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Screening and Adaptation in Some Varieties of Rice under Salinity Stress (Case Study at Paluh Merbau, Deli Serdang District, North Sumatera, Indonesia)

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Abstract

Rice growth and development are adversely affected by salinity; it was a major environmental stress that limits agricultural production. Paluh Merbau is a village in percut Sei Tuan District that had saline soil. It has EC=6,8 mmhos and rice production in this location is low. Aim of this research is to obtain tolerant variety with high adaptation under salinity stress. Research was conducted in Paluh Merbau village, Percut Sei Tuan, Deli Serdang District, North Sumatera, by using randomized block design non factorial with three replications. Response of growth and adaptation of 30 genotypes were tested and make classification based on criteria: highly susceptible, susceptible, moderate, tolerant and highly tolerant by using a scoring method (salt injury score). Result of this research showed that IR 42 and Banyuasin had the best growth and highly adaptability on saline soil as compared with other genotypes.

Keywords: Rice; Salinity; Adaptation; Growth

Introduction

Salinity is becoming a serious problem in several parts of the world. The saline area is three times larger than land used for agriculture [1]. Salinity is one of the key environmental factors that limit crop growth and agricultural productivity. Total area under salinity is about 953 million ha covering about 8% of the land surface [2]. Several physiological pathways, i.e. photosynthesis, respiration, nitrogen fixation and carbohydrate metabolism have been observed to be affected by high salinity [3].

Rice (*Oryza sativa* L.) is one of the most important crops in the world and is the primary stable food for over two billion people. With the rapid growth in population consuming rice and the deteriorating soil and water quality around the globe, there is an urgent need to understand the response of this important crop towards these environmental abuses. With the ultimate goal to raise rice plant with better suitability towards changing environmental inputs, intensive efforts are on worldwide employing physiological, biochemical and molecular tools to perform this task.

Abiotic stress is the main factor negatively affecting crop growth and productivity worldwide. Rice plants are relatively susceptible to soil salinity as an abiotic stress [4,5]. Salt-affected soil is one of the serious abiotic stresses that cause reduced plant growth, development and productivity worldwide [6]. In Iran, salinity has already become a major deterrent to crop production, including rice. Addition of salts to water lowers its osmotic potential, resulting in decreased availability of water to root cells.

Salt stress thus exposes the plant to secondary osmotic stress, which implies that all the physiological responses, which are invoked by drought stress, can also be observed in salt stress [7]. Growth and yield reduction of crops is a serious issue in salinity prone areas of the world [8]. Water-deficit and salt affected soil are two major abiotic stresses which reduce crop productivity, especially that of rice, by more than 50% world-wide [9,10]. Salinity is one of the important abiotic stresses limiting rice productivity. The capacity to tolerate salinity is a key factor in plant productivity.

Rice, most loved cereal of Asia, feeds the majority of the world's population. More than 90% of the world's rice is grown and consumed in Asia. where 60% of the earth's people and about two-thirds of the world's poor live [11]. Green revolution helped to solve the world's demand for food, but is not enough to meet the 21st century's exploding population. Improved rice varieties and hybrids developed by institutes throughout the world, including IRRI, have helped to improve the quality and quantity of rice production.

About 6.5% (831 million ha) of the world's total area (12.78 billion ha) is affected by salt in soils (FAO). Area under salt stress is on the increase due to many factors, including climate change, rise in sea levels and excessive irrigation without proper drainage in inlands, underlying rocks rich in harmful salts, etc. Vast areas of land are not utilized due to salinity and alkalinity problems.

Screening of germplasms at seedling stage is readily. Rice is the staple food of more than 50% of it provides reproductive stage. Screening under controlled rice production will be needed over that of year 2000, condition has the benefit of reduced environment effects Salinity is one of the major obstacles in increasing and the hydroponic system is free difficulties associated production in rice growing areas worldwide, which is an with soil related stress factors. The conventional methods ever-present threat to crop yield. Therefore, development of plant selection for salt tolerance are not easy because of salt tolerant varieties has been considered as one of the large effects of the environment and low narrow strategies to increase rice production.

Salinity appears to affect two plant processes, water relations and ionic relations. During initial exposure to salinity, plants experience

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water stress, which in turn, reduces leaf expansion. During long-term exposure to salinity, plants experience ionic stress, which can lead to premature senescence of adult leaves [12]. Salinity has three potential effects on plants:

- Lowering of the water potential
- Direct toxicity of any Na and Cl absorbed
- Interference with the uptake of essential nutrients

Materials and Methods

This experiment was conducted at Paluh Merbau, Percut Sei Tuan, Deli Serdang District, North Sumatra on January 2012 to July 2012. The region studied is geographically located in latitude 98,74850 N and longitude 3,75150 E and 1.5 m altitude. Thirty rice genotypes were used in this study, i.e Banyuasin, Batanghari, Dendang, Indragiri, Punggur, Martapura, Margasari, Siak Raya, Air Tenggulang, Lambur, Mendawak, Sei Lalan, Way Apo Buru, inpari 2, inpari 3, inpara 10, IR 42, IR 64, Ciherang, Mekongga, Fatmawati, CSR 9012, BW 267-3, IR 72593, IR 67075, IR 72049, IR 63731, IR 59418, IR 71829 dan IR 29. This research uses Completely Randomized Block Design non factorial with three replications on a plot size of 2 m×2 m.

Results and Discussions

Germination percentage

Germination percentages of some genotypes of rice are given in Table 1. As information, in seedling location, it has dhl=6.8 mmhos. In Table 1, Sei Lalan (V15) and Lambur (V19) showed have the highly germination percentage, i.e. 93% and 92%, this result showed that Sei Lalan and Lambur more tolerant than other varieties in germination phase. Based on the descriptions that have been recommended by the Rice Research Institute Sukamandi, Sei lalan is one of the varieties that are tolerant to salinity stress (dhl=up to 4 mmhos).

Evaluation of salt stress symptoms at seedling stage

By using "salt injury score" (Table 2) in rating the visual symptoms of salt toxicity are found the criteria. This scoring discriminates the highly susceptible genotype till highly tolerant genotype. Scoring was started at 21 days after sowing. A comparison of the responses of the different cultivars *indica*ted that germination percentage was based on type of cultivar. In germination phase, Sei Lalan (V_{15}) had the highest germination percentage.

Variety	Germination Percentage (%)	Variety	Germination Percentage (%)
V_1=Indragiri	74	V_{16}=BW-267-3	0.3
V_2 =IR 29	4	V_{17}=Mekongga	7.1
V_3=Martapura	62	V_{18}=IR 42	64
V_4=Banyuasin	81	V_{19}=Lambur	92
V_5=IR 72593	0.2	V_{20}=IR64	41
V_6=Punggur	22	V_{21}=Fatmawati	17
V_7=CSR 9012	0.3	V_{22}=IR 63731	0
V_8=Margasari	69	V_{23}=Inpari2	13
V_9 =Ciherang	83	V_{24}=Dendang	78
V_{10}=IR 67075	0.2	V_{25}=Inpara 10	9
V_{11}=Mendawak	32	V_{26}=IR 59418	0
V_{12}=Air Tenggulang	30	V_{27}=Siak Raya	29
V_{13}=IR 72049	0.2	V_{28}=Inpari 3	0
V_{14}=Batanghari	64	V_{29}=IR 71829	0
V_{15}=Sei Lalan	93	V_{30}=Way Apo Buru	0

Table 1: Germination percentage of 30 varieties of rice.

Table 3 showed that V_5 (IR 72593), V_7 (CSR 9012), V_{10} (IR 67075), V_{13} (IR 72049), V_{16} (BW-267-3), V_{17} (Mekongga), V_{22} (IR 63731), V_{26} (IR 59418), V_{28} (Inpari 3), V_{29} (IR 71829) and V_{30} (Way Apo Buru) had score 9. Then, some varieties got score 7, i.e: V_2 (IR 29), V_6 (Punggur), V_{20} (IR 64), V_{21} (Fatmawati), V_{23} (Inpari 2), V_{25} (Inpara 10) and V_{27} (Siak Raya). V_{11} (Mendawak) and V_{12} (Air Tenggulang) had score 5. V_3 (Martapura), V_4 (Banyuasin), V_8 (Margasari), V_9 (Ciherang), V_{14} (IR 42) and V_{24} (Dendang) had score 3. Sei Lalan (V_{15}) and Dendang (V_{19}) had score 1. From Table 3, are found ten varieties for the next observation.

Vegetative Phase

Data from Vegetative phase was showed on Table 4. The results showed that in vegetative phase of Batanghari (V_4) and Ciherang (V_9) had better growth than Margasari (V_8) and Sei Lalan (V_{15}). It can be seen in root volume variable and number of productive tillers. Sairam and Tyagi [7] stated that the excess amount of salt in the soil can affect plant growth and development. The process of growth, such as seed germination, seedling growth, vegetative growth and number of tillers. Salt stress had reducing effect on leaf area of vegetative phase. Furthermore, generative phase of ten varieties are showed on Table 5.

Generative Phase

Data from Generative phase was showed on Table 5 and heritability score can be seen on Table 6. Batanghari (V_{14}) showed the best growth in the generative phase than Martapura (V_3), Margasari (V_8), Sei Lalan (V_{15}) and Lambur (V_{19}) in the parameters were observed for the percentage of empty grain, seed weight per plot and weight of 10 seeds. Low production and high percentage of empty grain can occur due to very high salt stress resulted in the absorption of water not available so vulnerable to water shortages.

Furthermore, water stress also occurs in salt stressed plants. These circumstances lead to various disorders in plants, among others, the slow flowering, abscission of flowers and empty grain. Sairam and Tyagi [7] found that excess salt in the growing media (soil) can affect plant growth and development, smaller leaf area (leaf rolling occurred) and this condition made photosyntesis process was not optimal. Heritability value of eight genotypes can be seen in Table 6. Table 6 was showed that adaptability and tolerance of plants to salt stress is influenced by the nature of the genetic.

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Conclusion

Score	Observation	Tolerance
1	Normal Growth, no leaf symptoms	Highly tolerant
3	Nearly normal growth, but leaf tips or few leaves whitish are and rolled	Tolerant
5	Growth severely retarded, most leaves rolled, only a few are elongating	Moderately tolerant
7	Complete cessation of growth ; most leaves dry ; some plants dying	Susceptible
9	Almost all plants dead or dying	Highly susceptible

Table 2: Modified Standard Evaluation Score (SES) of visual salt injury at seedling stage.

Variety	Score	Grade	Variety	Score	Grade
V_1=Indragiri	3	Tolerant	V_{16}=BW-267-3	9	Highly susceptible
V_2=IR 29	7	Susceptible	V_{17}=Mekongga	9	Highly susceptible
V_3=Martapura	3	Tolerant	V_{18}=IR 42	3	Tolerant
V_4=Banyuasin	3	Tolerant	V_{19}=Lambur	1	Highly tolerant
V_5=IR 72593	9	Highly susceptible	V_{20}=IR64	7	Susceptible
V_6=Punggur	7	Susceptable	V_{21}=Fatmawati	7	Susceptable
V_7=CSR 9012	9	Highly susceptible	V_{22}=IR 63731	9	Highly tolerant
V_8=Margasari	3	Tolerant	V_{23}=Inpari 2	7	Susceptible
V_9=Ciherang	3	Tolerant	V_{24}=Dendang	3	Tolerant
V_{10}=IR 67075	9	Highly susceptible	V_{25}=Inpara 10	7	Susceptible
V_{11}=Mendawak	5	Moderate	V_{26}=IR 59418	9	Highly susceptible
V_{12}=Air Tenggulang	5	Moderate	V_{27}=Siak Raya	7	Susceptible
V_{13}=IR 72049	9	Highly susceptible	V_{28}=Inpari 3	9	Highly susceptible
V_{14}=Batanghari	3	Tolerant	V_{29}=IR 71829	9	Highly susceptible
V_{15}=Sei Lalan	1	Highly susceptible	V_{30}=Way Apo Buru	9	Highly susceptible

Table 3: Salt injury score of 30 genotypes of rice.

Variety	Leaf area (cm^2)	Number of chlorophyl	Volume of root (ml) in 9 WAT	Total number of tiller	Total number of productive tiller
V_1=Indragiri	10.98	25.42	58.67	33.59 de	11.52 b
V_3=Martapura	15.45	27.49	63.67	82.06 a	4.62 c
V_4=Banyuasin	12.84	31.91	70.67	58.69 bc	18.64 a
V_8=Margasari	15.47	33.97	42.33	70.66 ab	2.47 bc
V_9=Ciherang	14.63	29.87	79.67	55.07 bcd	7.97 bc
V_{14}=atanghari	12.81	25.67	69.33	68.31 abc	19.55 a
V_{15}=Sei Lalan	9.25	23.02	77.67	46.78 cde	2.13 c
V_{18}=IR 42	9.40	29.93	47.00	67.87 abc	11.11 b
V_{19}=Lambur	14.38	30.80	73.33	77.78 a	6.37 c
V_{24}=Dendang	15.52	32.26	47.33	32.93 e	4.16 c

Table 4: Leaf area, number of chlorophyl, volume of root, total number of tiller and total number of productive tiller of 10 genotypes of rice.

Variety	Percentage of empty grain per panicle	Weight of seed per plot	Weight of 10 seed per plant
V_1=Indragiri	97.95	0.17 c	0.07 b
V_3=Martapura	33.33	0.01 c	0.01 d
V_4=Banyuasin	93.97	1.13 ab	0.10 a
V_8=Margasari	33.33	0.01 c	0.01 d
V_9=Ciherang	98.72	0.33 bc	0.10 a
V_{14}=Batanghari	91.53	0.90 bc	0.10 c
V_{15}=Sei Lalan	65.60	0.07 c	0.03 b
V_{18}=IR 42	58.24	1.60 a	0.07 c
V_{19}=Lambur	65.00	0.20 bc	0.03 c
V_{24}=Dendang	65.80	0.13 cd	0.07 b

Table 5: Percentage of empty grain weight of seed per plot and weight of 10 seed per plot of 10 genotypes of rice.

No.	Caracter	Value (H)	Criteria (H)
1	Leaf Area (cm^2)	0.13	low
2	Chlorophyll number (cm^2)	0.12	low
3	Volume of Root (ml)	0.60	High
4	Total Number of tiller	0.65	High
5	Total Number of productive tiller	0.63	High
6	Weight of Seed per plot (g)	0.50	High

Table 6: Heritability value.

All of genotypes were tested in this study have decreased of growth both of germination percentage, vegetative phase and generative phase. Salinity had also a significant effect on germination percentage, vegetative phase and generative phase. Furthermore, Banyuasin (V_4) and Sei Lalan (V_{15}) have adaptability and high tolerance in saline soil.

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