The Effect of Salt Pretreatment on The Growth and Yield of Oryza sativa L. (Cv. Dendang) Under Saline Condition

by Nindya Arini

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ABSTRACT

Productivity of riceas the staple food of Indonesia need to be increased. One of the efforts is by using saline area as the agricultural land. Salinity can be a serious problem leading to the decrease of crop productivity. Adaptation of crop under salinity is a way to lower the risk. Plant adaptation to salinity can be improved by seedling pretreatment. The experiment had been conducted at Baros, Kretek, Bantul, Yogyakarta. The objective of this research was to determine the growth and yield response of Dendang rice cultivar as treated by salt pretreatment at early stage. It used an random complete design with one factor. The factor consisted of salt pretreatment (T1) and without salt pretreatment (T2). The salt pretreatment increased K^+ concentration, total dry matter, plant height and number of tillers. However, it decreased proline and Na^+ concentration of leaf. There was no significant difference on the yield and yield component. Increasing EC values up to 8.35 dSm-¹ at generative phase reduced the rice ability to cope this level of salinity despite the application of salt pretreatment. The benefit of salt pretreatment was evident on rice grown under EC value 5 dSm-¹.

Keywords: paddy, salinity, salt pretreatment

INTRODUCTION

Rice is one of the most important crops and it is the primary staple food in Indonesia. Paddy field area decreases along with the increase of population. Therefore, it needs an effort to enhance the growth and yield of rice to balance the increase of population. One of the effort is to improve productivity of rice in marginal land. Indonesia has 40-43 million ha marginal field of which around 13.2 million ha is saline area (Suriadikarta and Sutriadi, 2007)

Salinity itself becomes a serious problem in crop cultivation of rice. Chinnusamy *et al* (2005) stated that saline soils and saline water are becoming major constraints affecting the rice production and its quality. Rice is considered to be moderately sensitive to salinity (Maas and Hoffman, 1977). High concentration of salt in soil can significantly decrease the productivity of rice. Zeng and Shanon (2000) reported that about 50% yield of rice is loss because the soil salinity limits the rice growth and development.

An attempt is needed to reduce the impact of salinity on crop performance and yield. One of them is by inducing the salinity tolerance. Pre-planting treatment is one component of the cultivation technology in the saline field by increasing the germination and performance or vigorous index in a wide spectrum; which is also effective for tense conditions (Liming *et al*., 1992) such as water and saline stress. This treatment is an easy, low cost and low risk technique which can be used to overcome the salinity problem (Nawaz *et al*.,2013). Suwignyo *et al* (2011) stated that the pre-planting treatment can increase plant tolerance to salinity.

Seed pretreatment stimulates many of the metabolic processes (physiological and chemical) involved in the early phases of germination. The seedling from salt pretreatment increases the germination rate and produces more vigorous and better seedling performance in saline conditions (Cramer, 2002). Previous study in *Aeluropus macrostachys* plant have shown that the use of salt pretreatment has a relatively tolerance against salinity. Sivritepe *et al.*, 2003 observed that EC values 5 dSm^{-1} as pretreatment on Melon crop induced higher adaptation capacity of salinity. The other study on Maize (Gebreegziabher and Qufa, 2017) showed that EC values 5 and 7 dSm^{-1} stimulates the physiological activities of maize seeds which resulted in rapid and uniform seed germination. Dendang is one of the varieties that can adapted to the saline soil.The potential yield of Dendang is 5 ton/ha. This research was aimed to study the impact of salt pretreatment on the growth and yield of Dendang rice cultivar.

MATERIALS AND METHODS

This research had been conducted since October 2016 to Februari 2017 in Baros, Kretek, Bantul, Yogyakarta. The primary materials used in this research were the Dendang seed, manure and NPK fertilizer (15% N, 15% P_2O_5, 15% K_2O, and 10% S), groundwater (EC 4-5 dSm^{-1}), $NaNO_3$, ninhydrin acid, 1% sulphanilamide, HCL 3 N, 0.02% Naphtylefilendiamide, 3% sulphosalicylic acid, HNO_3, toluene, and aquadest. The laboratory tools used were, spectrophotometer, LICOR LI-6400, EC meter, micro pipette, digital scales, flame photometer, water pump, hose, hand counter, roll meter, oven, plants scissors, nets, stationery, cultivation tools, paper bags, plastic bags and raffia straps..

The experiment was arranged in a Random Complete Block Design (RCBD) with one factor. The factor consisted of two levels, salt pretreatment (T1) and non salt pretreatment (T2). The salt pretreatment was applied at the beginning of radicle and coleoptile emergence until the seedling were transplant to the field. EC values of salt pretreatment at seedling stage was 5 dSm^{-1}. The seedlings were transplant to the field at 28 days after seedling. The size of this experimental unit used was 3x3 m each plot. Saline stress condition in the field used river water as the irrigation source with EC values range of 4 – 7 dSm^{-1}. The EC values of irrigation water was checked before it pumped into the land. It was applied in 2-3 a days until flowering stage.The data were observed on leaf Na^+ and K^+ concentration (Munns, *et al.*, 2010); proline concentration (Bates *et al.*, 1974); nitrat reductase acitivty (Hari *et al.*, 1982); photosynthesis rate (Sunghening, 2015); plant height; number of tiller; total dry weight; number of grain/panicles; percentage of filled grain/panicles; panicle length; grain weight/plant, number of grain/plant and dry grain yield. All the data observed were analyzed by using t-test.

RESULT AND DISCUSSION

The electrical conductivity (EC) of river water as irrigation was fluctuated from the beginning to the end of the experiment. It was due to low and high rain fall. The highest EC value (8.35dSm-1) occurred at 10 weeks after planting (WAP). The high EC value was suspected as affected by the accumulation from previous irrigation.

Na^+ and K^+ Concentration of Dendang

Plant responses to salinity were first determined by measuring the Na^+ and K^+ concentration in the leaves. Table 1 showed that there was significant difference of Na^+ concentration at 25 days after planting (DAP) in which seedling without salt pretreatment had a higher Na^+ concentration than seedling with salt pretreatment. Plants accumulate more Na^+ in leaf tissue than in the other organs. The high salinity in the root area causes the plant to accumulate more salt.

In this study, plant with salt pretreatment had a lower Na^+ concentration than plant without salt pretreatment at 25 days after planting. Meanwhile, K^+ was higher in salt pretreatment than non salt pretreatment. In salinity stress conditions, the presence of Na^+ concentration is inversely proportional to K^+ concentration. Increased absorption of Na^+ ions results in the accumulation of high ions in plant tissues (Staples *et al.*, 1984), resulting in obstacles in the absorption of K^+, Ca^{2+} and NO^{3-} (Maas, 1997). Greenway and Munns (1980) reported that the plants which contain low concentration of Na^+ in the roots and other organs under salt stress are suspected to have salt tolerance. However, there was no any significant difference of Na^+ concentration between treatments at 54 DAP and harvest time. Concentration of K^+ also showed that there was no significant difference between salt pretreatment and non salt pretreatment at 54 days after planting and harvest time.

Table 1. Na^+ and K^+ concentration of leaf at 25 DAP, 54 DAP, and at harvest time

	Na^+ (mmol/g FW)			K^+ (mmol/g FW)		
Treatment	25 DAP	54 DAP	harvest	25 DAP	54 DAP	Harvest
Salt pretreatment (T1)	1.13	1.74	109	62.4	60.2	42.1
Non Salt pretreatment (T2)	2.24 (*)	2.47	113	49.9 (*)	60.7	52.8

FW : Fresh Weight
DAP : Days After Planting
Note: The note (*) indicate statistically significant differences based on the t-test at $\alpha = 5\%$.

Proline and Nitrate Reductase Activity Content

Accumulation of solutes especially proline is a common observation under the saline stress condition. Proline accumulation in salt stressed plants is a primary defense response to maintain the osmotic pressure in a cell (Turan *et al.*, 2009). Leaf is a part of plant that contains highest accumulation of proline. The data (Table 2) showed that proline concentration of leaf without salt preteatment was significantly ($p \leq 0.05$) higher than proline concentration with salt pretreatment at 54 days after planting. The increase Na^{+} concentration causes the plant with salt pretreatment had a higher salt concentration. Plants have developed an efficient method to keep the ion concentration in the cytoplasm in a balance. In these plants, osmotic balance is generally achieved via extensive accumulation of organic solutes and/or inorganic ions (Gupta and Huang, 2014). Proline and glycine betaine were reported as the best known compatible solutes that increase greatly under salt stress (Carillo *et al*, 2011). Plants without salt pretreatment accumulate more compatible solutes in response to the presence of excess Na^{+}, so that the concentration of proline is high. There was no significantly difference on nitrate reductase activity between salt pretreatment and without salt pretreatment.

Table 2. Proline and Nitrate Reductase Activity of Leaf at 25 and 54 DAP

Treatment	Prolin (ppm)		NRA (µmol NO_2^{-}/g/hour)	
	25 DAP	54 DAP	25 DAP	54 DAP
Salt pretreatment (T1)	13.8	7.0	5.4	3.8
Non Salt pretreatment (T2)	12.8	7.2 (*)	11.8	5.6

Note: The note (*) indicate statistically significant differences based on the t-test at $\alpha = 5\%$.

Photosynthesis Rate

The result of photosynthesis rate at 54 days after planting under saline condition was not significantly affected by salt pretreatment. It may happened because the high salt stress was just occurred at the generative phase, so the plant was quite strong enough to tolerant the salt. In this study, the high salt stress at generative phase caused by decrease of rainfall, so the river water as saline irrigation source had a high concentration of salt.

Table 3. Photosynthesis Rate at 54 DAP

Treatment	Photosynthesis Rate (µmol CO_2 m^{-2} s^{-1})
Salt pretreatment (T1)	0.044
Non Salt pretreatment (T2)	0.039

Note: The note (*) indicate statistically significant differences based on the t-test at $\alpha = 5\%$.

Plant Height, Number of Tillers, and Total Dry Matter

Based on the t test data anylsis, plant height was not significantly ($p \leq 0.05$) different between salt pretreatment and non salt pretreatment. But, From the graph (Figure 1), salt pretreatment had a higher plant height than non salt pretreatment until 42 DAP. A good impact of salt pretreatment on plant height had been reported by Sivritrepe *et al.*, (2003) in which seedling pretreatment with salt on the saline condition (EC values 5 dSm^{-1}) allows a higher plant height than those without pretreatment of Melon crops.

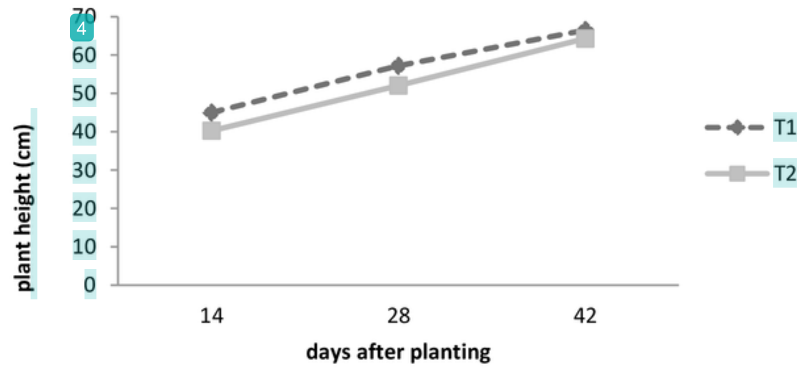

Figure 1. Plant Height of Dendang Rice Cultivar with Salt pretreatment (T1) and Non Salt pretreatment (T2)

Table 4. Plant Height And Number of Tiller at 42 Days After Planting, Total Dry Matter at 108 Days After Planting

Treatment	Plant Height (cm)	Number of Tiller	Total Dry Matter (g)
Salt pretreatment (T1)	66.5	17.6	53.6
Non Salt pretreatment (T2)	64.3	15.6	42.6

Note: The note (*) indicate statistically significant differences based on the t-test at $\alpha = 5\%$.

According to Table 4, the effect between salt pretreatment and non salt pretratment on the number of tiller was not significant ($p<0.005$) although Figure 2 showed a trend that tiller number of salt pretreatment is higher than without salt pretreatment along with the passage of time. The number of tiller that tended to be high in this phase was thought to be associated with good performance on salt pretreatment seedling (data not showed). Krishnasamy and Seshu (1989) inform that yield and tiller number per plant showed positive association with the good performance at seedling stage. The performance of seedlings affected the condition of the plant after being planted in the field.

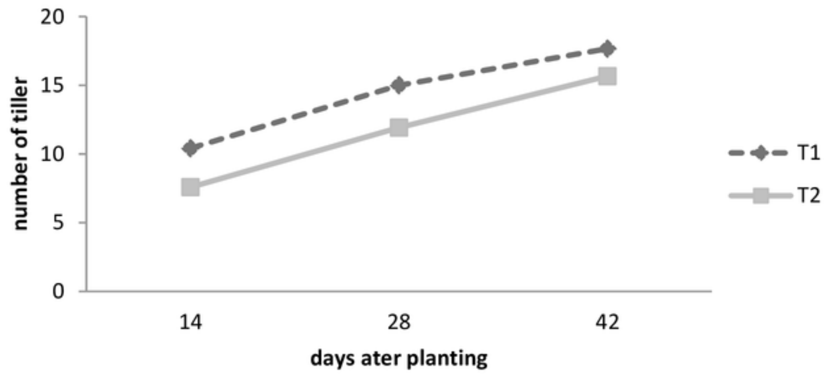

Figure 2. Number of Tiller Dendang Rice Cultivar with Salt pre treatment (T1) and Non Salt pretreatment (T2)

According to the Table 4, it showed that there was no significant different between salt pretreatment and non salt pretreatment on total dry matter. Total crop dry matter is the spatial and temporal integration of all plants processes. From the data of EC values during the experiment, the highest soil EC values is at generative phase (49-63 DAP) on range 6-9 dSm^{-1}. However, plant is more tolerant of salinity at the generative phase.

Grain Yield

Although previous data showed that salt pretreatment gave a higher plant height, more number of tiller, higher K^+ concentration, lower Na^+ concentration and proline concentration at vegetative phase, however Tabel 5 and 6 showed the data that there was no significant difference ($p>0.005$) between salt pretreatment and non salt pretreatment. The electrical conductivity (EC) of irrigation water used from the beginning to the end of the experiment was fluctuated. The highest EC value (8.35 dSm^{-1}) occurred at 74 days after planting when the plant was on the generative phase. It was presumably due to low and high rainfall. The high EC value was suspected as affected by the accumulation from previous irrigation and low rainfall. The rapid increase of EC values on the generative phase made the effect of salt pretreatment was not as significant as the effect on vegetative phase.

Table 5. Number of grain/panicles, percentage of filled grain/plant and panicle length

Treatment	Number of grains/panicles	Percentage of filled grain/plant (%)	Panicle Length (cm)
Salt pretreatment (T1)	103	79.1	22.4
NonSalt pretreatment (T2)	93	76.8	22.5

Note: The note (*) indicate statistically significant differences based on the t-test at $\alpha = 5\%$.

Table 6. Grain weight/plant, number of grain/plant and dry grain yield

Treatment	Grain Weight/plant (g)	Number of grain/plant	Dry Grain Yield (ton/ha)
Salt pretreatment (T1)	17.4	986	4.35
Non Salt pretreatment (T2)	15.9	969	3.97

Note: The note (*) indicate statistically significant differences based on the t-test at α = 5%.

Table 6 showed there was no significant difference on grain weight/plant, number of grain/plant and dry grain yield. Binang *et al*., (2012) informed that the effect of salt pretreatment on yield would depend on the type of stresses that seedling was exposed to. Cayuela *et al*., (2001) also reported that the stress level used for seedling pretreatment will affect the salt tolerance in which if salt concentration in the pretreatment is under the stress threshold, the plants are unable to increase their salt tolerance levels.

CONCLUSION

It was apparent that at the vegetative phase, salt seedling pretreatment increased K^+ concentration, plant height and number of tiller. However it decreased Na^+ and proline concentrations. Salt pretreatment did not give effect when EC value reaches 8.35 dSm^{-1}. It was also proved that salt pretreatment with EC values 5 dSm^{-1} can be used as a way to enhance salinity tolerance when rice is grown under 5 dSm^{-1}.

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