Morphology and physiology characteristic of some varities of rice under salinity stress

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Abstract. This experiment was aimed to evaluate yield potential and adaptability of some varieties of rice based on some morphological and physiological characters. This study was conducted at Paluh Merbau village, Percut Sei Tuan Sub-District, Deli Serdang District, North Sumatera, Indonesia on March 2012 till July 2012. This research was arranged in a randomized block design non factorial with three replications. Eight varieties used are Ciherang, IR 64, Lambur, Batanghari, Banyuasin, IR 42, Inpara 10 and Margasari. Salinity stress in rice leads to changes in both morphological and physiological characters of plants, where the response of each genotype varies depending on the nature of tolerance or sensitivity to salt stress. Observation of growth and production showed that genotif IR 42 had the best growth and the highest production as compared with other varieties.

Keywords: Rice, Salinity, Morphology, Physiology, Character

Introduction

About 6.5% (831 million ha) of the world's total area (12.78 billion ha) is affected by salt in soils (FAO, 2008). Salinity is one of the important abiotic stresses limiting rice productivity, that cause reduced plant growth, development and productivity worldwide . The capacity to tolerate salinity is a key factor in plant productivity (Momayezi *et al.*, 2009 and Siringam *et al.*, 2011). Specific effects of salt stress on plant metabolism, especially on leaf senescence, have been related to the accumulation of toxic Na+ and Cl- ions and to K+ and Ca2+ depletion (Al-Karaki, 2000). Salinity associated with excess NaCl adversely affects the growth and yield of plants by depressing the uptake of water and minerals and normal metabolism (Akhtar *et al.*, 2001; Akram *et al.*, 2001).

Salinity reduces the growth of plant through osmotic effects, reduces the ability of plants to take up water and this causes reduction in growth. There may be salt specific effects. If excessive amount of salt enter the plant, the concentration of salt will eventually rise to a toxic level in older transpiring leaves causing premature senescence and reduced the photosynthetic leaf area of a plant to a level that can not sustain growth (Munns, 2002 ; Shereen *et al.*, 2005). Salinity appears to affect two plant processes water relations and ionic relations. During initial exposure to salinity, plants experience 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 (Amirjani, 2011). Salinity has three potential effects on plants : Lowering of the water potential, Direct toxicity of any Na and Cl, absorbed and Interference with the uptake of essential nutrients (Flowers and Flowers, 2005).

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 (Khush and Virk, 2000). 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. Rice, the main cereal crop of many countries including Indonesia, is not in general salt tolerant. Rice is the second largest cereal crop in the world and forms the basic diet of more than half of the world's population. Salinity stress triggers the expression of several osmoresponsive genes and proteins in rice tissues (Chourey *et al.*, 2003). The response of rice to salinity varies with growth stage. In the most commonly cultivated rice cultivars, young seedlings were very sensitive to salinity (Lutts *et al.*, 1995; Zeng and Shannon, 2000). Tillering and booting phases are two physiologically important growth stages contributing to good plant population stand as well as yield (Alamgir and Yousuf Ali, 2006). Rice is considered moderately tolerant to exchangeable Na.

Rice is moderately sensitive to salt in the field as almost all the other crop species (Joseph *et al.*, 2010). The responses of rice genotypes grown under dense saline–sodic soil are complex and involve many kinds of physiological and biochemical reactions. Such reactions are induced in different rice cultivars depending upon their genetic ability to grow under stress environments and overcome, avoid, or neutralize the effect of stress (Khan and Abdullah, 2003). Leaf area can also affect sodium concentration in rice leaves by confounding effects of dilution and the transpirational driving force (Akita and Cabuslay, 1990). Additionally, leaf area has been shown to be highly correlated to grain yield in rice under salt stress (Zeng *et al.*, 2003; Zeng *et al.*, 2004). Rice cultivars vary in their ability to tolerate salt stress, with both salt–tolerant and salt–sensitive lines being available (Zeng, 2005; Darwish *et al.*, 2009). The high levels of salts in irrigation water can restrict or even scupper the rice cultivation, also by the presence of some elements in toxic concentrations (Silva, 2004). Asch and Wopereis (2001) studied the effect of field–grown irrigated rice cultivars to varying levels of floodwater salinity and stated that floodwater salinity reduced rice yield relative to the control treatment regardless of timing of stress occurrence and season. Depending on the season, different yield building processes may have been the direct cause for these losses. Also concluded that up to a level of 2 dS m_1 saline floodwater can be tolerated in terms of potential yield loss, salinity control, and economic considerations of the farmer. Zeng and Shannon (2000) stated that Grain yield per plant was reduced primarily by a reduction in number of tillers per plant, number of spikelets per panicle, and the grain weight per panicle. Although, salinity affects all stages of the growth and development of rice plant and the crop responses to salinity varies with growth stages, concentration and duration of exposure to salt (Shereen *et al.*, 2005).

Materials and Methods

Ten rice genotypes were used in this study, Ciherang (V_1), IR 64 (V_2), Lambur (V_3), Batanghari (V_4), Banyuasin (V_5), IR 42 (V_6), Inpara 10 (V_7) and Margasari (V_8). V_1, V_2 and V_6 are the susceptible variety on salt stress, but V_3, V_4, V_5, V_6 and V_8 are moderate and tolerant variety on salt stress (Barus, 2011). The experiment was conducted at Paluh Merbau village, Percut Sei Tuan Sub-District, Deli Serdang District, North Sumatera, Indonesia on March 2012 till July 2012. This research was arranged in a randomized block design non factorial with three replications.

Results and Discussion

Germination percentages and salt injury score of some varieties are given in Table 1. A comparison of the responses of the different cultivars indicated that germination percentage was based on type of cultivar. In germination phase, Ciherang had the highest germination percentage. Sembiring and Gani (2005) and Hosseni.et al. (2012) reported that salt stress resulted in reduced germination rate. From Table 1 it can be seen the highest germination obtained in Ciherang (V1) is equal to 57.07% and the lowest in Indragiri varieties (V7) is equal to 6:13%. Based on salt injury score was obtained the highest scores on Ciherang (V1) and Banyuasin (V6) is 1 (very tolerant) and lowest scores are the varieties Dendang (V3) and Indragiri (V7) ie 9 (highly susceptible).

Table 1. Germination Percentage (%) and Salt Injury Score

Variety	Germination Percentage (%)	Salt Injury Score
Ciherang (V_1)	57.07	1
IR 64 (V_2)	36.93	3
Dendang (V_3)	9.20	9
Lambur (V_4)	30.47	5
Batanghari (V_5)	19.13	3
Banyuasin (V_6)	20.73	1
Indragiri (V_7)	6.13	9
IR 42 (V_8)	20.93	3
Inpara 10 (V_9)	33.53	3
Margasari (V_{10})	21.87	3

Furthermore, the effect of salt stress on morphological characters can be seen in Table 2.

Table 2. Some Morphological Characteristics of Rice Cultivars on Saline Soil

Variety	Plant Height (cm)	Leaf Area (cm^2)	Total of Productive Tiller Number (pc)	Length of Panicle (cm)
Ciherang (V_1)	56.20 bc	22.28 bc	16.33 ab	19.22 b
IR 64 (V_2)	63.53 a	21.28 c	16.67 bc	18.55 b
Lambur (V_4)	59.95 abc	28.02 ab	15.50 a	19.77 ab
Batanghari (V_5)	55.58 c	26.15 abc	16.10 ab	22.48 a
Banyuasin (V_6)	58.27 abc	29.00 a	20.73 d	20.39 ab
IR 42 (V_8)	54.82 c	23.18 abc	22.50 ef	21.35 ab
Inpara 10 (V_9)	58.91 abc	21.96 bc	18.23 c	19.05 b
Margasari (V_{10})	62.49 ab	27.08 abc	21.50 e	20.76 ab

Morphological response of eight genotype were grown in saline soil is very significant (Table 2). IR 42 showed a high tolerance to salt stress. Results in Table 2 clearly showed that the eight tested cultivars of rice significantly varied for averages of plant height (cm), leaf area (cm^2), total of productive tiller number (pc) and Length of panicle (cm). Based on the observation of morphological character parameters except for plant height, ir 42 has the lowest height. Highest mean plant height on IR 64 (V2) is: 63.53 cm. While the lowest mean plant height on IR 42 (V8) is: 54.82 cm. Rad et al (2012), Ali et al (2012) and Zhang et.al (2012), reported that salt stress greatly influence the growth and development of morphological components. Correspondingly, Sitompul and Guritno (1995), reported that the plants have differences in phenotypes and genotype. Differences in the genetic makeup is one of the factors causing the appearance of crop diversity. Genetic program which will be expressed in a different phase of growth can be expressed in various plant traits that include form and function of plants that produce a diversity of plant growth. Furtheremore, the mean value of physiological characters of some cultivars are presented in Table 3.

Table 3. Some Physiological Characteristics of Rice Cultivars on Saline Soil

Variety	Chlorophyll Number (pc)	Filled grain Number /Panicle (grain)	Empty Grain Number /Panicle (grain)
Ciherang (V_1)	40.93	63.80 ab	12.03 c
IR 64 (V_2)	37.82	43.40 b	20.43 abc
Lambur (V_4)	39.63	76.93 ab	18.16 abc
Batanghari (V_5)	37.27	88.93 a	23.50 ab
Banyuasin (V_6)	38.63	79.90 ab	15.96 abc
IR 42 (V_8)	41.33	73.46 ab	18.23 abc
Inpara 10 (V_9)	38.63	60.76 ab	9.90 c
Margasari (V_{10})	37.59	65.26 ab	24.10 a

Results in Table 3 clearly showed that the eight tested cultivars of rice significantly varied for averages of chlorophyll number (pc), filled grain number/panicle (grain) and empty grain number/panicle (grain). Theit amount of chlorophyll is not significant for all genotypes but the highest amount of chlorophyll present in the IR 42 ie. 41.33. salt stress affects filled grain number and empty grain weight, were obtained in Banyuasin (88.93 g) and the empty seed number, ie. Margasari (24.10 g).Therefore primary stages, i.e. tillering and panicle initiation had more sensitivity to salinity but final growth stages (panicle emergence and ripening) were more resistant. Tolerance of plants isn't a constant characteristic and maybe at different stage of growth for various species will be different (Linghe and Shannon, 2000; Karami *et al.*, 2010). Salinity affects the crop during vegetative and reproductive stages and therefore causes reductions in both dry biomass and crop yield (Aslam *et al.*, 1993). Salinity tolerance is very important at reproductive stage of plant growth (Francois and Kleiman, 1990; Akram *et al.*, 2001).

Conclusions

All of genotypes were tested in this study have decreased of growth both of morphology characters and physiology characters due to salt stress. however, genotype ir 42 showed the best tolerance based on observations of morphological and physiological characters.

Acknowledgements

Thank you to the Rice Research Institute, Sukamandi, Subang on support for giving of seeds and also to the Directorate General of Higher Education for the financial support .

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