



Character Selection and Tolerance Screening Effectivity on Static Hydroponic Method Under Drought Stress in Rice

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Abstract

This research was aimed to evaluate the effectivity of screening method and identification of tolerance screening selection character in static hydroponic system towards drought stress. The research was carried out in Hydroponic Screenhouse Perdos Unhas, Tamalanrea, Makassar which throughout February-April 2020. This research was conducted in factorial design in nested patterns, where environment was the nested replication. Environments used were normal (0% PEG) and drought stress (10% PEG). Five rice varieties were used: Inpari 34, Ciherang, IR29 and Jeliteng. Research result showed that canopy height and fresh weight were the suitable selection character in drought tolerance screening through static hydroponic cultivation. Grouping consistency was found between drought and salinity stress. Inpari 34, Ciherang, Jeliteng and Inpari 29 was considered to be have drought tolerance, whilst IR29 was examined to be responsive to drought stress in hydroponic culture. From the overall result, it can be concluded that hydroponic screening and PEG application was quite effective in rice drought stress tolerance screening

Keywords: osmotic stress, screening effectivity, static hydroponic, selection character, PEG 6000

A. Introduction

There are 53,963.705 ha or 28.67% area of unoptimized dry lands for agriculture development purposes in Indonesia. Such land optimization can be done in order to increase agriculture production, mainly rice as the primary staple of Indonesian people. Along with population increase which is estimated to reach 1.49% in 2025-2030 (BBSDL, 2020; Dirjen PSP, 2013), so will the demand of rice, reaching to 39.8 million tons. However, dry land cultivation are facing a number of obstacles in terms of the plant's survival. To ensure rice plants survival in drought condition, drought tolerance variety cultivation is the most simple and economical solution.

Rice is sensitive to drought stress and has various amount of water needed for its growth. Production decline due to drought is influenced by the stress level, the growing phase where the stress was occurred, and variety (Lang, Binth, Nha, & Buu, 2010). Plants that experienced drought throughout their vegetative state will continue to the generative state and will cause yield loss for more than 50% (Akram, Ali, Sattar, Rehman & Bibi, 2013). Water deficiency will disrupt cellular functions in plants and will negatively impact plant growth and reproduction (Bray, 2001). Afrianingsih, Susanto, & Ardiarini (2018) argued that the capability of a genotype to recover following a stress in the early stages of growth is a positive sign in rice development, hence it is necessary to understand the morphological, physiology, and biochemistry aspects in tolerance mechanisms as a strategic effort in developing salinity tolerant cultivar and adaptable in dry lands. Determination of drought tolerant genotype characters can be done through tolerance screening.

Drought tolerance screening can be conducted in the target environment or artificially. Targeted environment screening requires lengthy amount of time and comes with expensive cost (Anshori, Purwoko, Dewi, Ardie, & Suwarno, 2018). Furthermore, varied soil conditions will cause uncontrollable drought levels in an area. Artificial screening enables more controlled selection environment, making it more precised in determining genotype tolerance (Faisal, Mustafa, & Yunus, 2019). Rice artificial screening has been reported in a number of research, both in vegetative and generative growing stage (Anshori et al. 2018; Akbar, Purwoko, Dewi, & Suwarno, 2018a; Akbar, Dewi, Suwarno, & Sugiyanta, 2018b). Tolerance screening in rice vegetative phase were mostly done through controlled water application. This was considered less definitive due to uneven soil nutrient availability management, hence lacked in information regarding optimal line character in drought stress. Therefore, hydroponic screening was considered as an alternative in determining optimal potential of a genotype under drought stress.

Hydroponic based drought induction can be carried out with polyethylene glycol (PEG) 6000 which is identical to the drought stress in the field. According to Sumadji & Ganjairi (2017), PEG 6000 solution of high molecule weight decreases plant's water potential in nutrient solution without absorption to plants, making it non toxic. This method had been applied on various plants as reported by Pharmawati, Made, Wirasti, & Wrasati (2017) that under -0.52 Mpa water potential concentration with PEG 6000 given during generative phase could cause straw fresh weight decline and panicle total weight in IR64 up to 50%. PEG 6000 usage in dihaploid rice

lines germinating phase screening under drought stress had been reported by Akbar et al (2018a). The solution is able to be used as an alternative to drought stress selection in hydroponic culture. The determination was necessary to be conducted on a number of released varieties to examine their effectivities. The research aimed to evaluate screening method and identify selection character tolerance screening in static hydroponic system under drought stress.

B. Methodology

This research was carried out throughout February-April 2020 in Perumahan Dosen Unhas Jl. Algazali Blok BG. 9, Makassar, South Sulawesi. The research was conducted in randomized group nested design, where PEG 6000 was the nested replication. PEG concentration used were 0% (normal) and 10% (stress). Five rice varieties were used: Inpari 34 Salin Agritan (V1), Ciherang (V2), IR 29 (V3), Inpari 29 (v4), and Jeliteng (V5). The experiment was replicated three times, resulting in 30 experimental units. Each experimental unit consisted of three samples, therefore resulting 90 observation units.

The experiment was done with hydroponic system according to modified IRRI Standard Evaluation System (SES) (IRRI, 2013). Seeds from each variety were firstly germinated in germinating containers. Seeds that grew well were transplanted in treatment container seven days after sowing with Abmix volume 8 L per container. AB mix concentration used was 5 mL/L water each stock solution. Seedlings then were transplanted in foam container and inserted in styrofoam holes. Each hole was 2 cm in diameter with 4 cm x 3 cm spacing. PEG application was done as osmotic stress induction on 14 days after sowing gradually to prevent osmotic shock (Swapna & Shylaraj, 2017). 5% PEG 6000 was given in the first stage of concentration application, equal to 500 g PEG per liter. PEG concentration was optimized to 10% after three days. On contrary, plants with PEG 0% treatment (control) were planted in normal condition with AB mix hydroponic solution. Maintenance included nutrient application, pH value checking and water checking and nutrient container cleaning. Solution pH was maintained at 5,0-5,1 with NaOH 1N and HCl 1N.

Tolerance character and biomass harvest was observed at 14 days after application. Observed parameters included canopy height (cm), number of tillers, number of leaves, root length (cm), fresh root weight (g) and fresh canopy weight (g). Obtained data were then analysis with ANOVA. Characters that indicated significant interaction will be proceeded with relative derivation analysis and tolerance mapping from five tested varieties. Software used for analysis was STAR 2.1.

C. Result and Discussion

Analysis of variance showed variety influenced significantly towards number of leaves, canopy height and fresh canopy weight. Significant effect was also shown in varied PEG concentration towards number of tussels, number of leaves, canopy height and fresh canopy weight. Even so, interactions between varieties and PEG concentration only presented significant value on canopy height and fresh weight. According to the result, these two characters are recommended as selection characters.

Table 1. Analysis of variance of six morphology characters in drought screening through hydroponic culture

Character	Source of Variance			CV
	Variety (V)	Concentration (K)	V*K	
Number of tussels	0.0613	0.002**	0.3849	16.59
Number of leaves	0.0129*	0.0006**	0.2407	10.10
Canopy Height	0.0001**	0.0000**	0.0043**	6.08
Root Length	0.0043**	0.5092	0.9701	12.92
Fresh Canopy Weight	0.0001**	0.0004**	0.0000**	12.05
Fresh Root Weight	0.8651	0.2454	0.1689	25.62

Analysis of variance is one of determining indicator on tolerance screening effectivity under a certain stress (Al-Amin, Islam, Begum, Alam, Moniruzzaman, & Patwary, 2013; Al-Naggar, Sabry, Atta & El-Aleem, 2015; Safitri, Purwoko, Dewi, & Ardie, 2016). Effectivity evaluation was weighed on the significant influence of the interactions. Significant interaction effects between

genotypes and environment will deliver varied respon pattern of genotype on different growing environment (Akçura & Çeri, 2011; Safitri *et al.* 2016; Anshori *et al.*, 2019). If this was related with drought stress tolerance, significant interactions of a character would show different adaptability respond of genotypes under drought stress. For this reason, canopy height and fresh weight can be used in tolerance screening evaluation. This was also supported by research conducted by Anshori *et al.* (2020) that delivered significant interactions of canopy height and fresh weight in rice tolerance screening through hydroponic culture. Despite the fact that salinity was used in the research, the stress was relatively similar to drought in terms of osmotic stress (Ghosh, Ali, & Saikat, 2016; Reddy, Kim, Yoon, Kim, & Kwon, 2017), thus making them tolerance screening indicator to osmotic stress. Therefore, both characters were the base for the next analysis in this research.

Canopy height and fresh weight as selection characters in static hydroponic system also indicated that drought stress or osmotic effected more on canopy compared to the roots. Generally, when plants experience drought stress, the growth will be focused on root development. This is to optimize water and nutrient absorbtion width for fulfilling both of needs in plants (Mohamadi, Bagheri, Kiani, & Jelodar, 2017). However, relatively tolerant tenotype are able to make efficient water balance for plant growth, resulting in more adaptable cell division or canopy growth compared to responsive genotypes (Anshori *et al.*, 2020). Osmotic stress will induce a number of osmoticum regulator compounds. Relatively responsive plants will produce large amount of osmoticum compound. The similar result was also discovered by Anshori *et al.* (2019) on dihaploid rice towards salinity stress. The occurance caused minimal canopy growth due to decreased energy and photosintate, influencing some of canopy characters. Inhibited canopy growth was also supported with absisic acid hormone induced during the occurred drought stress (Chaturvedi, Singh, Bahadur, 2012; Sah, Reddy, & Li, 2016). Thus, canopy growth was more considered as selection character compared to root characters.

Relative reduction from canopy height and fresh weight is shown in Table 2. The relative reduction from canopy height averaged in 31.02%, while the average relative reduction from canopy fresh weight was 65%. V3 was the most impacted variety, indicated in plant height (41.01%) and fresh canopy weight (79.38%). Varieties with low relative reduction were V1 (26.66%), V2 (27.36%), and V5 (26.74%) on canopy height as well as V4 (58.20%) for fresh canopy weight.

Table 2. Average value and relative reduction of characters with significant interactions in drought screening through hydroponic culture

Character	Environment	Variety					Avg.
		V1	V2	V3	V4	V5	
Canopy Height	Normal (cm)	55.13	52.33	64.61	62.49	48.28	56.57
	Drought (cm)	40.43	38.01	38.11	41.68	35.37	38.72
	RD (%)	26.66	27.36	41.01	33.31	26.74	31.02
Canopy Fresh Weight	Normal (g)	4.8	4.56	7.45	4.96	4.3	5.21
	Drought (g)	1.78	1.71	1.54	2.07	1.64	1.75
	RD (%)	62.99	62.55	79.38	58.20	61.89	65.00

Relative reduction is an approach in order to evaluate tolerance of a genotype. This variable using has been widely reported in researches related to environmental stress screening in various plants (Ali, Yeasmin, Gantait, Goswami, & Chakraborty, 2014; Krishnamurthy, Sharma, Gautama, & Kumar, 2014; Souleymane, Nartey, Manneh, Danquah & Ofori, 2016; Safitri *et al.* 2016). Based on this analysis, fresh canopy weight gave more relative reduction value compared to canopy height in drought stress. Commonly, fresh canopy weight is a character directly related to canopy water content. On the other hand, plant height indirectly related to water content in the plant (Anshori *et al.*, 2020). Based on the statement, Fresh canopy weight gave more negative impact result compared to plant height under salinity through hydroponic screening. Similarly, it was also reported by Anshori *et al.* (2020) on rice salinity screening and Kumar, Binodh, Saravanan, Senthil, & Kumar, (2019) on rice drough screening. Therefore, fresh canopy weight screening was more prioritized as selection character.

Tolerance mapping result of five rice varieties under drought stress was shown in Picture 1. V3 is shown in the first quadrant with high relative reduction in canopy height and fresh weight. V1, V2, and V5 is found in third quadrant with below average relative reduction values both on

canopy height and fresh weight. V4 found in fourth quadrant indicated low relative reduction towards canopy fresh weight yet with above average canopy height relative reduction.

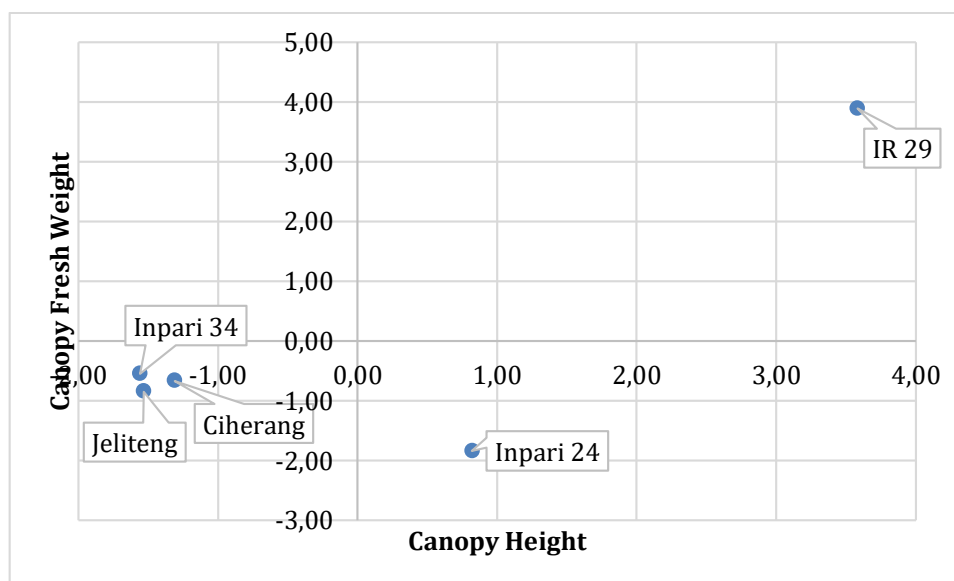


Figure 1. Tolerance mapping of five characters according to selection character

According to the mapping in Picture 1., canopy height and fresh weight was shown having the same tolerance, excluding Inpari 29. This indicated that the drought tolerance character evaluation based on the two characters had high precision. Based on the previous discussion, however, canopy fresh weight was more prioritized in genotype evaluation compared to canopy height. Thus, Inpari 29 was considered having moderate tolerance under drought stress. This was caused due to high amount of abscisic acid and cell resistency in order to maintain its turgor (Munns & Tester, 2008), therefore pushing lower canopy weight reduction and inhibit relative plant growth. Despite the stated fact, the two characters can be recommended as a pair of drought tolerance selection criteria in hydroponic culture.

Mapping result can be used to illustrated consistency between drought stress and salinity according to the mapping result in this research. Inpari Agritan 34 as salinity tolerant also has good tolerance in PEG induced drought stress. Toxicity is also a primary stress besides osmotic. However, relative salinity tolerance plants have good drought tolerance. The overall result can be concluded that static hydroponic with PEG selection had good effectivity in drought stress genotype selection.

D. Conclusion

Hydroponic screening and PEG 6000 application was considered quite effective in rice tolerance screening towards drought stress. Canopy height and fresh weight were good selection characters in drought stress tolerance screening. Grouping consistency was found between drought and salinity stress. Inpari 34, Ciherang, Jebbliteng and Inpari 29 was considered having good tolerance under drought stress, whilst IR29 was considered as responsive variety under drought stress in hydroponic culture.

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