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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 saliency 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 Ddevelopment 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, Paltten, & 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.

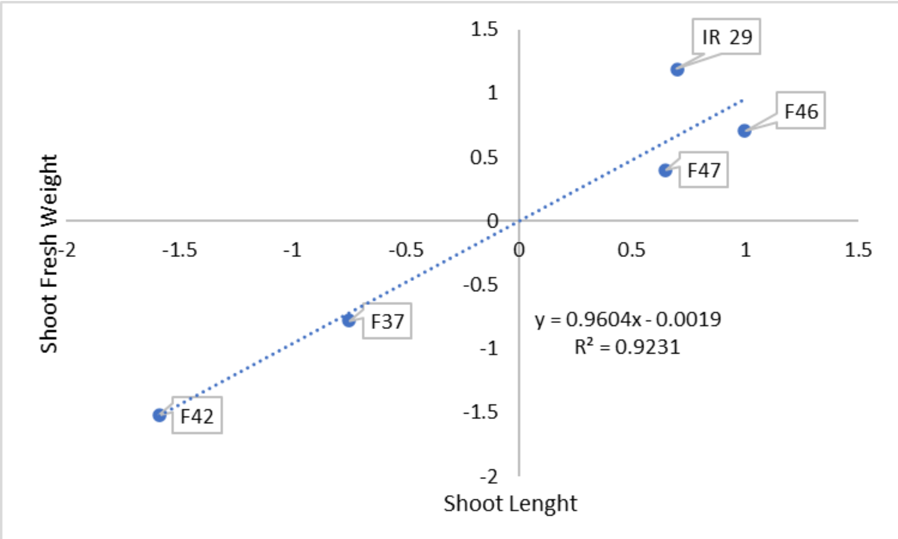

Figure 1. Regression analysis of shoot length and shoot fresh weight

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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