient requirements of cabbage plants.

Bat guano has high nitrogen, phosphorus, and potassium content. Based on test results, bat guano compost added with straw, husks, and bran contained 4.89% nitrogen, 1.65% phosphorus, and 1.89% potassium (Hayanti, et al., 2014). Bat guano is an organic fertilizer rich in nitrogen and phosphorus contents. Bat guano also contains ammonia, phosphoric acid, oxalic acid, and carbonic acid. In addition, bat guano has a good cation exchange ability, so plants can easily absorb nutrients useful in fertilizers. Furthermore, bat guano was also rich in organic matter, thus improving the soil structure (Syahbudin & Budiyanto, 2019).

The availability of macronutrients, especially nitrogen, phosphorus, and potassium in organic fertilizer will stimulate plant growth and production. The nutrient requirements of plants for nitrogen, phosphorus, and potassium will activate the cell division, specifically cells in meristem tissues for faster plant growth (Gardner, Brent, & Mitchell, 1991). Nitrogen is required by plants to stimulate the formation of plant vegetative organs, such as roots, stems, and leaves, in addition to assisting the formation of chlorophyll which plays an important role in absorbing solar radiation as an energy source for photosynthesis. Phosphorus plays a role in stimulating root development, flowering, fruit and seed formations. Meanwhile, potassium plays a role in forming proteins and carbohydrates in plants and increases the plant's resistance to biotic and abiotic stresses (Fachawati, 2020).

Nutrients that have been fulfilled will make plants grow optimally. A well-formed vegetative organ may cause the plants to enter the generative phase more quickly, whereas the 150 g of bat guano per plant formed a crop more quickly than other treatments. The fulfilled phosphorus requirement will accelerate plant maturity and stimulate the formation of generative organs, such as flowers, fruits, and seeds. Better plant growth will accelerate crop formation in cabbage plants (Sihaloho, Purba, Halolo, 2020).

Plant growth will affect its production. Plants that grow well will produce maximum production. Based on the study results, 150 g of bat guano per plant could increase the crop weight of cabbage plants. Rondonuwu, Paulus, & Pinaria (2016) stated that the provision of nutrients largely determined the crop weight of cabbage plants. The cabbage crop weight is affected by plant growth. Cabbage plants that were administered with the highest fertilizer concentration had a more optimal growth response and affected greater crop weight. The macronutrients in bat guano could meet the plant nutrient requirements, resulting in a high production level (Hasan, Lewar, Lehar & Duan, 2018). According to Hasan, et al. (2018), applying bat guano at 150 ml/L to kale plants obtained the best results compared to plants administered with bat guano at lower concentrations. High phosphorus content in bat guano supports the growth and development of the plant's vegetative and generative organs. Phosphorus is needed by plants for the formation of energy sources (ATP and ADP) (Winarti, et al., 2023).

E. Conclusion

Based on the study results, various bat guano doses significantly affect all observed parameters in cabbage plants cultivated at lowlands. The best treatment is found in 150 g of bat guano per plant, based on the cabbage height (27.75 cm), leaf width (27 cm), crop-forming age (36.5 days), and crop weight (1106.5 g).

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Evaluation of Double Cross on Growth and Production of Cayenne Pepper (*Capsicum frutescens* L.)

AUTHORS INFO

Muh. Farid BDR
Universitas Hasanuddin
farid_deni@yahoo.co.id

Yunus Musa
Universitas Hasanuddin
yunusmusa@yahoo.com

Azmi Nur Karimah Amas
Universitas Hasanuddin
azmikaarimah08@gmail.com

Muh. Fuad Anshori
Universitas Hasanuddin
fuad.anshori@unhas.ac.id

Nirwansyah Amier
Universitas Hasanuddin
amieramier1819@gmail.com

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Abstract

Cayenne pepper is one of the horticultural commodities with high economic value in Indonesia. In addition, this plant also never runs out of enthusiast because almost everyone needs it. Therefore, the fulfillment of this demand must be supported by the availability of sufficient cayenne pepper in Indonesia. This research aims to obtain better diversity in the results of double cross and three way cross than their parents, to obtain characters with good genetic parameters in predicting the results of double cross and three way cross crosses, and to obtain hybrid combinations of cayenne pepper resulting from double cross and three way cross which has purple fruit properties. The results of the evaluation of crosses showed that all cross-evaluation characters had a high heritability predictive value and were followed by high genetic diversity in the characters of plant height, dichotomous height, plant habitus, flowering age, harvesting age, fruit weight, fruit length, fruit diameter, fruit stalks length, and yield.

Keywords: double cross, three-way cross, heritability, diversity

A. Introduction

Cayenne pepper (*Capsicum frutescens* L.) is one of the horticultural commodities with high economic value in Indonesia. In addition, this plant also never runs out of enthusiasts because almost everyone needs it. A sizeable population increase of around 270 million people in 2020 (BPS, 2021), means that the demand for cayenne pepper will continue to increase. Therefore, the

fulfillment of this demand must be supported by the availability of sufficient cayenne pepper in Indonesia. One of the reasons is the production gap to the demand for cayenne pepper, which is less than optimal productivity. Therefore, the development of intensification such as assembling high-yielding varieties needs to be carried out.

The plant breeding program is one of the strategies to produce superior varieties with high yield potential and good quality. However, the effectiveness of the program greatly depends on the genotypic diversity of the basic population. The combination of crosses with many parents allows the formation of high diversity. This is supported by the statement of Syukur, Sujiprihati & Rahmi (2015), plant breeding is highly dependent on the existence of genetic diversity, because the higher the genetic diversity, the greater the opportunity to get superior varieties. Without genetic diversity, the efficiency and effectiveness of breeding programs is very low. Genetic diversity can be obtained from local varieties, national superior varieties, introduced lines, and breeding lines. In assembling hybrid varieties, the selection of parents and crossing methods are the first steps that must be taken (Arif, Sujiprihati, & Syukur, 2012). Genetic variation in plant populations can be due to domestication, segregation, germplasm collection, plant introduction, hybridization, mutation, polyploidy, somaclonal variation, and genetic engineering (Abrham, 2019). Genetic information is essential for more efficient and effective plant selection (Amas, Musa, Farid & Anshori, 2023).

The concept of hybridization is often combined with cross-design to optimize the combined potential of different parent cultivars used (Muthoni & Hussein, 2020). The chosen parents are parents who have some specific characteristics that will be combined in their offspring. Meanwhile, the crossing method should be adjusted to the resources owned. One method that is widely used is the double cross and three way-cross. A double cross is a cross between F1 and F1 resulting from two single crosses. A cross between two parents who have superior characters and both are hybrids (F1) of a single cross. This cross will produce good F1 and if it is continued it will produce high diversity (Syukur et al., 2015). Meanwhile, a three-way cross is a cross between a single cross and one pure line, where the three pure lines are not related, so they are more genetically different and have a more diverse appearance (Pathy, Rao, & Ramesh, 2019). The genetic diversity of the three-way cross hybrid is greater than the single cross hybrid because it uses three different types of inbred lines.

High heritability values indicate that the influence of genetic factors was more significant and prevailing than environmental factors. The higher the heritability value, the more variability production traits gain influence by differences in genotypes and less by environmental variations. Traits with high heritability values will increase the effectiveness of selection because such attributes reflect the influence of genetic factors compared with environmental factors (Bdr, Nasaruddin, Iswoyo, Ridwan, & Arsyad, 2020; Afa, Mustafa, Syahri, Bulawan, & Musdalifa, 2021).

In this case the researcher will use the Double cross (DC) and Three Way Cross (TWC) methods. In this cross only involves several hybrid varieties to be crossed. The two crossing methods have significant differences, one of which is the ability to produce antioxidant content (cayenne pepper with purple young fruit characters). The researcher hopes that in carrying out crosses, the ability of the two parents to produce the character of cayenne pepper can be known. In addition, the superior traits possessed by some of the parents can be incorporated into the F1 genotype resulting from the artificial crosses that were carried out.

B. Methodology

The research was conducted at the Experimental Garden of the Faculty of Agriculture, Hasanuddin University, in Tamalanrea District, Makassar City, South Sulawesi. At an altitude of 22.4 m asl with an average temperature of 24 °C in the morning and 32 °C during the day. This research was conducted from August to December 2021.

The materials used in the research were 10 genotypes resulting from crosses and 4 parental varieties of cayenne pepper seeds, namely G1 (U/B//D/K), G2 (U/D//B/U), G3 (U/D//D /K), G4 (U/K//D/B), G5 (U/D//D/B), G6 (U/B//D/U), G7 (U/B//D/B), G8 (U/D//B), G9 (U/B//D), G10 (D/U//B), G11 (Bara), G12 (Dewata 43 F1), G13 (Ungara IPB), G14 (Katokkon), soil, manure, rice husk charcoal, compost, polybags measuring 10 cm x 15 cm and 30 cm x 35 cm, furadan, patent fertilizer, AB Mix, NPK Mutiara 16-16-16, herbicide with active ingredients paraquat dichloride, insecticide with the active ingredient profenopos, fungicide with the active ingredient propineb and zinc, rapia rope, stake, plastic scrap, plastic bag and research board.

This research was arranged using a randomized block design consisting of 10 genotypes resulting from crosses and 4 parental varieties of cayenne pepper. The experiment was repeated

3 times and each experimental unit consisted of 4 plant samples, so there were 168 experimental units. Observation of cross character evaluation of cayenne pepper was carried out by measuring the observed variables for each plant sample. The diversity of plant characters that appear is determined based on the measurements that have been made. The observed variables included plant height, dichotomous height, plant habitus, stem diameter, flowering age, harvest age, fruit weight, fruit length, fruit diameter, fruit stalk length, and yield. The data obtained was analyzed for variance (Anova), cluster analysis using the STAR (Statistical Tool for Agricultural Research) program and if there is a real or very significant effect, then proceed with the BNT test ($\alpha = 0.05$). Meanwhile, to see the relationship of each parameter, a correlation analysis was carried out.

C. Result

The results of the BNT test at the 0.05 level in Table 1 show that the U/B//D/B (G7) and U/D//B/U (G2) genotype treatments produced the best plant height with respective values (69.67 cm) and (69.53 cm), so that it is significantly different from all the comparison varieties. The genotype treatments U/D//D/B (G5) and U/B//D/B (G7) had the best dichotomous height (31.57 cm) and (30.92 cm) so that they were significantly different from the Bara (a) control variety, Dewata 43 F1 (b), Ungara IPB (c), and Katokkon (d). Plant habitus characters showed that the genotype treatments U/K//D/B (G4), U/D//B/U (G2), and U/D//D/B (G5) had the best plant habitus with a value respectively (79.75 cm), (78.25 cm), and (74.46 cm), so that they were significantly different from the control varieties Bara (a), Dewata 43 F1 (b), Ungara IPB (c), and Katokkon (d). The stem diameter character of the U/K//D/B (G4) genotype treatment produced the best stem diameter with a value of (11.07 cm), so it was significantly different from the reference variety Dewata 43 F1 (b). Genotype treatments U/B//D/K (G1), U/K//D/B (G4), and U/B//D/B (G7) produced the fastest flowering time with their respective values (38.83 DAP), (39.92 DAP), and (41.08 DAP), so that they were significantly different from the control varieties Bara (a), Dewata 43 F1 (b) and Katokkon (d). While the characters of harvesting age showed that genotype treatment U/B//D/K (G1) and U/K//D/B (G4) had the fastest harvesting age with respective values (70.42 DAP) and (71.42 DAP) so that significantly different from the control varieties Bara (a), Dewata 43 F1 (b), Ungara IPB (c), and Katokkon (d)

Table 1. Average plant height (cm), dichotomous height (cm), plant habitus (cm), stem diameter (mm), flowering age (DAP), and harvesting age (DAP).

Genotypes	Observation Parameters					
	Plant Height	Dichotomous Height	Plant Habitus	Stem Diameter	Flowering Age	Harvesting Age
G1 (U/B//D/K)	61.83 b	21.35 c	60.63	10.94b	38.83abd	70.42 a-d
G2 (U/D//B/U)	69.53 a-d	28.99 cd	78.25 a-d	10.89b	43.00d	73.17 ad
G3 (U/D//D/K)	60.83 b	27.31 cd	72.88 bcd	10.29b	41.58d	72.75 abd
G4 (U/K//D/B)	69.50 bcd	29.85 bcd	79.75 a-d	11.07b	39.92abd	71.42 a-d
G5 (U/D//D/B)	67.25 bcd	31.57 a-d	74.46 a-d	10.19	41.92d	73.00 ad
G6 (U/B//D/U)	63.42 b	25.53 cd	70.13 bc	10.27b	42.58d	73.42 ad
G7 (U/B//D/B)	69.67 a-d	30.92 a-d	66.49	10.48b	41.08 abd	73.75 ad
G8 (Bara) a	60.58	26.34	66.44	10.65	44.08	76.25
G9 (Dewata) b	51.00	25.10	62.65	9.00	43.83	75.42
G10 (Ungara) c	58.17	15.80	62.50	11.73	39.58	74.08
G11 (Katokkon) d	57.61	21.37	65.31	10.92	48.00	84.67
NP BNT 0.05 %	8.94	3.95	6.80	1.20	2.65	2.49

Note: Numbers followed by the same letters in columns (a,b,c,d) mean that they are significantly different from the genotypes for comparison G11 Bara (a), G12 Dewata 43 F1 (b), G13 Ungara IPB (c), G14 Katokkon (d), in the BNT test $\alpha = 0.05\%$. (B = Bara, D = Dewata, U = Ungara, K = Katokkon).

The results of the BNT test at the level of 0.05 in Table 2 show that the U/D//D/K (G3) and U/K//D/B (G4) genotype treatments had higher weight per fruit with their respective values (1.93 g) and (1.82 g) so that they were significantly different from the comparison variety Bara (a), Dewata 43 F1 (b). The U/D//B/U (G2) and U/B//D/B (G7) genotype treatments produced the highest fruit length with values (3.83 cm) and (3.61 cm), so that they were significantly different from the Bara control variety (a), Ungara IPB (c), and Katokkon (d). The fruit diameter character indicated that the genotype treatments were U/D//D/K (G3), U/B//D/U (G6),

U/K//D/B (G4), and U/B//D /B (G7) has the highest fruit diameter with respective values (10.49 mm), (10.11 mm), (9.57 mm), and (8.98 mm) so that it is significantly different from the comparison varieties Bara (a) and Dewata 43 F1 (b). The character of fruit stalk length indicated that the U/B//D/B (G7) and U/D//B/U (G2) genotype treatments had the highest fruit stalk length with values of (3.16 cm) and (3.03 cm) respectively, so that it is significantly different from the control varieties Bara (a), Dewata 43 F1 (b), Ungara IPB (c), and Katokkon (d). Meanwhile, the character of crop production showed that genotype treatments U/D//B/U (G2), U/D//D/B (G5), U/B//D/U (G6) had more crop production with respective values (582.05 g), (523.06 g), and (501.08 g), so that they were significantly different from the comparison varieties Ungara IPB (c), and Katokkon (d).

Table 2. Average fruit weight (g), fruit length (cm), fruit diameter (mm), fruit stalk length (cm), yield (g)

Genotypes	Observation Parameter				
	Fruit Weight	Fruit Length	Fruit Diameter	Fruit Stalk Length	Yield
G1 (U/B//D/K)	1.22	2.57	8.37	2.68	457.75 d
G2 (U/D//B/U)	1.72 a	3.83 acd	8.18	3.03 a-d	582.05 cd
G3 (U/D//D/K)	1.93 ab	3.93 cd	10.49 ab	2.75 c	472.23 d
G4 (U/K//D/B)	1.82 ab	3.53 cd	9.57 ab	2.89 bcd	476.51 d
G5 (U/D//D/B)	1.41	3.00 c	8.72 a	2.86 bcd	523.06 cd
G6 (U/B//D/U)	1.52 a	2.71	10.11 ab	2.64	501.08 cd
G7 (U/B//D/B)	1.69 a	3.61 acd	8.98 ab	3.16 a-d	468.43 d
G8 (Bara) a	0.96	3.00	7.37	2.68	555.53
G9 (Dewata) b	1.27	3.82	7.70	2.52	584.83
G10 (Ungara) c	2.03	2.31	13.12	2.41	384.53
G11 (Katokkon) d	4.19	2.44	22.79	2.42	203.32
NP BNT 0.05 %	0.51	0.57	1.22	0.34	101.83

Note: Numbers followed by the same letters in columns (a,b,c,d) mean that they are significantly different from the genotypes for comparison G11 Bara (a), G12 Dewata 43 F1 (b), G13 Ungara IPB (c), G14 Katokkon (d), in the BNT test $\alpha = 0.05\%$. (B = Bara, D = Dewata, U = Ungara, K = Katokkon).

Table 3. Heritability

No.	Parameter	Heritability	Note
		Value of h^2 (%)	
1	Plant Height	49	Medium
2	Dichotomous Height	80	High
3	Plant Habitus	70	High
4	Stem Diameter	39	Medium
5	Flowering Age	70	High
6	Harvesting Age	86	High
7	Fruit Weight	89	High
8	Fruit Length	71	High
9	Fruit Diameter	93	High
10	Fruit Stalk Length	53	High
11	Yield	74	High

Note: $0 < h^2 \leq 20$ (low), $21 < h^2 \leq 50$ (medium), $50 < h^2 \leq 100$ (high)

Table 3 shows that all the characters observed, both vegetative, generative and production components have moderate to high heritability values based on the index value of each character. The results of the heritability analysis in Table 3 show that there are 9 characters that have high heritability values and two characters have moderate heritability values. The highest heritability value was indicated by the character of fruit diameter (93%), weight per fruit (89%), harvest age (86%), dichotomous height (80%), crop production (74%), plant habitus (70%), age flowering (70%), fruit length (71%), fruit stalk length (53%). Characters with

moderate heritability values were owned by plant height and stem diameter with (49%) and (39%) values.

The results of the correlation coefficient analysis in Table 4 show the relationship between crop production characters and other characters. The results showed that the characters that were positively correlated were highly significant with the production of cayenne pepper, namely dichotomous height and fruit length with values of 0.41 and 0.56. The characters that have a very significant negative correlation with cayenne pepper crop production are harvesting age, fruit weight, and fruit diameter with each correlation value being -0.50, -0.73, and -0.86. While the other characters have no significant correlation with the production character of cayenne pepper plants.

Table 4. Correlation

	1	2	3	4	5	6	7	8	9	10	11
1	1.00	0.56**	0.39*	0.37*	-0.24tn	-0.29*	-0.10tn	0.19tn	-0.18tn	0.64**	0.19tn
2		1.00	0.57**	-0.35*	0.02tn	-0.27tn	-0.28tn	0.57**	-0.42**	0.55*	0.41**
3			1.00	-0.02tn	-0.04tn	-0.24tn	0.01tn	0.39*	-0.16tn	0.32*	0.27tn
4				1.00	-0.18tn	0.01tn	0.16tn	-0.35tn	0.23tn	0.15tn	-0.27tn
5					1.00	0.78**	0.50**	0.01tn	0.47**	-0.30*	-0.16tn
6						1.00	0.74**	-0.17tn	0.76**	-0.32*	-0.50**
7							1.00	-0.24tn	0.93**	-0.25tn	-0.73**
8								1.00	-0.49**	0.46**	0.56**
9									1.00	-0.42**	-0.86**
10										1.00	0.28tn
11											1.00

Note: numbers followed by signs are significantly different from table $r 0.05 = 0.29$ (*); $r 0.01 = 0.40$ ()**

- | | |
|-----------------------|------------------------|
| 1. Plant Height | 7. Fruit Weight |
| 2. Dichotomous Height | 8. Fruit Length |
| 3. Plant Habitus | 9. Fruit Diameter |
| 4. Stem Diameter | 10. Fruit Stalk Length |
| 5. Flowering Age | 11. Yield |
| 6. Harvesting Age | |

Based on this research, four varieties of double cross were carried out with double crosses which had specific characteristics and differed between varieties (Bara, Dewata 43 F1, Ungara IPB, and Katokkon). From the evaluation of these crosses, it was obtained characters that had a variety that had a very significant effect on several parameters except plant height and stem diameter. All genotypes observed showed differences due to the different genetic background of each cayenne pepper genotype. Therefore, these characters can be used as the defining character of the diversity of plant crosses. According to Ritonga, Sujiprihati, & Anggoro (2016), genetic diversity can describe variation between individuals in a population, so deeper studies are needed to determine the role of genetic factors in the variation that appears in each character.

Based on research conducted on several genotypes of cayenne pepper on the growth and production of cayenne pepper, three genotypes with high crop production were obtained and significantly different from the Ungara and Katokkon comparison varieties. The treatments were U/D//B/U (G2), U/D//D/B (G5), and U/B//D/U (G6) genotypes. This is due to the provision of a combination of fertilizers, namely organic and inorganic fertilizers. Where organic fertilizer (patent fertilizer) contains macro and micro nutrients and is easily absorbed by plants. The addition of a combination of fertilizers will trigger the addition of new branches and shoots, and will lead to the production of cayenne pepper. This is supported by the statements of Ege & Julung (2019), that a lack of nutrients in the soil can result in low productivity of cayenne pepper. If nutrients in the soil are not available, plant growth will be stunted and production will decrease. The expected crop production can be achieved if the amount and type of nutrients in the soil for plant growth are sufficient, balanced, and available according to the needs of the cayenne pepper plant.

Analysis of heritability can be a genetic parameter that needs to be known in relation to the process of selecting and incorporating important characters into a genotype. Characters that

have a high heritability value are dichotomous height, plant habitus, flowering age, harvesting age, fruit weight, fruit length, fruit diameter, fruit stalk length, crop production, and characters that have moderate heritability values, namely plant height and stem diameter. These characters indicate that high heritability values are influenced by genetic factors and can be used as characters for the selection process because they have a great chance of inheriting the next offspring. This is supported by the statement of Hakim, Syukur, & Wahyu (2019) that characters with high heritability values will facilitate character improvement through selection compared to characters with low heritability values. Estimation of heritability value has not fully demonstrated that this character is very effective as a reference as a selection character. So, it needs to be supported by knowing the magnitude of the direct and indirect influence given to these characters in influencing crop production. According to Sofian, Nandariyah, Djati & Sutarno (2019), selecting populations with high heritability proved more effective than the selection with low heritability. High heritability values indicated that most of the phenotypic variability resulted from genetic variability, hence, selection will experience genetic improvement. So, according to Amas et al. (2023), based on the analysis of variance and heritability, the selection process for the double and three-way cross populations of cayenne pepper was effective.

The results of the correlation analysis in Table 4 show that dichotomous height and fruit length have a very significant positive and negative correlation with crop production. This means that the height of the dichotomous and the length of the fruit will increase along with the increase in some characters of cayenne pepper. Characters that have a very significant positive and negative correlation show a high relationship between these traits, so that they can support the selection according to these characters. This is supported by the statement of Yakub, Kartina, Isminingsih, & Suroso (2012) that the correlation of two or more positive traits will facilitate selection because it is followed by an increase in one trait followed by another, so one or a selection index can be determined. However, this correlation cannot yet be an accurate proof. This is because the correlation value between the two characters is still influenced by the variety of the other characters which are indirect. According to Akbar, Bambang, Iswari, Willy & Sugiyanta (2019) and Hastini, Willy, Munif, & Hajrial (2019), correlation analysis aims to evaluate the relationship between the traits and their association with yield.

D. Conclusion

All the evaluation characters of double cross and three way-cross based on high heritability predictive value and followed by high genetic diversity are possessed by the characters of plant height, dichotomous height, plant habitus, flowering age, harvesting age, fruit weight, fruit length, fruit diameter, fruit stalk length, and crop production.

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Early Growth of Chrysanthemum Explants Due to Various Concentration of Coconut Water During In Vitro Propagation

AUTHORS INFO

Ifayanti Ridwan*
Universitas Hasanuddin
ifayanti@unhas.ac.id

Yunus Musa
Universitas Hasanuddin
yunusmusa@yahoo.com

Novaty E. Dunga
Universitas Hasanuddin
ndunga@agri.unhas.ac.id

Katriani Mantja
Universitas Hasanuddin
katriani@yahoo.co.id

Arfina Sukmawati Arifin
Universitas Hasanuddin
arfinasarifin@unhas.ac.id

Gusmiaty
Universitas Hasanuddin
unyhody@gmail.com

Idarni Tenri Pada Badwi
Tissue Culture Laboratory, Horticultural Plant
Seed Center, Gowa Regency
darnimks55@gmail.com

Muh. Farid BDR
Universitas Hasanuddin
farid_deni@yahoo.co.id

Rahmawati S.
Universitas Hasanuddin
rahmawatisainuddin@gmail.com

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Abstract

A study aimed to determine the effect of coconut water on the growth of *Chrysanthemum* explants was conducted. The study was carried out in the form of factorial experiments at Tissue Culture Laboratory, Department of Agronomy, Faculty of Agriculture, Hasanuddin University from December 2022 to March 2023. Media used was Murashige and Skoog (MS) added with three dose of coconut water, 100, 200, and 300 ml, respectively. Plantlets of five varieties of *Chrysanthemum*, Pinka Pinky, White Bakardy, Maruta, Kineta, and Dera obtained from Tissue Culture Laboratory, Horticultural Plant Seed Center, Bonto-bonto District, Gowa Regency. The explants were planted in Murashige and Skoog (MS) media containing the coconut water according to the treatments. Each combination of treatment was repeated three times. Results show that addition of 100 ml coconut water into the MS media was the best dose for plantlets growth indicated by earliest shoot emergence (9.04 days) and plantlet formation (9.25 days), and highest average number of leaves (15.00 leaves). The coconut water treatment of 200 ml showed the highest average number of roots (14.67 roots). Variation in responses between varieties were observed.

Keywords: *Chrysanthemum morifolium*, coconut water, in vitro, variety, auxins, cytokinins

A. Introduction

Chrysanthemum morifolium is an ornamental plant that has high economic value and has been very popular in Indonesia for the last two decades. Demand for chrysanthemums tends to increase every year. *Chrysanthemum* is the second largest traded cut flower in the world after roses. The demand for cut flowers and potted chrysanthemum plants in the both domestic and the international market is increasing from year to year. The development of chrysanthemum production in Indonesia has declined during the 2018-2022 period with an average decline of 13.35% per year (Indonesian Statistics Bureau, 2022). The large number of requests for chrysanthemum plants is not proportional to the parent plant preparations and the flower quality desired by the market. The number of mother plants is not enough to meet the availability of seeds for chrysanthemum propagation. The method that can be used to overcome the problem of availability of chrysanthemum seeds is by in vitro propagation. In vitro plant propagation method large quantities of chrysanthemum seeds can be produced in a short time.

The success of plant production using the tissue culture method is determined by the composition of the nutrients in the media. The medium used for in vitro propagation consists of macro and micro nutrients, vitamins, and hormones. One of the organic materials that can be added in tissue culture media is coconut water. Coconut water contains a complete chemical and nutritional composition such as hormones, macronutrients, micronutrients, vitamins, minerals and amino acids (Tuyekar, Tawade, Singh, Wagh, Vidhate, Yevale, Gaikwad & Kale, 2021) which have a positive effect on plant growth when applied to the plants. Some of the macronutrients contained in coconut water such as sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), protein, sugar, and are supported by two hormones, namely auxins and cytokinins (Aishwarya, Prashanth, Seenivasan, & Saida, 2022), that play a role in supporting cell division and plant growth.

Previous studies showed that the use of coconut water in the media can increase the growth of plants when added in to the basic growth media. The organic compound has been used in the in vitro propagation of different types of plants such as garlic (Nandariyah, Mahmudah, Arniputri & Sakya, 2021), orchids (Pratama & Nilahayati, 2018), mustard greens (Musawira, 2017). The best organogenesis of chrysanthemum in vitro for the formation of the number of shoots, shoot height and number of leaves was obtained on MS media + 200 ml of coconut water, but the response varied between varieties (Solihah, Supriyatna, & Adawiah, 2021).

B. Methodology

The study was conducted at Tissue Culture Laboratory, Department of Agronomy, Faculty of Agriculture, Hasanuddin University from December 2022 to March 2023. A Split Plot Design

was employed with coconut water as the main plot and Chrysanthemum variety as the Subplots. Three doses of coconut water of 100 ml, 200 ml, and 300 ml were added in to the Murashige and Skoog (MS) media as the basic media for the in vitro propagation. Five varieties of Chrysanthemum of Pinka Pinky, White Bakardy, Maruta, Kineta, and Dera were used. A total of 15 treatment combination was obtained. Each treatment combination consisted of two bottles with four explants planted in each culture bottle and repeated three times resulted in a total of 360 explants.

Culture bottles and planting tools were sterilized using autoclave set to temperature of 121 °C at 17.5 psi (pound per square inch) for 1 h. Media was prepared by mixing all stock solution (A, B, C, D, E, F, G and H) components sequentially one by one while stirring. The mix then added with 100 ml of coconut water, 20 grams of sugar, and the dose of coconut water according to the treatment. Sterile distilled water was added until the total volume reached to 1,000 ml. pH of the media was adjusted to 5.8 by adding NaOH or HCl before poured to a saucepan and add 7 gr of agar. The media is heated over an electric stove while stirring until it approaches the boiling point of 98°C. After the media boils, the media is removed and poured into culture bottles as much as 25 ml each. Furthermore, the culture bottle was covered with aluminum foil and tied with a rubber band. Media was sterilized using autoclave at temperature of 121 °C at 17.5 psi (pound per square inch) for 15 minutes

Source of explants was obtained from Tissue Culture Laboratory, Horticultural Plant Seed Center, Bonto-bonto District, Gowa Regency. Planting was conducted in a laminar air flow cabinet (LAF) that previously sterilized with alcohol 70% and UV light turned on for one hour. Plantlets of each variety were cut and sub cultured into the MS media contained coconut water according to the treatment levels. Plantlets were cut including two nodes with one node was immersed into the media.

Observation was made on growth of the explants as response to different coconut water and variety treatments. Data was then analyzed using a two-way analysis of variance (ANOVA). If there is a significant effect of treatments, a Tukey's further test was carried out at confidence level of 95% to test the difference between averages.

C. Result

Time to root emergence

Analysis of variance showed that the coconut water treatment did not have any significant effect on the time of root emergence of Chrysanthemum explants. No differences between the coconut water concentration of 100, 200, and 300 ml added to the MS media used, were observed. The parameter only significantly varied between the varieties. Table 1 shows time to roots emergence on the explants of Chrysanthemum. Kineta variety showed earliest root emergence of 5.24 days and was not significantly different to Dera and Maruta. Longest root emergence time of 7.71 days was observed in White Bakardy variety that was not different significantly to Pinky Pink variety (6.55 days). Variation detected in the recent study among the varieties of the chrysanthemum explants can be caused by the high degree of heterozygosity in the plant (Nasri, Zakizadeh, Vafae, & Mozafari (2021). Variation also found the previous studies such as in Solihah et al. (2021).

Table 1. Average time to root emergence (days) of Chrysanthemum explants in different coconut water treatments.

Variety	Media			Mean	Tukey's [V] 0.05
	MS + 100ml Coconut Water	MS + 200ml Coconut Water	MS + 300ml Coconut Water		
Pinka Pinky	6.17	6.67	6.81	6.55ab	
White Bakardy	6.33	8.29	8.50	7.71a	
Maruta	6.00	5.79	6.51	6.10bc	1.24
Kineta	4.75	5.54	5.42	5.24c	
Dera	4.69	5.83	6.33	5.62bc	
Mean	5.59	6.42	6.71	6.24	

Numbers followed by the same letter mean not significantly different based on Tukey's test at level of confidence of 95% ($\alpha=0.05$).

Time to Shoot Emergence

Based on analysis of variance, shoot emergence parameter on Chrysanthemum explants was significantly affected by the coconut water treatment and variety. Addition of 100 ml of coconut water into MS media resulted in earliest time to shoot emergence of 9.04 days in explant of White Bakardy variety (Table 2). Use of higher dose of coconut water of 200 ml and 300 ml resulted in earlier time to shoot emergence in variety of Maruta (9.58 days) and White Bakardy (9.87 days), respectively. The latest shoot emergence time was observed in Kineta variety (13.50 days) with 300 ml of coconut water in the MS media. Shoot formation on explants during in vitro propagation is regulated by the division and development of cells in the meristematic tissue of the plant. Coconut water in the media contain a complete composition of nutrients to allow the process. In addition, content of auxin and cytokine in the organic compound also stimulate the cell division and development (Aishwarya et al., 2022). In the recent study, a varied responses in the variety to increased coconut water doses were observed, in general higher doses of coconut water delay shoot emergence.

Table 2. Average time to shoot emergence (days) of Chrysanthemum explants in different coconut water treatments.

Variety (V)	Media (P)			Tukey's [V] 0.05
	MS + 100ml Coconut Water	MS + 200ml Coconut Water	MS + 300ml Coconut Water	
Pinka Pinky	10.30 ^a _p	10.92 ^a _p	10.38 ^a _q	2.02
White Bakardy	9.04 ^b _p	11.42 ^a _p	9.87 ^{ab} _q	
Maruta	9.08 ^a _p	9.58 ^a _p	9.92 ^a _q	
Kineta	9.55 ^b _p	9.72 ^b _p	13.50 ^a _p	
Dera	9.37 ^b _p	11.82 ^a _p	10.68 ^{ab} _q	
Tukey's [P] 0.05	2.54			

Numbers followed by the same letter (a,b) in the same row and (p,q) in the same column, mean not significantly different based on Tukey's test at level of confidence of 95% ($\alpha=0.05$).

Time to plantlet formation

Recent research show that plantlets formation of Chrysanthemum explants was varied between the coconut water dose and variety. Addition of 100 ml coconut water in Dera variety resulted in earliest time to plantlet formation (9.25 days) (Table 3). On the other hand, earlier time to plantlet formation was observed from the use of higher concentration of coconut water in the MS media (200 and 300 ml) in White Bakardy variety compared to other varieties. Successful of plant propagation using in vitro method depends on the composition of nutrients in the media. MS media is a basic in vitro media generally used to meet the requirement of the explants for formation of new shoots and roots on the explants. Despite the content of the basic media, presence of hormones also needed to direct the further growth of the newly formed organ. Coconut water serve to the media to provide the hormone namely auxin and cytokine (Aishwarya et al., 2022). Auxin is known to regulated the cell division and cytokine helps the plant in shoot formation, presence of both growth regulator will result in more effective growth of the planlets (Nandariyah et al., 2021).

Table 3. Average time to plantlet formation (days) of Chrysanthemum explants in different coconut water treatments.

Variety (V)	Media (P)			Tukey's [V] 0.05
	MS + 100ml Coconut Water	MS + 200ml Coconut Water	MS + 300ml Coconut Water	
Pinka Pinky	9.46 ^b _p	12.58 ^a _p	10.03 ^b _q	1.35
White Bakardy	9.63 ^a _p	9.45 ^a _q	10.00 ^a _q	
Maruta	9.33 ^a _p	10.17 ^a _q	10.08 ^a _q	
Kineta	9.55 ^b _p	9.75 ^b _q	12.50 ^a _p	
Dera	9.25 ^b _p	9.67 ^{ab} _q	10.92 ^a _q	

Tukey's [P] 0.05

1.38

Numbers followed by the same letter (a,b) in the same row and (p,q) in the same column, mean not significantly different based on Tukey's test at level of confidence of 95% ($\alpha=0.05$).

Number of leaves

Analysis of variance showed that number of leaves on the Chrysanthemum plantlets were differed between the concentration of coconut water added to the MS media. No significant difference were found between variety. Table 4 shows that concentration of 100 ml coconut water in the MS media resulted in highest leave numbers of Chrysanthemum plantlets of 15.00 leaves. Higher coconut water concentration in the media did not necessarily increase the number of plantlet leaves. A decreased value of the parameter observed when the concentration increased. However, a slight increase was observed in the parameter when the concentration increased to 300 ml. Organogenesis during in vitro propagation, including the formation of leaves, is mostly directed to the balance of auxins and cytokines hormones contained in the media. In this parameter, no difference found between varieties and leaves formation on the plantlets was significantly affected by the coconut water in the MS media. In addition to hormones, coconut water also contains sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), protein and sugar (Tuyekar et al., 2021). Study of Prando, Chiavazza, Faggio, & Contessa (2014) showed that the addition of 20% coconut water increased the number of adventitious shoots per explant.

Table 4. Average number of leaves (leaves) of Chrysanthemum plantlets in different coconut water treatments.

Variety (V)	Media (P)		
	MS + 100ml Coconut Water	MS + 200ml Coconut Water	MS + 300ml Coconut Water
Pinka Pinky	14.33	9.67	13.67
White Bakardy	14.33	10.67	11.33
Maruta	18.00	13.33	14.00
Kineta	14.00	14.33	13.33
Dera	14.33	12.67	13.67
Mean	15.00a	12.13b	13.20ab
Tukey's [P] 0.05		2.32	

Numbers followed by the same letter mean not significantly different based on Tukey's test at level of confidence of 95% ($\alpha=0.05$).

Number of Roots

Results show that number of roots formed on the plantlet of Chrysanthemum was affected significantly by the coconut water and variety treatments. Highest plantlet roots number of 14.67 roots was observed in the 200 ml of coconut water in Maruta variety. In fact, almost all variety showed higher root formation the 200 ml coconut water treatment added to MS media compared to other two treatments of 100 and 300 ml of coconut water in all variety except in Kineta variety which number of roots increased with the coconut water concentration (Table 5). Root formation is one of important processes in the plant propagation using in vitro method. Roots play important role in nutrition absorption of the plantlets from the media. Initiation of root and further growth can be hastened by the addition of plant growth regulator in the media. Due to its content of different plant growth regulators, coconut water is considered as root hormone (Prando et al., 2014). The natural Auxin in coconut water help the development of the adventitious roots on the Chrysanthemum explants.

Table 5. Average number of root (roots) of Chrysanthemum plantlets in different coconut water treatments.

Variety (V)	Media (P)			Tukey's [V] 0.05
	MS + 100ml Coconut Water	MS + 200ml Coconut Water	MS + 300ml Coconut Water	

Pinka Pinky	2.81 ^{c_r}	14.27 ^{a_p}	7.10 ^{b_{qr}}	
White Bakardy	8.10 ^{b_{pq}}	12.20 ^{a_p}	10.20 ^{ab_q}	
Maruta	9.38^{b_p}	14.67^{a_p}	14.65^{a_p}	3.36
Kineta	4.91 ^{b_{qr}}	5.83 ^{b_q}	10.05 ^{a_q}	
Dera	7.88 ^{ab_{pq}}	10.86 ^{a_p}	5.50 ^{b_c}	
Tukey's [P] 0.05		4.26		

Numbers followed by the same letter (a,b) in the same row and (p,q) in the same column, mean not significantly different based on Tukey's test at level of confidence of 95% ($\alpha=0.05$).

Number of Shoots

Shoot formation in all variety of Chrysanthemum's plantlets was not significantly affected by the coconut water treatments. Number of shoots varied between varieties and ranged between 1 and 1.67 shoots. Highest number of shoots was shown by White Bakardy and Kineta variety each with the use of 300 ml coconut water in the MS media (Figure 1). While the lowest shoot numbers was observed in Maruta and Kineta variety. Despite the insignificant results of the treatments, number of shoots tend to increase with the dose of coconut water in the MS media. Highest average number of shoots (1.4 shoots) was observed in the 300 ml coconut water treatment. The dose of coconut water in the recent study was higher than what use in the previous study by Musawira (2017) which was 200 ml + MS media. Nutrition in the coconut water in addition to the content of macronutrients, micronutrients, and vitamin the MS media can support the cell division in the meristematic tissue of the plantlets which at the later stage forming new shoots.

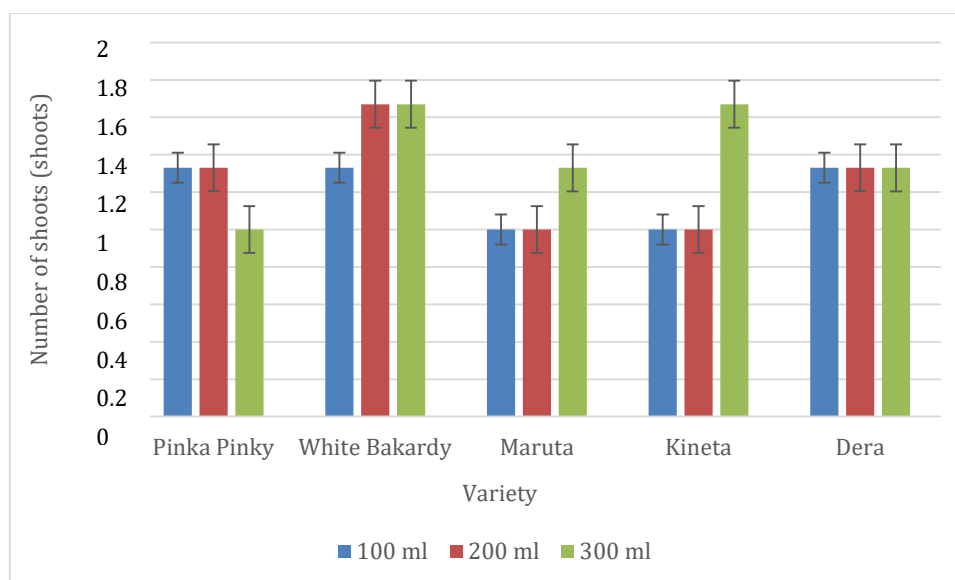


Figure 1. Average Number of Shoots (shoots) of Chrysanthemum plantlets in different coconut water treatments.

D. Conclusion

Modified MS media used by the addition of coconut water for in vitro propagation of Chrysanthemum explants can improve the early growth of explants. The best dose for plantlets growth was 100 ml indicated by earliest shoot emergence (9.04 days) and plantlet formation (9.25 days), and highest average number of leaves (15.00 leaves). The coconut water treatment of 200 ml showed the highest average number of roots (14.67 roots). Varied responses of the varieties used in this study indicated a strong genetically differences between the varieties in responding to the coconut water treatments in all parameter observed.

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Number of Seedlings per Clump and NPK fertilization Effect on Growth and Yield of Lowland Rice Based on The Leaf-Color Chart

AUTHORS INFO

Hairmaudiana
Student of Agrotechnology Departement
USN Kolaka
hairmaudianairma0@gmail.com

Marlina Mustafa*
USN Kolaka
linamarlinamus@gmail.com

Mustafa R
USN Kolaka
mustafa.usn64@gmail.com

Musadia Afa
USN Kolaka
musadiaafa@gmail.com

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Abstract

Excellent seedling selection and NPK fertilization can accelerate seedling, stem, leaf, and fruit growth. This study aimed to determine the effect of the number of seedlings and NPK-Phonska fertilizer on the growth and yield of lowland rice based on the leaf-color chart approach. This study was conducted from December 2021 to April 2022 in Puuroda Village, Baula, Kolaka. This study applied a randomized block experimental design with two-factor treatments, namely the number of seedlings and NPK-Phonska fertilizer dose. For the number of seedlings factor, there were one seedling per clump (B1), two seedlings per clump (B2), and three seedlings per clump (B3). The NPK-Phonska fertilizer factor contained two treatments, namely, without fertilizer treatment (M0) and fertilizer treatment based on the average dose of leaf-color chart (M1). The results of this study showed that two and three seedlings per clump had higher growth and yield of lowland rice, based on the plant height, maximum number of tillers, number of productive tillers, panicle length, dry grain yield (kg/plot), grain yield (ton/ha). The NPK fertilizer affects the growth and yield of lowland rice based on the leaf-color chart.

Keywords: Number of seeds, NPK Fertilization, leaf color chart

A. Introduction

Rice plant (*Oryza sativa* L.) is one of the important food commodities for the Indonesian community as most Indonesians utilize rice as a consumed staple food. In Indonesia, several rice plants have been applied by farmers, i.e. lowland rice plants. Therefore, these rice plants are highly recommended as an important and strategic plan for national food security (BALITPA, 2009).

According to the Southeast Sulawesi Bureau of Statistics (BPS Sultra, 2021), Southeast Sulawesi is one of the potential regions for lowland rice plant development, with a field area of 93,000 ha. The productivity of lowland rice plants in Southeast Sulawesi is considered as low, with an average production of 4.1 ton ha⁻¹. The lowland rice production in Kolaka District only reaches 3.8 ton ha⁻¹. This production value is below the average production of Southeast Sulawesi. The low production of lowland rice plants is caused by limited fertilized land, as the developing lands for lowland rice plants around Southeast Sulawesi are ultisol marginal lands Nurmas, Nofianti, Abdul, & Andi, 2014). Furthermore, Nurmas *et al.* (2014) also stated that these lands had extremely low carrying capacity levels due to poor nutrient contents, thus requiring fertilizer.

Obtaining an optimal level of seedling production is a highly influential component. However, many farmers still use seeds with a relatively large number of seedlings (7-9 seedlings per clump, even more than 10 seedlings per clump). According to Gani (2003) and Abdullah (2004), planting with relatively more seeds (5-10 seedlings per clump or > 10 seedlings per clump) causes intense competition among rice plants (inter-species competition) to obtain water, nutrients, CO₂, O₂, light, and space to grow, resulting in an abnormal growth in plants.

Lowland rice productivity faces various problems, including massive technological innovation in producing lowland rice cultivation systems and high farming cost reduction requirements. Using overdosed fertilizers imbalances the types and doses of fertilizers as nutrient supplies needed by plants. Instead of increasing crop productivity, this condition causes the lands to become increasingly depleted, and plants to grow improperly. Intensive and continuous utilization of rice fields for years can decrease the soil fertility level and damage the physical and chemical properties of the soil.

According to Sutedjo (1995), nitrogen, phosphorus, and potassium supplies in soil are limited for plant growth, thus, fertilization should be applied using N, P, and K fertilizers. The N, P, and K fertilizers have important roles in plant growth and production, whereas the interaction of these matters will support plant growth and production. The leaf-color chart (LCC) is useful for identifying the adequacy of N in lowland rice plants. If N is adequate, other nutrient requirements, such as P and K, will increase to compensate for the fast plant growth rate (Fairhurst, Dobermaan, Quijono-Guerta, & Balasubramanian, 2007).

The leaf-color chart (LCC) is a color scale that contains four color scales of leaves, whereas scale 2 possesses a yellowish-green color and scale 5 possesses dark green color. These scales are calculated based on the scales in the tool to measure an effective leaf chlorophyll content that can be used as a consideration for nitrogen fertilization in rice plants. This tool can also detect nitrogen contents in the leaves.

B. Methodology and Method

This study was performed in Puuroda Village, Baula District, Kolaka Regency, Southeast Sulawesi, from December 2021 to April 2022. This study used a randomized block design in a factorial treatment pattern with two factors: the number of seedlings and NPK fertilizer dose factors. For the number of seedlings factor, there were three treatments applied, i.e. one seedling per clump (B1), two seedlings per clump (B2), and three seedlings per clump (B3). Two treatments are applied for the NPK fertilizer factor, i.e., without NPK fertilizer application (M0) and fertilizer application, based on the average recommended dose in LCC (M1).

The experiment was started by sowing the seedlings for 21 days and transplanting the seedlings to a 3 m x 4 m experimental plot with 25 cm x 25 cm spacing. Seedlings were maintained until the harvest period, followed by pest and disease control. The observed characters were plant height (cm), maximum number of tillers, number of productive tillers, 50% flowering age, panicle length (cm), number of grains per panicle, number of filled grains per panicle, weight of 1000 milled dry grains, total plant dry weight (gram), dried grain yield (kg/plot), and grain yield (ton/ha).

Data were analyzed using the analysis of variance, continued by Duncan's multiple range test, when the F-count was higher than the F-table at 95% and 99% degree of confidence. This test was proposed to obtain a significant or a highly significant difference among the treatments applied.

C. Result

Based on the analysis of variance results, no interaction occurred between number of seedlings and NPK fertilization factors on all observed variables in this study, namely plant height, maximum number of tillers, number of productive tillers, 50% flowering age, panicle

length, number of grain per panicle, number of filled grains per panicle, weight of 1000 grains, total plant dry weight, dried grain yield (kg/plot), and grain yield (ton/ha).

The number of seedlings per clump has a highly significant effect on plant height, whereas the bigger the plant population, the higher plant height growth because the initial nutrients for growth have been fulfilled. Dangulo, Lapanjang, & Made (2017) stated that the highest plant height was produced in bigger plant populations in one stretch. Likewise, the fertilization treatment significantly affected plant height, indicating that the application of fertilizer is sufficient for the nutrient availability in the soil. Lakitan (1996) stated that light intensity was important for plant growth because it affected the photosynthesis process and height growth. However, the interaction between the two treatments had no significant effect on plant height.

Table 1. Growth variable observation

Treatment	Variable				
	Plant height (cm)	Maximum number of tillers	Number of productive tillers	50% flowering age	Total dry weight (gram)
B1	-	11.27 ^q	8.17 ^r	-	-
B2	-	14.53 ^q	15.67 ^p	-	-
B3	-	20.83 ^p	12.33 ^q	-	-
M0	112.88 ^b	13.22 ^b	11.33 ^b	54.56 ^b	346.11 ^b
M1	123.18 ^a	17.87 ^a	12.78 ^a	56.00 ^a	587.42 ^a

Note: The average numbers followed by similar superscript letters at the same line (a,b) or column (p,q) show a significantly different value, based on Duncan's multiple range with 0.05 degree of confidence.

The number of seedlings per clump significantly affects the number of productive tillers because a greater number of seedlings per clump will produce more productive tillers. However, the presence of rat pests that attack stems will reduce the maximum number of tillers and productive tillers. Number of seedlings per clump affected the existing population, growth of productive tillers, and rice production yield. The fertilization treatment significantly affected the maximum number of tillers and the number of productive tillers because applying fertilizer can provide the N, P, and K nutrients required by plants. According to Lingga and Marsono (2001), adding nitrogen (N) as a component in amino acids and proteins can stimulate vegetative growth in branches, stems, and leaves by assisting the cell protoplasm formation, thus stimulating growth. However, the interaction of the two factors had no significant effect on the maximum number of tillers and productive tillers.

The number of seedlings per clump had no significant effect on 50% flowering age. Genetic factors and environmental conditions influence the flowering age, so the number of seedlings per clump obtained no significant difference in the harvesting age. According to Susilo (2015), vegetative growth allows plants to accumulate greater photosynthetic results and possibly extend the flowering age, when environmental factors, such as light, temperature, and water are mutually supportive. The harvesting period is influenced by many factors, including plant genetics, temperature, rainfall, and light intensity received by the plants.

Table 2. Variable observation result

Treatment	Variable					
	Panicle length (cm)	Number of grains per panicle (grains)	Number of filled grains per panicle (grains)	Weight of 1000 grains (gram)	Dry grain yield (kg/plot)	Grain yield (ton/ha)
B1	-	-	134.17 ^q	-	5.05 ^r	4.23 ^r
B2	-	-	151.13 ^p	-	11.01 ^p	9.17 ^p
B3	-	-	148.28 ^q	-	9.25 ^q	7.71 ^q
M0	28.32 ^b	158.42 ^b	132.64 ^b	24.91 ^b	7.50 ^b	6.26 ^b
M1	29.93 ^a	180.13 ^a	147.91 ^a	25.72 ^a	9.38 ^a	7.81 ^a

Note: The average numbers followed by similar superscript letters at the same line (a,b) or column (p,q) show a significantly different value, based on Duncan's multiple range with 0.05 degree of confidence.

The fertilization treatment significantly affected the total plant dry weight, because fertilizer provides N, P, and K nutrients. The availability of macro-nutrients, e.g., nitrogen (N), phosphorus (P), and potassium (K) in the soil could activate the meristematic cells at the tip of the stem, facilitate photosynthesis, and increase the organic matter accumulation, thereby producing a maximum grain.

The number of seedlings per clump significantly affected panicle length as a small number of seedlings could utilize the available nutrients, sunlight, and water well. The panicle length also depends on the plant variety, which affects the number of grains per panicle. The amount of grain formed in each panicle is determined by the panicle length, as each can produce grain (Darwis, 1979). The fertilization treatment significantly affected panicle length, because this treatment could fulfill the nutrient availability in the formation of panicle length. By applying a proper fertilizer dose, plants can increase their panicle length optimally. Setyamidjaja & Wirasmoko (1999) stated that optimal fertilization efficiency was achieved if the fertilizer was stocked with an appropriate dose for plants. The panicle length influences the number of grains per panicle, whereas panicle length is influenced by the panicle initiation period, namely the cropping period. However, the fertilization treatment did not significantly affect the number of grains per panicle, the number of grains in each panicle was determined by the length of the panicle and the number of panicle branches, where each of which could produce grain (Masdar, 2005).

The number of seedlings per clump had a significant effect on dry grain yield (kg/plot) and grain yield (tonnes/ha). This condition was occurred because grain filling was ongoing along with the photosynthesis process. Based on Gardner, Pearce & Mitchell (1991), the photosynthesis process during the grain filling period is the most important part to gain an optimal yield. Before filling, the assimilate grains are used for the vegetative phase and flower formation. During the filling, most of the assimilate products are used for the filling process. The fertilization treatment significantly affected dry grain yield (kg/plot) and grain yield (ton/ha), because NPK fertilizer could provide sufficient nutrients for plant growth to reduce empty grain. A decreased empty grain indicates that rice plants responded to P and K fertilizers. Phosphorus absorbed by plants will be distributed to living cells, especially in the reproductive plant parts, such as stimulating the tiller development, increasing the number of grains per panicle, and accelerating the flowering period and seed formation.

D. Conclusion

Based on the results performed in Puuroda Village, Baula Sub-district, Kolaka District, this study concludes that:

1. The best seedlings per clump treatment is presented in 2 seedlings per clump. This treatment significantly affected the plant height, number of productive tillers, maximum number of tillers, panicle length, dry grain yield (kg/plot), and grain yield (ton/ha). However, no significant effect occurred in the 50% flowering period, panicle length, number of grains per panicle, number of filled grains per panicle, and weight of 1000 grains.
2. The NPK compound fertilizer had a significant effect on all observed variables, namely the plant height, maximum number of tillers, number of productive tillers, 50% flowering period, panicle length, number of grains per panicle, number of filled grains per panicle, weight of 1000 grains, dry grain yield (kg/plot), and grain yield (ton/ha).
3. There are no interactions between the number of seedlings per clump and *Phonska* NPK compound fertilizer on the growth and yield of lowland rice, based on the leaf-color chart.

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

AUTHORS INFO

Muh. Farid BDR*
Universitas Hasanuddin
farid_deni@yahoo.co.id

Haris Syaputra Renhard
Universitas Hasanuddin
harissyaputra00@gmail.com

Nur Qalbi Zaesar Muharram
Universitas Hasanuddin
zaizarizar@gmail.com

Mukminati
Universitas Hasanuddin
mukminatinina@gmail.com

Muh. Fuad Anshori
Universitas Hasanuddin
fuad.anshori@unhas.ac.id

Nirwansyah Amier
Universitas Hasanuddin
amieramier1819@gmail.com

Andi Isti Sakinah
Universitas Hasanuddin
andiistisakinah@gmail.com

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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 inpage 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 Inpage 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 inpage 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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