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Selection of Rice Genotypes for Salinity Tolerance Through Morpho-Biochemical Assessment

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Abstract: The present study reported the morpho-biochemical evaluation of 15 selected rice genotypes for salt tolerance at the seedling stage. Growth parameters including shoot length, root length, plant biomass, plant turgid weight, plant dry weight along with relative water content were measured after exposure to saline solution (with electrical conductivity value of 12 dS/m). Genotypes, showing significant differential responses towards salinity in the fields, were assessed through 14 salinity-linked morpho-biochemical attributes, measured at 14 d after exposure of seedling in saline nutrient solution. Relative water content, chlorophyll a/b, peroxidase activity and plant biomass were identified as potential indicators of salt tolerance. Principal component analysis and successive Hierarchical clustering using Euclidean distance revealed that Talmugur, Gheus, Ghunsi, Langalmura, Sabitapalui, and Sholerpona were promising genotypes for further breeding programmes in rice. The maximum Euclidean distance was plotted between Thavallakanan and Talmugur (7.49), followed by Thavallakanan and Langalmura (6.82), indicating these combinations may be exploited as parental lines in hybridization programmes to develop salinity tolerant variety.
Key words: chlorophyll content; electrical conductivity; *Oryza sativa* L.; peroxidase activity; proline content; relative water content; salinity tolerance; sugar content; superoxide dismutase

Rice (*Oryza sativa* L.), which belongs to the family *Poaceae*, is the most important food crop accounting for about 29% of the total calorie in terms of food intake. It is said that 100 g of rice provides 345.0 kcal energy, 78.2 g of carbohydrates and 6.8 g of protein (Gopalan et al, 1976), and also provides the considerable amount of recommended zinc and niacin. Rice protein is biologically richest for its high digestibility (88%). Rice can also be used as cereal, snack food, brewed beverage, flour, oil (rice bran oil), syrup and religious ceremonies, to name a few other uses. It is one of the three major food crops in the world and forms the staple diet of about half of the world's population. The demand of rice is expected to increase further in future, in view of presumable increase of the world population. India has a long history of rice cultivation, and contributes 21.5% of global rice production, thus being the second rice producer after China. Within the country, rice occupies one quarter of the total cropping area, contributes about 40%–43% of total food grain production and continues to play a vital role in the national food and livelihood security system.

Salinity is one of the major abiotic stress that can severely limit the production of crops (Shannon, 1997). It is a soil condition characterized by a high concentration of soluble salts. Soils are classified as saline when the electric conductivity (EC) is 4 dS/m or more (USDA-ARS, 2008), which is equivalent to approximate 40 mmol/L NaCl and generates an osmotic pressure of approximate 0.2 MPa. According to FAO (2008), over 6% of the world's land is affected by salinity which accounts for more than 800 million hectares lands covering about 5% of cultivated area (Munns et al, 1999). In India, about 8.4 million hectares lands have been affected by salinity. Economically, even though rice is considered as one of the most important crops in the world and being

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cultivated in 114 countries (FAO, 2004; Bajaj and Mohanty, 2005; Walia et al, 2007), environmental stress such as water and soil salinity has markedly reduced its yield. This crisis will be even prominent with increase of global population, wherein, it will be intricate to attain the sufficiency of food sources (Kumar et al, 2007). Differential salinity sensitivity at various growth stages is one of the factors affecting salt tolerance phenotype. Rice is considered to be susceptible to salinity, particularly during early vegetative and late reproductive stages (Mass and Hoffman, 1977; Shannon et al, 1998), but proved to be tolerant to salinity at seed germination stage (Heenan et al, 1988; Khan et al, 1997), which is not significantly affected by EC even up to 16.3 dS/m (Heenan et al, 1988). Hence, improvement of salt tolerance of rice should target the specific growth stages that are more sensitive to salinity stress and can substantially affect grain yield.

To observe and assess the response of germplasms to salinity, a proper screening technique is required. In rice the screening can be done at its two salt sensitive stages (early vegetative stage and late reproductive stages), though screening at the seedling stage based on simple criteria is a rapid method. Screening can be done at the field level or under the laboratory condition. The former is difficult because of the presence of soil heterogeneity, climatic and other environmental factors which tend to modulate the physiological processes (Shannon, 1997). Hence, screening under laboratory condition has many advantages over field screening. A combined pleotropic effect of different factors alters plant growth and development at physiological, biochemical and molecular levels. Recent reports ensure that screening for salinity tolerance is based on agronomic characters (Noble and Rogers, 1992), which, however, may not prove to be a practicable and fruitful technique since they are highly influenced by the environment. Therefore, development of salt tolerant genotypes solely relies on conventional selection and breeding techniques (Noble et al, 1984; Al-Khatib et al, 1992; Shannon, 1997; Ashraf, 2002).

One of the important plant defenses is the osmotic adjustment, which can occur by the accumulation of high concentrations of either inorganic ions or low molecular weight organic solutes. An increase level of leaf relative water content (RWC) in rice under salinity suggests the role of osmoprotectants, preventing cell injury from salt stress-induced dehydration (Yancey et al, 1982). Dionisio-sese and Tobita (1998) reported a significant decrease of superoxide dismutase (SOD) activity in the salt-sensitive variety whereas slightly increased in the salt-tolerant variety in response to salt treatment. A number of researchers dealing with rice (Mittal and Dubey, 1991) and other plants (Kalir et al, 1984) have also reported an increase in peroxidase activity (POD) in salt-tolerant variety under salt stress. The accumulation of soluble carbohydrates has been widely reported as a response to salinity or drought despite the significant decrease of net CO_2 assimilation rate (Popp and Smirnoff, 1995). Several studies have been done to correlate response to salinity stress in accordance with changes of carbohydrate concentrations (Ashraf and Tutail, 1995) as well as proline accumulation in many monocotyledons (Jones and Storey, 1978). According to Pareek et al (1997), proteins may be synthesized *de novo* in response to salt stress or may be present constitutively at low concentration and increase when plants are exposed to salt stress. Similarly, chlorophyll (Chl) concentration in stressed tissue can be construed as an index of tissue tolerance to NaCl. However, it is not a necessary exhaustive index of tissue tolerance.

Based on the clear and illustrative idea perceived from the earlier studies, the present investigation has been carried out with the objectives to study the performance of selected genotypes of rice: to compare the seedling growth and biochemical parameters in saline environment (EC as 12 dS/m) with those in control (EC as 0 dS/m); to asses salinity induced biochemical changes in selected rice germplasms; to study the association among the selected morpho-biochemical parameters under salinity; and finally, to identify true salt tolerant genotypes among the selected germplasms.

MATERIALS AND METHODS

Rice materials

The seeds of selected rice genotypes (Table 1) were obtained from Development Research Communication and Services Centre (DRCSC), South 24-Parganas, West Bengal, India. And screening for salt tolerance was done in two treatments (EC as 0 and 12 dS/m, respectively).

Seed germination and exposure to salinity stress

Surface sterilized rice seeds, treated with 2% Bavistin for 8 h, were germinated in the glass plate for 4–5 d.