

EFFECT OF SALT STRESS ON SOME PHYSIOLOGICAL PARAMETERS OF RICE (*ORYZA SATIVA* L.) AT SEEDLING STAGE

M. I. S. Safeena

*Department of Biological Sciences, Faculty of Applied Sciences,
South Eastern University of Sri Lanka, Sammanthurai.*

Keywords: *Chlorophyll, leaf area, photosynthesis rate (PR), salinity*

Introduction

In Sri Lanka, salinity problems are primarily associated with the coastal area and irrigated lands of the dry zone, where the total irrigated area is about 0.5 million hectares. Since irrigation has been practiced in these areas from ancient times, salinity could be a problem at least in patches of irrigated land, and with the development of modern irrigation networks due to the accumulation of salt in the basins of irrigation channels. Unfortunately, water supplied is often of poor quality, and evapotranspiration leads to the concentration of salts in the soil added during irrigation. Therefore it is possible that salinity would become a problem over the years in this region of Sri Lanka as in many other countries. This can be still enhanced due to the tsunami disaster in the coastal area of Sri Lanka.

Leaf area and photosynthesis rates at different growth stages determine the growth, development and ultimately the yield of any plant. Salinity decreases both growth and net photosynthesis of higher plants (Maria *et al.*, 2000). For rice, the threshold electrical conductance (EC) is 3dS/m, and a 1dS/m increase in salinity over this can reduce yield by 12% while an EC value of 6-10 dS/m is associated with a 50% decrease in yield. This is due to the competition of different physiological processes among sink organs for the limited carbon supplies under salinity (Munns and Termaat, 1986).

Morphological screening programs of rice have shown an inadequacy on the basis of salt tolerance and yield. Many varieties which show good salt tolerance are low yielding due to biochemical and physiological inadequacies (Erikson *et al.*, 1995). The negative influence of salinity particularly at seedling stage affects growth significantly on subsequent stages. For example, if a rice variety is highly sensitive at low salt level during seedling stage, then it can not be grown even under mild salt condition. In order to understand the metabolic adjustments and to quantify the degree of effect of salinity, the information on effect of salinity on leaf area, photosynthesis rate, chlorophyll content and damage index were studied during the seedling stage, which is the prime growth stage that determines the plant growth further.

Methodology

Three rice cultivars contrasting in tolerance of salt stress were selected for this investigation. Pokkali (Salt tolerant) At 353 (Moderately tolerant) and IR 28 (Salt susceptible) were surface sterilized with 1% sodium hypochlorite and washed thrice thoroughly in distilled water and then imbibed in water for 48 h at room temperature. Plants were grown under green house conditions in hydroponics using a nutrient solution (Yoshida *et al.*, 1976). Each variety had three replicates and seedling density was fifteen per 1L plastic pot at the beginning and later at the flowering stage it was thinned out to two plants. Pots were inserted in to the tubes of the hydroponic system. The spacing between pots in

the tube was 12 inches. The temperature varied from 28 – 31° C during day and 24 to 28° C in the night.

Salt stress was applied to 14-day old plants: Chloride dominant salt solution (Peiris, 1992) was added to the nutrient medium and a range of salinity levels was induced similar to that found under natural conditions (4, 6 and 8 dS/m) by adjusting the concentration of NaCl, CaCl₂, KCl and MgSO₄. None salinized nutrient medium (Electrical conductance 1.0 - 1.03 dS/m) was used as the control. Conductivity and pH of growth medium (5 - 5.5) were checked and adjusted every two days.

Leaf total chlorophyll content (mg/ g fresh weight) in the 80% acetone extract was measured using the UV – VIS spectrophotometer (UV-1201, Shimadzu Corp., Kyoto, Japan). Leaf area was measured in fully expanded leaves of nine randomly selected plants by a portable leaf area meter (Li- 3000, Li- Co- R, Inc.). Photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) was measured by a portable photosynthesis system (Li- 6400, Li- Co- R, Inc.) under full sunlight (9:30 am. to 11:30 pm.). Plant survival rate was estimated during the stress period considering all dead plants including those which showed necrosis in all leaves.

Discussion and Conclusion

The total chlorophyll decreased significantly with increasing salinity. However, at 4 dS/ m, it increased in values compared to the control in all varieties. Highly tolerant variety, Pokkali maintained high leaf chlorophyll content even after exposure to high salt treatment (Fig. 1a). dS/ m respectively (Fig. 1a). This indicates the lesser breaking down of chlorophyll molecules in Pokkali under high salinity. This also may be due to the inherent ability of the variety for salt tolerance. The decrease in total chlorophyll with increasing salt stress had severe impact on the rate of photosynthesis (PR) in all varieties at all sampling dates (Fig. 1 b). At the end of the salinization period, the salt level 4 dS/ m significantly ($P > 0.05$) reduced the PR of Pokkali by 14%, At 353 by 18% and IR 28 by 24% compared to the control. However, it is considered that high salinity causes breakdown of chlorophyll molecules, because of the accumulation of toxic ions such as Na⁺ and Cl⁻. Hence, the rate of photosynthesis was decreased significantly in moderately tolerant and sensitive varieties compared to the highly tolerant variety.

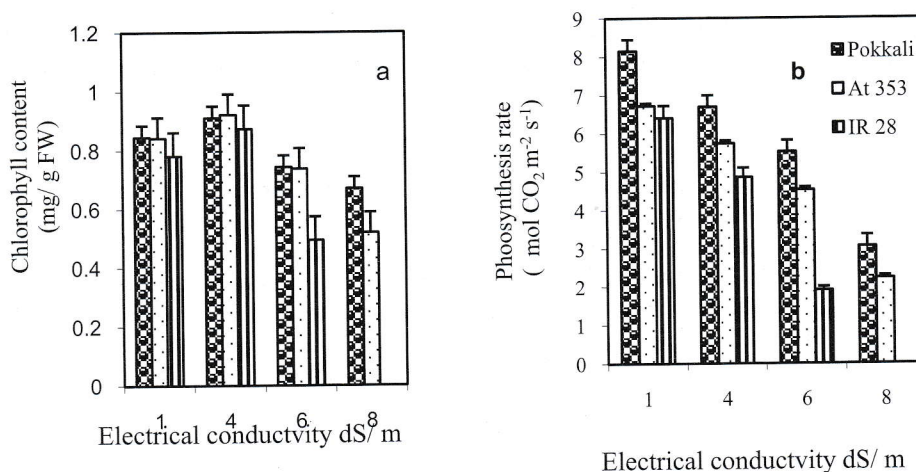


Figure 1. Effect of salinity on chlorophyll content (a) and photosynthesis rate (b) of rice varieties in response to different salt treatment.

The most important morphological character that responded to salinity was changes in leaf area. Leaf area decreased by 15-19% and 25-48% over the control for all varieties, at salt levels 4 and 6 dS/m (Table 1). During the experimental period leaf area reduction of Pokkali and At353 was not significantly different at P=0.05 at 4 and 6 dS/m.

Table 1. The effect of salinity on the leaf area mean and mean plan survival rate during the total growing season.

Parameter	Electrical conductance dS/ m	Varieties		
		Pokkali	At 353	IR 28
Leaf area cm ²	Control	33.61a	29.05a	28.89a
	4	27.20a	24.75a	23.53a
	6	25.53a	19.60a	14.98b
	8	21.01b	12.11b	*
	CV%	5.63	4.89	7.10
Survival rate %	Control	100	100	100
	4	100	100	95
	6	95	80	50
	8	80	28	*

The reduction in leaf area could be due to the accumulation of high concentration of Na⁺ and Cl⁻ ions which induces chlorosis and leaf senescence. This will ultimately lead to a decrease in active photosynthetic leaf area. As a result, and in agreement with the finding of Munns and Termaat (1986), the production of carbohydrate declines and productivity falls below a level capable of sustaining further growth. At EC= 8dS/m, 58% reduction of leaf area in At353 was observed compared to the control. However, reduction of leaf area significantly affected photosynthesis rate in all varieties.

The study showed that high salinity levels significantly reduced leaf area, chlorophyll content and photosynthesis rate. Reduction of photosynthetic leaf area directly affected the photosynthetic rate. This limited PR would reduce allocation of carbon resources to overall plant development and yield. Therefore, with the increase of salinity, survival of plants decreased. Growth of At353 and IR28 was highly affected at salt levels 8 and 6 dS/m during tillering and seedling stages respectively. This implies that these varieties can not be grown at these salt levels.

References

- Erikson, J., Rogers, W.J. and Perera, A.L.T. (1995). Genetic screening of rice varieties using RAPD markers for indication of salt sensitivity/resistance. Sri Lankan Journal of Agric. Sci. 32: 16 – 29.
- Maria, E.B., Jose Dell, A., Maria, C.B. and Francisco, P.A. (2000). Carbon partitioning and sucrose metabolism in tomato plants growing under salinity. *Physiol.Plant.* 110: 503 – 511.
- Munns, R. and Termaat, A. (1986). Whole plant responses to salinity. *Aust. J. plant Physiol.* 13: 143 – 160.
- Peiris, B.D. (1992). The effect of saline media of varying ionic composition on stomatal resistance of rice (*Oryza sativa* L.) leaves. *J. Natn. Sci. Coun. Sri Lanka.* 20(1): 127 – 131.
- Yoshida, S., Forno, D.A., Cock, J.H. and Gomez, K.A. (1976). Laboratory manual for physiological studies of rice. IRRI, Los Banos, Laguna, Philippines.