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Hydroponic Salinity Screening by Deep Flow Technique on All Paddy Growing Phases

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Abstract

Salinity screening under hydroponic Deep Flow Technique (DFT) has not been widely studied, especially on the nature of rice tolerance to salinity stress. According to previous screening studies, this method was effective in distinguishing the nature of rice tolerance to salinity stress. However, they were tested only at generative phase. Therefore, evaluation on screening method with hydroponic DFT at all phases of paddy growth is essential. The objective of this study is to evaluate the filtering under hydroponic DFT at all paddy phase and to determine secondary character that support productivity which can be utilized as selection character in this screening process. The experiment was arranged with a complete nested group design with nested replication is the NaCl stress. There were 5 (Five) tested rice varieties and the stress environment consisted of three levels: 0, 60, and 120 mM of NaCl, all with 3 (three) replications. The nutrient culture screening was adapted to the modified Egdane method. The results showed that screening under hydroponic DFT was effective at the concentration of 60 nM of NaCl. The best selection character was yields per clump, number of productive tillers and total chlorophyll. The variety of Jeliteng, Ciherang and Inpari 34 of Salin Agritan, were classified as tolerant group. This hydroponic DFT Filtering method could be recommended as one salinity screening method for all paddy growing phases

Keywords: DFT, rice screening, *Oryza sativa,* path analysis, salinity tolerance rice

A. Introduction

Rice has been main food consumed by most Indonesian people. Indonesia's population growth rate in 2025-2030 is estimated to reach 1.49% or 286.02 million people with rice consumption can be as much as 139.5 kg per capita, resulting in rice demand for the nation reaching 39.8 million tons (Directorate General of Agricultural Facilities and Infrastructure, 2013). Efforts for increasing production such as expansion of planting fields, especially in sub-optimal areas. However, such areas have several limiting factors including salinity stress. Salinity has been a main abiotic stresses on coastal and tidal lands. Indonesia being a nation with thousand islands, suffers salt water intrusion to many of its mainland which increase salt concentration in rice farmland, resulting in the decline of productivity. Rad HE, Aref F, Rezaei M. (2012) report that increased salinity has an impact on decreased productivity and also responsible for plants total failure at high concentration of about 12 ds/m. According Ghosh B, Ali Md N, Saikat G. (2016) and Ismail AM, Platten JD, Miro B. (2013) salinity gave negative impact through some stresses such as osmotic, ion toxicity, ion homeostasis and oxidative stress (Ghosh et al., 2016; Ismail et al., 2013). Therefore, the development of tolerant varieties is essential in overcoming the impact of salinity on coastal land.

Tolerant varieties are those which are able to maintain metabolic processes even in stressed conditions. According to De Leon TB, Linscombe S, Gregorio G, Subudhi PK. (2015) salinity tolerant varieties are able to minimize the damage during the stressed period. Anshori MF, Purwoko BS, Dewi IS, Ardie SW, and Suwarno WB. (2018), Anshori MF, Purwoko BS, Dewi IS, Suwarno WB, Ardie SW (2020) reported the nature of tolerance correlates with the rate of plant damage. Hence the lower the damage, the more tolerant the plants. Assembly of tolerant varieties closely relates to the selection method, selection environment and selection parameters.

Selection methods is possible artificially. It has been reported by Ali MdN, Yeasmin L, Gantait S, Goswami R, Chakraborty. (2014), Mondal and Borromeo (2016), Arifuddin M, Musa Y, Farid M, Anshori MF, Nasaruddin N, Nur A, Sakinah AI. (2021) who performed the selection hydroponically and Hariadi YC, Nurhayati AY, Soeparjono S, Arif I. (2014), Safitri H, Purwoko BS, Dewi IS, Ardie SW. (2016). and Anshori et al. (2018) who did it on soil media. Hydroponics method is the most widely performed due to possibility for more controllable selection and the absence of cofactors that affect salinity levels in the testing media (Faiyue, 2012; Safitri, 2016; Anshori et al. 2020; Farid M, Nasaruddin, Musa Y, Ridwan I, Anshori MF. (2021). However, the general hydroponic method focused only on the vegetative phase. According to Ismail et al. (2013) and Kranto S, Chankaew S, Monkham T, Theerakulpisut P, Sanitchon J. (2016) there was no significant correlations between the properties of salinity density tolerance in the vegetative and reproductive phases.

It is an indication that the screening for salinity tolerance on rice by hydroponic method is possible until its reproductive phase. One hydroponic method that is practicable for this screening is the Deep Flow Technique (DFT). According to Arifuddin et al. (2021), selection with DFT methods was effective in distinguishing the tolerant and sensitive properties. However, the research only focused on the generative phase. Therefore, testing and identifying secondary characters for salinity screening at all growing phases of rice through DFT method becomes important. The purpose of this study was to evaluate the DFT hydroponic screening at all growing phases and to determine the secondary production supporting character that can be used as a selection character in the screening process.

B. Methology

Salinity stress experiment was performed on nutrient cultures adapted to the modified method of Egdane JA, Vispo NA, Mohammadi R, Amas J, Katimbang ML, Platten JD, Ismail A, Gregorio GB. (2003). The parallel experiments were conducted greenhouses at the altitude of 22.4 m above sea level from August to November 2020.

1. Research Design and Procedures

The experiment was arranged in a nested and randomized complete group design, where the nested replication was on the NaCl environment. The tested rice varieties were Inpari 34 Salin Agritan, Ciherang, IR 29, Inpari 29, and Jeliteng. The salinity environments in the experiment were 0 mM of NaCl (normal), 60 mM of NaCl and 120 mM of NaCl.

The seedling was grown on rockwool media for 15 days then transferred to a DFT hydroponics system running on PVC pipes. Each pipe has holes with a diameter of 5 cm each and the distance between the holes was 20 cm. The seedlings on the rockwool were placed in a netpot container by ensuring the seedling's root are in contact with the nutrient culture. The nutrient culture media was AB mix with a concentration of 5 ml per liter of water. The volume of nutrients in each DFT installation was 120 L. Induction of salinity stress was applied at the age of 7 days in the DFT. Stress induction was applied gradually to avoid osmotic shock. The first application of NaCl was 50% of the prescribed concentration, it is then increased to 60 mM and 120 mM (as the treatments) in the following three days. The stress condition was sustained for 14 days and then transferred to normal environmental conditions. The nutrient solution was replaced after 7 days under normal conditions. Administration of HCL or NaOH was to maintain the pH of the solution in the range of 5.5-6.5.

The observed characters of this experiment were plant height, root length, number of leaves, number of tillers, number of productive tillers, flowering age, chlorophyll A, chlorophyll B, total chlorophyll, stomata density, wet weight of shoots, dry weight of shoots, dry weight of roots, length of panicles, length of flag leaves, percentage of filled seeds, percentage of hollow seeds, weight of 100 seeds, and production per clump.

2. Data Analysis

The significant different characters in the interactions of each character under the variance analysis were further analyzed with pearson correlation tests, cross-prints, and key component analysis based on the value of each character's stress tolerance index. Heatmap cluster analysis was further performed to visualize kinship patterns of complex variable whish is more simple through color gradation.

The Index of Stress Tolerance was calculated by equation (Fernandez, 1992): ITC = $\frac{Yp \times Ys}{\bar{Y}p^2}$

Yp = The character value of each variety under normal circumstances/ not stressed.
Ys = The character value of each variety in a stressed state.
Ȳs = Average character values of all varieties under normal/not stressed circumstances

C. Result and Discussion

Results of analysis of the variance for the entire growth phase of rice is shown in Table 1. It shows that the stressed environment affected the entire observed character, whereas the different rice varieties affected almost all of the observed characters except the plant height, percentage of filled seeds, and the percentage of hollow seeds. The interaction of varieties and salinity stress had a significant to very significant effect on the character of root length, number of leaves, number of tillers, number of productive tillers, flowering age, chlorophyll A, chlorophyll B, total chlorophyll, stomata density, shoots wet weight, shoots dry weight, roots wet weight, roots dry weight, length of flag leaves, weight of 100 seeds and production per clump.

Significant interactions shown by the variance analysis are early indicators in stress screening, this has been reported by Anshori (2019); Farid BDR M, Nasaruddin, Anshori MF, Chaerunnisa ANJ. (2020) that characters which have significant interactions have different response patterns among genotypes in normal and stressed environments. Based on the analysis, the characters of root length, number of leaves, number of tillers, number of productive tillers, flowering age, chlorophyll A, chlorophyll B, total chlorophyll, stomata density, shoots wet weight, shoots dry weight, roots wet weight, roots dry weight, length of flag leaves, weight of 100 seeds and production per clump, all can be used as candidates of rice selection criteria for salinity stress on DFT hydroponic screening. However, it is necessary to do more in-depth analysis with several other multivariate analysis series.

The assessment of the variety's response to the stress condition should operate a tolerance index. It has been reported by Mau YS, Ndiwa ASS, and Arsa AGBA. (2014), Aboughadareh AP, Yousefian M, Moradkhani H, Vahed MM, Poczai P, and Siddique KHM. (2019), Aboughadareh AP, Mohammadi R, Etminan A, Shooshtari L, Tabrizi NM, Poczai P. (2020), and Farid et al. (2021) that the Index of Stress Tolerance (ITC) is the appropriate index for characterizing the most stress tolerant ones. The use of ITC values had previously been reported by El-Hashash & Agwa (2018) in drought-stressed barley, Anshori et al. (2018) in salinity stressed rice, Farid and Ridwan (2019) in drought stressed rice, and Fadhli N, Farid M, Rafiuddin, Effendi R, Azrai M, Anshori MF (2020) in drought-stressed maize. The Value of the Tolerance Index for characters with significant interaction values is shown in Table 2. ITC1 is the value of the tolerance index at 60 mM of NaCl, and ITC2 is the value of the tolerance index at 120 mM of NaCl. The value of this index will be used as the basis for the next multivariate analysis in determining the character of selection. Correlation analysis is the most common analysis in identifying the best selection characters. Correlation analysis in this experiment focused on production per clump as its main character. The relationship between other characters to production per clump can be used as the best selection character against salinity stress. The use of this analysis has been reported by Afa L O, Purwoko B S, Junaedi A, Haridjaja O and Dewi I S (2018); Aman, J., Bantte, K., Alamerew, S. & Sbhatu, D.B. (2020); Saleh MM, Salem KFM, Elabd AB. (2020). The results of the correlation analysis based on the values of the Index of Stress Tolerance (ITC) (Table 3) shows that the root length character (0.78), the number of leaves (0.91), chlorophyll A (0.93), chlorophyll B (0.95), total chlorophyll (0.94), stomata density (0.83), shoots wet weight (0.88), shoots dry weight (0.88), roots wet weight (0.93), roots dry weight (0.78), length of flag leaves (0.89) flowering age (0.87), The number of tillers (0.81), the number of productive tillers (0.97), and the weight of 100 seeds (0.93), all have a significant correlation to production per clump. Based on this correlation analysis results, it is not possible to distinguish the direct and indirect effects of each character on the production character. Therefore, it is necessary to continue with cross-print analysis to understand the magnitude of both direct and indirect effects on production (Singh and Chaudhary 2007; Rohaeni and Permadi 2012; Anshori *et al.*2018).

Table 1. Middle square analysis of variance of the observed characters

Character	Varieties	Stress	Var:Stress	Error	CV	Vg	Vp	Repeatability (%)
TT	102.56ns	9588.57**	27.21ns	90.56	15.89	-21.12	69.45	0.00
PA	114.93**	1821.02**	70.02**	11.49	12.60	19.51	31.00	62.95
JD	5.97**	155.78**	2.17**	0.44	10.56tr	0.58	1.01	56.77
JA	1.91**	15.47**	0.86**	0.09	12.62tr	0.25	0.35	73.14
JAP	0.23**	28.12**	0.08*	0.03	12.26tr	0.02	0.05	37.14
UB	123.86**	29767.20**	141.92**	7.20	5.28	44.91	52.11	86.18
Chl A	7270.30**	201173.78**	5888.35**	221.99	11.61	1888.79	2110.78	89.48
Chl B	305.20**	35287.22**	219.04**	25.01	9.08	64.68	89.69	72.11
Chl Tot	11776.69**	421967.17**	9399.63**	411.65	10.84	2996.00	3407.64	87.92
KS	145.92*	13532.79**	123.74*	43.88	19.12	26.62	70.50	37.76
BBT	1043.28**	29669.96**	760.09**	46.43	20.14	237.89	284.32	83.67
BKT	1.55**	50.97**	1.89**	0.30	20.25tr	0.53	0.83	63.81
BBA	0.97**	30.95**	1.34**	0.06	10.91tr	0.43	0.48	88.08
BKA	0.15**	4.90**	0.27**	0.03	17.16tr	0.08	0.11	70.59
PM	7.23*	2654.33**	2.82tn	2.05	10.08	0.26	2.31	11.19
GDP	11.46**	3691.62**	16.94**	2.57	8.95	4.79	7.36	65.10
%JGB	0.00ns	2.60**	0.00tn	0.00	12.45	0.00	0.00	0.00
%JGH	0.00ns	1.54**	0.00tn	0.00	19.44	0.00	0.00	0.00
100BJ	0.08**	15.58**	0.08**	0.01	8.96	0.02	0.04	69.71
Prod	0.04*	48.12**	0.07**	0.01	7.72tr	0.02	0.03	62.33

Notes: *: significant effect, **: very significant effect, tr: results of $\sqrt{x}$ transformation, TT: plant height, PA: root length, JD: number of leaves, JA: number of tillers, JAP: number of productive tillers, UB: flowering age, Chl A: chlorophyll A, Chl B: chlorophyll B, Chl Tot: total chlorophyll, KS : stomata density, BBT: shoots wet weight, BKT : shoots dry weight, BBA : roots wet weight, BKA : roots dry weight, PM : length of panicles, PDB : length of flag leaf, %JGB : percentage of filled seeds, %JGH : percentage of hollow seeds, 100BJ : weight of 100 seeds, Prod : production per clump.

Correlation analysis is an overview of the level of kinship between one character to the others, but the value of correlation cannot explain the causal relationship of the kinship level among characters. Therefore, in order to elaborate the correlation coefficient to be more useful, come the role of cross-print analysis. The results of cross-print analysis could describe how significant the direct and indirect effects of a character to the main character (Rohaeni and Permadi, 2012). The use of correlation analysis and cross-print analysis in determining the character of selection has also been performed by many researchers including Milligan SB, Gravois KA, Bischoff KP, Martin FA. (1990), Akhmadi (2016), Anshori et *al.,* (2019), Fadhli et *al.,*(2020), Farid et *al.,*(2020) and Farid et *al.,* (2021). The cross-print of IST of the production per clump character shows a representative result on the determinant coefficient value of 0.80 (Table 4). Based on the cross-print analysis, the character of total chlorophyll (5.77) had the highest and significant direct effect on the character of production per clump, followed by the character of the number of productive tillers (1.08). Consequently, based on these results the total chlorophyll character and number of productive tillers can be recommended as the selection characters in screening for salinity tolerance throughout the rice growing phase on the DFT hydroponic system. However, these findings need to be supported by other multivariate analyses such as major component analysis and heat map cluster analysis.

Table 2. Average tolerance index of stress on the combination of varieties and concentrations of NaCl

Varieties	PA	JD	Chl_A	Chl_B	Chl_Tot	KS	BBT	BKT	BBA	BKA	GDP	UB	JA	JAP	100BJ	Prod
V1_ITC1	0.76	0.75	0.77	0.8	0.78	0.89	0.26	0.75	0.73	0.72	1.01	1.32	0.89	0.61	0.99	0.25
V2_ITC1	0.87	0.8	0.89	0.9	0.89	0.87	0.13	1.04	0.69	0.6	0.8	0.91	0.88	0.57	0.85	0.24
V3_ITC1	0.68	0.49	0.08	0.5	0.18	1.19	0.06	0.33	0.37	0.39	0.97	1.26	0.42	0.34	0.64	0.1
V4_ITC1	0.97	0.61	0.88	0.89	0.88	0.91	0.2	0.5	0.46	0.53	0.94	1.3	0.79	0.47	0.71	0.17
V5_ITC1	1.47	1.06	0.98	0.97	0.98	1.45	0.34	0.76	0.92	0.97	1.12	1.21	1.56	0.73	0.69	0.23
V1_ITC2	0.37	0.29	0	0	0	0	0.01	0.12	0.15	0.21	0	0	0.49	0	0	0
V2_ITC2	0.46	0.29	0	0	0	0	0.01	0.12	0.25	0.2	0	0	0.4	0	0	0
V3_ITC2	0.33	0.26	0	0	0	0	0.01	0.13	0.16	0.26	0	0	0.29	0	0	0
V4_ITC2	0.47	0.28	0	0	0	0	0.01	0.3	0.18	0.53	0	0	0.37	0	0	0
V5_ITC2	0.45	0.42	0	0	0	0	0.03	0.15	0.23	0.24	0	0	0.45	0	0	0

Notes: ITC1 : index value at 60 mM of NaCl, ITC2 : index value at 120 mM of NaCl, V1 : Inpari 34, V2 : Ciherang, V3 : IR29, V4 : Inpari 29, V5 : Jeliteng, PA: root length, JD: number of leaves, JA: number of tillers, JAP: number of productive tillers, UB: flowering age, Chl A: chlorophyll A, Chl B: chlorophyll B, Chl Tot: total chlorophyll, KS : stomata density, BBT: shoots wet weight, BKT : shoots dry weight, BBA : roots wet weight, BKA : roots dry weight, PM : length of panicles, PDB : length of flag leaf, %JGB : percentage of filled seeds, %JGH : percentage of hollow seeds, 100BJ : weight of 100 seeds, Prod : production per clump.

Table 3. Correlation of the Stress Tolerance Index (ITC)

	PA	JD	Chl_A	Chl_B	Chl_Tot	KS	BBT	BKT	BBA	BKAr	GDP	UB	JA	JAP	100BJ	Prod
PA	1.00															
JD	0.91	1.00														
Chl_A	0.85	0.89	1.00													
Chl_B	0.86	0.90	0.96	1.00												
Chl_Tot	0.86	0.90	1.00	0.97	1.00											
KS	0.84	0.85	0.78	0.90	0.81	1.00										
BBT	0.88	0.92	0.90	0.88	0.90	0.80	1.00									
BKT	0.70	0.82	0.84	0.83	0.85	0.67	0.71	1.00								
BBA	0.87	0.97	0.90	0.91	0.91	0.82	0.93	0.85	1.00							
BKA	0.84	0.84	0.79	0.78	0.79	0.73	0.86	0.77	0.87	1.00						
GDP	0.81	0.84	0.82	0.94	0.86	0.95	0.83	0.74	0.85	0.75	1.00					
UB	0.75	0.78	0.80	0.93	0.84	0.93	0.80	0.69	0.80	0.68	0.98	1.00				
JA	0.90	0.93	0.84	0.80	0.84	0.73	0.92	0.74	0.91	0.84	0.72	0.65	1.00			
JAP	0.86	0.93	0.91	0.96	0.93	0.89	0.91	0.86	0.95	0.84	0.94	0.91	0.86	1.00		
100BJ	0.71	0.81	0.86	0.94	0.88	0.86	0.79	0.81	0.85	0.71	0.95	0.95	0.66	0.92	1.00	
Prod	0.78	0.91	0.93	0.95	0.94	0.83	0.88	0.88	0.93	0.78	0.89	0.87	0.81	0.97	0.93	1.00

Notes: PA: root length, JD: number of leaves, JA: number of tillers, JAP: number of productive tillers, UB: flowering age, Chl A: chlorophyll A, Chl B: chlorophyll B, Chl Tot: total chlorophyll, KS : stomata density, BBT: shoots wet weight, BKT : shoots dry weight, BBA : roots wet weight, BKA : roots dry weight, PM : length of panicles, PDB : length of flag leaf, %JGB : percentage of filled seeds, %JGH : percentage of hollow seeds, 100BJ : weight of 100 seeds, Prod : production per clump.

Table 4. ITC cross-print of rice to the main character of production per clump.

Character	Direct Influence	Indirect Influence															Total Influence	Residual
		PA	JD	Chl_A	Chl_B	Chl_Tot	KS	BBT	BKT	BBA	BKA	GDP	UB	JA	JAP	100BJ		
PA	**-0.02**		0.38	-3.27	-1.88	4.93	0.07	0.01	0.11	-0.12	-0.09	-0.55	0.46	-0.28	0.92	0.10	0.78	-0.01
JD	**0.42**	-0.02		-3.46	-1.97	5.22	0.07	0.01	0.13	-0.14	-0.09	-0.57	0.48	-0.29	1.01	0.11	0.91	0.38
Chl_A	**-3.86**	-0.01	0.37		-2.10	5.75	0.07	0.01	0.14	-0.13	-0.08	-0.56	0.49	-0.26	0.99	0.12	0.93	-3.57
Chl_B	**-2.19**	-0.01	0.37	-3.69		5.62	0.08	0.01	0.14	-0.13	-0.08	-0.64	0.57	-0.25	1.04	0.13	0.95	-2.08
Chl_Tot	**5.77****	-0.01	0.38	-3.85	-2.14		0.07	0.01	0.14	-0.13	-0.08	-0.59	0.51	-0.26	1.01	0.12	0.94	5.41
KS	**0.09**	-0.01	0.35	-3.01	-1.97	4.68		0.01	0.11	-0.12	-0.07	-0.65	0.57	-0.23	0.97	0.12	0.83	0.07
BBT	**0.01**	-0.02	0.38	-3.46	-1.92	5.19	0.07		0.12	-0.13	-0.09	-0.57	0.49	-0.28	0.99	0.11	0.88	0.01
BKT	**0.16**	-0.01	0.34	-3.25	-1.83	4.88	0.06	0.01		-0.12	-0.08	-0.51	0.42	-0.23	0.92	0.11	0.88	0.14
BBA	**-0.14**	-0.01	0.40	-3.47	-1.99	5.24	0.07	0.01	0.14		-0.09	-0.58	0.49	-0.28	1.03	0.12	0.93	-0.13
BKA	**-0.10**	-0.01	0.35	-3.05	-1.71	4.58	0.06	0.01	0.13	-0.12		-0.51	0.42	-0.26	0.91	0.10	0.78	-0.08
GDP	**-0.68**	-0.01	0.35	-3.18	-2.06	4.95	0.08	0.01	0.12	-0.12	-0.08		0.60	-0.22	1.02	0.13	0.89	-0.61
UB	**0.61**	-0.01	0.32	-3.10	-2.04	4.84	0.08	0.01	0.11	-0.11	-0.07	-0.67		-0.20	0.98	0.13	0.87	0.53
JA	**-0.31**	-0.02	0.39	-3.26	-1.75	4.85	0.06	0.01	0.12	-0.13	-0.09	-0.49	0.40		0.93	0.09	0.81	-0.25
JAP	**1.08****	-0.01	0.39	-3.53	-2.11	5.38	0.08	0.01	0.14	-0.13	-0.09	-0.64	0.55	-0.27		0.13	0.97	1.05
100BJ	**0.14**	-0.01	0.34	-3.31	-2.07	5.10	0.07	0.01	0.13	-0.12	-0.07	-0.65	0.58	-0.20	0.99		0.93	0.13

Notes: R square: 80%, PA: root length, JD: number of leaves, JA: number of tillers, JAP: number of productive tillers, UB: flowering age, Chl A: chlorophyll A, Chl B: chlorophyll B, Chl Tot: total chlorophyll, KS : stomata density, BBT: shoots wet weight, BKT : shoots dry weight, BBA : roots wet weight, BKA : roots dry weight, PM : length of panicles, PDB : length of flag leaf, %JGB : percentage of filled seeds, %JGH : percentage of hollow seeds, 100BJ : weight of 100 seeds, Prod : production per clump.

Major Component Analysis is one of the multivariate analyses that analyzes the data of several interrelated variables. The purpose of this analysis is to extract important information from the data and describe it as a new set of orthogonal variables called the main components, and to display patterns of observational similarity in other words to summarize the data with a smaller number of variables (Ilmaniati and Putro, 2018). The results of the main component analysis (AKU) produced one main component that could describe the character of productivity (Table 5) i.e. the first major component (KU1) with a total proportion of 98% and eigenvalue of 2.93. Based on main component 1 (KU1), the production character (0.58) in stressed condition is within same direction with total chlorophyll character (0.57) and the number of productive tillers (0.58).

Table 5. Main component Analysis of ITC value.

Character	KU1	KU2	KU3
Chl_Tot	0.57	-0.82	-0.07
JAP	0.58	0.46	-0.67
Prod	0.58	0.35	0.74
EV	2.93	0.05	0.02
P	0.98	0.02	0.01
CP	0.98	1.00	1.00

Notes: CP: Cumulative Proportion, EV: EigenValues, KU: Main Component, Chl_tot: total chlorophyll, JAP: number of productive tillers, Prod: production per clump.

Cluster analysis is a common method in plant breeding. There are two main functions of cluster analysis applications: measurement to identify outliers and classifying sample subtypes (Zhao S, Guo Y, Sheng Q, Shyr Y., 2014). However, in the current development, cluster analysis is often combined with heatmap analysis (Virga G, Licata M, Consentino BB, Tuttolomondo T, Sabatino L, Leto C, Bella SL., 2020; Anshori et al. 2020). Based on the GROUPING OF ITC characters, productivity is separate from other character groups, while the other group consists of the number of productive tillers and chlorophyll A. Based on the grouping of varieties, the first group consists of Jeliteng ITC1, Ciherang ITC1, Inpari 34 Salin Agritan ITC1 and Inpari 29 ITC1 while the second group are IR 29 ITC1 and ITC2 for all varieties (Figure 1).

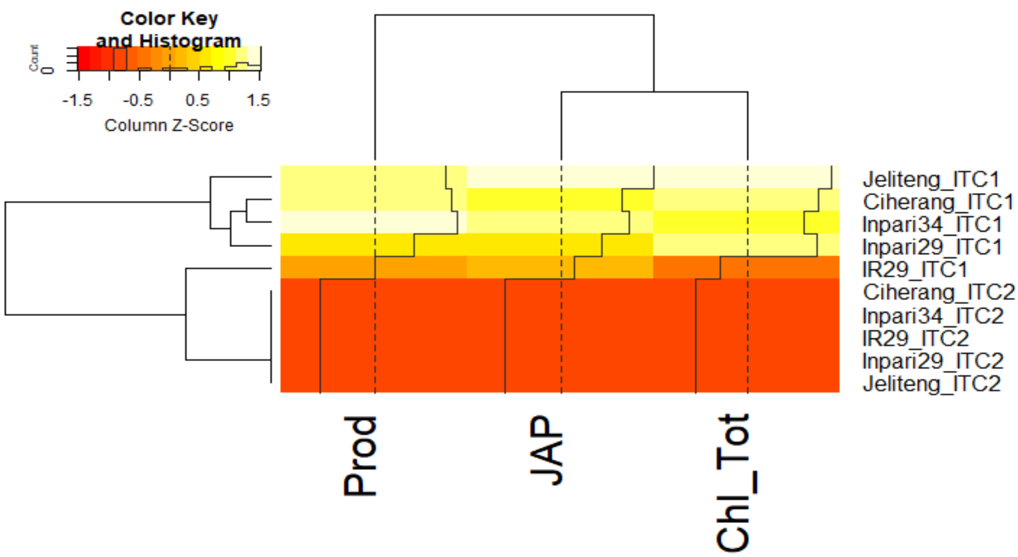

Figure 1. Analysis *of heatmap cluster* on the treatment of 5 varieties on the stress tolerance index (ITC) values and 5 character selection on stress treatment throughout all rice growing phases. Prod: production per clump, JAP: number of productive tillerd, total chlorophyll.

D. Conclusion

The environment at a concentration of 60 mM of NaCl was the best stressed environment in screening rice salinity at all growing phases. A good selection character in this screening procedure was the production per clump, the number of productive tillers and the total chlorophyll. Varieties of Jeliteng, Ciherang, Inpari 34 Salin Agritan were those that considered tolerant to salinity in the screening procedures at all growing phases on DFT hydroponic system. The DFT hydroponic screening method at all growing phases can be recommended as one of the artificial salinity screening methods.

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