Bangladesh J. Bot. **35**(2): 99-107, 2006 (December)

EFFECTS OF NaCl SALINITY ON LEAF CHARACTERS AND PHYSIOLOGICAL GROWTH ATTRIBUTES OF DIFFERENT GENOTYPES OF RICE (*ORYZA SATIVA* L.)

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Key words: Salinity, Leaf area index, Net assimilation rate, Relative growth rate, Tolerance index

Abstract

Effects of salinity on leaf characters and physiological growth attributes of different 33 rice genotypes were investigated at tillering and booting stages of growth. Salinity affected leaf number, leaf area (LA), leaf area index (LAI) and leaf dry wt. in a number of varieties such as BR 1, BR 18, IR-21015-196-3-1-3, Kalojira at tillering and BR 14, IR-21015-196-3-1-3, Kaloboroi and SR × SP-2-2-2 for most of the characters at booting stages to a higher extent. But Birpala, Canning-7, Zorabati and a few others revealed better performances for leaf characters at both growth stages. At tillering stage, salinity increased and/or did not affect substantially leaf number, LA, LAI and dry wt. in Deshipajam and Borobalamdhan. Similar trend under salinity was also noted in Borobalamdhan, MC-12 and Rashiraj at booting stage. Tolerance indices (TI) for leaf number, LA, LAI and leaf dry wt. were variable, ranged from 30 - 117% of control, but Borobalamdhan, BR 14, Canning-7, Deshipazam, MC-12, Pokkali, Raildhan, Rashiraj, Zorabati and a few others revealed better TI score for these characters at one or another growth stages. For leaf area ratio (LAR), net assimilation rate (NAR) and relative growth rate (RGR) Azobbati, Binasail, Birpala, BR 1, BR 3, BR 9, BR 18, BR 19, Kalojira, Pokkali and Rashiraj revealed higher TI score under stressful condition than others. For most of the leaf growth characters, the number of moderately tolerant (MT) genotypes was higher than that of other tolerance grades.

Introduction

Salinity combines elements of water deficit and sodium chloride as well as other ion toxicity. Plant responses to salinity stress involve complex multi-factorial processes (Cheeseman 1988, Ducovsky *et al.* 1992). Different plant species under halophytic group through evolution have adapted to cope with salinity stress. Adaptive potential of the cereal crop to salt stress is very insignificant for their culture in the salt affected land. Rice, the main cereal crop of many countries including Bangladesh, is not in general salt tolerant. It is a crop of fresh-water marshy land and is cultivated in Bangladesh for centuries. According to Vavilov (1951) Bangladesh constitutes a part of the centre of origin of rice. The number of indigenous cultivars is fairly large - more than several thousands and their wild relatives (wild rice) are also available in Bangladesh. So, one can find here a wide range of different edaphic and/or cultural diversity for different rice genotypes. Edaphic diversity may include drought and saline environments, and stress tolerant cultivars are important for the farmers from economic as well as to the scientists from the academic point of view. A wide range of variation in stress responses due to salinity between and within rice varieties has been reported (Yeo *et al.* 1988, 1990). Some recent workers cast light on the molecular mechanisms of plant responses and adaptations to environmental stresses (McCue and Hanson 1990, Bray 1993, Delauney and Verma 1993, Bohnert *et al.* 1995). It has been reported that two major physiological traits enable the plant to tolerate salinity : (a) compensatory growth following adjustment to salinity and (b) ability to increase both leaf area ratio (LAR) and net assimilation rate (NAR) to achieve this increased growth (Wiynarah 1990). Structural components of plants including leaf structure that undergo changes due to salinity are intimately linked to physiological and biochemical activities of the plant (Cushman and Bohnert 1995, Bohnert and Jensen 1996). Adverse changes in morphological structures associated with physiological modifications due to salinity may be the main elicitors of growth decline under salt stress. Salt accumulation in the expanding leaves has been correlated with photosynthetic decline and with ultra-structural and metabolic damages and sequential death of leaves (Yeo and Flowers 1986), and growth vigor may be related to the survival efficiency of different varieties (Yeo *et al.*1990). So, leaf characters and physiological growth attributes may be important criteria for a tolerant variety. Tillering and booting phases are two physiologically important growth stages contributing to good plant population stand as well as yield. Therefore, in the present work the effect of NaCl salinity on some leaf characters and physiological growth attributes of different rice genotypes was investigated at these growth stages.

Materials and Methods

Thirty three rice (*Oryza sativa* L.) genotypes were taken in the present investigation. They include both indigenous, exotic and HYV germplasms. Seedlings at 20 days old stage were transplanted in 10 L plastic pots. Three healthy seedlings per hill and three hills per pot, each of which contained 8 kg mixed soil (soil : cow-dung = 3 : 1). Mineral nutrients were applied following the recipe of Arnon and Hoagland (1940). Nutrients were applied as basal dose two days before transplantation. For treatment NaCl (0.1 Molal) was applied after seedling establishment (Ten days following transplantation). Control pots were without NaCl. Electric conductivities (EC) of the growth media were determined in the representative saturated soil extracts at room temperature (25^0C) and were found 1.82×10^{-3} and 10.89×10^{-3} $dS.m^{-1}$ in control and treatment respectively. After, two days interval irrigation was done as per requirement and a constant water level (5 cm above soil surface) was maintained. Weeding was done manually from time to time. For growth assessment plant samples were harvested at peak tillering and at early booting stages of growth. From treatment nine hills, three from each pot were collected per genotype. Shoot was rinsed by water and was dried in an oven at 65^0C for several days until it attained a constant weight. For the calculation of leaf area formula initially developed by Watson (1958) and Mckee (1964) was used after necessary modification as described by Alamgir (1972). Tolerance index (TI) and tolerance grades for different characters were determined following the methods of Fageria (1985). Tolerance grades on the basis of TI scores were as follows: Tolerant-T (score 80-100 %), moderately tolerant-MT (score 60-79 %), moderately susceptible-MS (score 40-59 %) and susceptible-S (score < 40 %).

From dry weight of shoot and leaf area data at two different harvests (tillering and booting) LAR, NAR and RGR were calculated according to Radford (1967). There were 3-4 replications for each set of experiment. Pots were arranged in a completely randomized design under the sun.

Results and Discussion

The higher total number of leaf was found in Birpala, BR 14 and Canning-7 at tillering and Azobbati, DMI-52 and MC-12 at booting stages (Tables 1-2). Besides, Kalojira had the lowest leaf number at both tillering- and booting stages. At booting stage others which revealed low leaf number under stress were: Binasail, BINA-5-153-8-163, Bismali, Canning-7 etc. Compared to control (in %) some of the local germplasms revealed high leaf number under stress at tillering- (e.g. Bismali-95.45 %, Borobalamdhan-88.24 %, BR 14- 80.65 %, Deshipajam-94.44 %, Raildhan-85.0 % etc.) and at booting (e.g. Azobbati-84.21 %, MC-12-96.15 %, Nazersail-90.20

%, Pokkali-93.55 %, Rashiraj-102.08 %, Zorabati-89.66 % etc.) stages. Iyenger *et al*. (1977) reported that saline irrigation water reduced the number of leaves, tillers and other growth attributes of barley. Green leaves and dry matter production per plant were reported to reduce with the increase of soil salinity (Bal and Dutt 1984). Inhibition of the formation of leaf primodia under salinity stress could be the probable reason for low leaf number. Salinity also affected leaf area (LA) and leaf area index (LAI) in different ways. Salinity in few instances stimulated the development of LA as well as LAI of some plants at tillering or booting growth stages (e.g. Borobalamdhan- > 100 %, BR 9- > 103 %, Deshipajam- > 103 %, MC-12- > 109 % and Rashiraj- > 117 % over control), but in other cases inhibited them; the degree, however, was different in different germplasms. Inhibition, in % of control was found to be the least in Raildhan (< 2 %) at tillering- and in Borobalamdhan (1 %), Birpala (4 %) and Pokkali (2 %) at booting stages, but both LA and LAI under salinity, expressed in % of control were found to be the lowest in BR 1 (34 %), BR 18 (34 %), IR-21015-196-3-1-3 (35 %) at tillering- and BR 14 (46 %), IR- 12015-196-3-1-3 (40 %), Kalobori (45 %), SR × PS-2-2-2 (39 %) at booting stages (Tables 1 and 2). Gosset and Lucas (1994) reported that NaCl highly reduced total leaf area and fresh weight of salt sensitive cotton cultivar compared to salt tolerant cultivars.

In the present work, in different genotypes the range of LAI was 7.04 (Borobalamdhan) to 72.79 (Birpala) without salt treatment and 4.60 to 59.80 in BR 1 and Birpala, respectively under salt treatment at tillering stage corresponding to 34.23 and 82.15 % of control, but at booting stage the range was 27.83 (Kalojira) to 174.87 (Dolichokkol) without salinity and 14.12 to 120.72 with salinity which was also revealed by Kalojira and Dolichokkol, respectively corresponding to 50.73 and 69.03 % of control. Similarly, leaf area was also inhibited due to salt stress, the range was different in different germplasms but found to vary from 34.23 (in BR 1) to 103.44 % (in Deshipajam) at tillering and 39.97 (IR-21015-196-3-1-30) to 117.02 % (Rashiraj) at booting stages compared to control. Although the levels of LAI were increased with the advancement of growth stage, still there was a notable inhibitory effect of salt stress (39.40 - 59.29 % of control) in at least eight germplasms on the development of LAI. Mahmood and Quarine (1993) reported that the growth of wheat in terms of leaf area and dry wt. were reduced by salt treatment.

Yeo *et al.* (1991) noted inhibitory effect of salinity on leaf growth within 1 - 20 min of exposure to 50 mM NaCl and complete resumption of growth after 24 h, but thereafter occurred reduction of leaf growth, longivity and ultimate death. High salinity (100 mM) severely affected leaf growth. Initial cessation of growth under low salinity was due to limitation of water supply and under high concentration it could be due to accumulation of salt in the expanded leaf. The mode of action of salt under short and long term exposure and/or low and high concentrations seemed to be quite different (Bohnert and Jensen 1996). However, the existence of varietal difference could be an important factor for selection and development of resistant variety. Leaf growth in length and area was reported to decrease in susceptible, but increase in tolerant varieties (Misra *et al.*1997). It corroborates, to some extent, with the findings of the present work as Raildhan - a local Chittagong coastal area rice as well as Pokkali, a salt tolerant variety, revealed the least possible leaf growth (LA, LAI) inhibition (< 2 % of control) under stress. Accordingly the varieties revealing high leaf growth inhibition (i.e. > 60 % of control) under stress are susceptible or moderately susceptible and those with low inhibition (i.e. > 80 % of control) or showing increasing trend in leaf growth are considered to be tolerant in 33 germplasms (Tables 1 and 2).

Under salinity stress, leaf dry wt. was reduced in most of the genotypes excepting in a few where compared to control a small inhibition (e.g., 0.5 - 8.0 % in Borbalamdhan, Canning-7, Raildhan, BR 9, MC-12 etc.) and/or stimulation (e.g. 1.0 - 6.0 % in Deshipazam, Rashiraj etc.) at

one or another growth stages was noted. Under salinity dry wt. of Deshipajam and Rashiraj was increased up to 101.45 and 106.46 % over control at tillering and booting stages, respectively (Tables 1 and 2) and therefore, these and others (e.g. BINA-5-153-8-163, Birpala, Borobalamdhan, BR 14, 15, Canning-7, Raildhan , Zorabati etc. at tillering- and Birpala, Borobalamdhan, BR 9, Canning-7, MC-12, Pokkali etc. at booting stages) where, compared to control, the inhibition was minimum (< 20 %) i.e., growth was maximum (> 80 %) may be considered better than the rest. Similarly, Misra *et al.* (1997) reported that leaf fresh and dry masses were increased in the salt tolerant Damondor rice under stress. In the present work, under salinity stress the lowest dry wt. was in BR 1 and Kalojira at tillering and booting stages whereas Borobalamdhan and MC-12 were the least affected genotypes at tillering and booting stages, respectively. Similar inhibitory effect of salinity on plant dry wt. was also reported by others (Flowers and Yeo 1981, Verma and Neune 1984, Fageria 1985, Bal and Dutt 1986, Alamgir *et al*. 1989). Reduction in biomass production under salinity stress may be due to its effect on photosynthesis as salt stress reduces carboxylation in chloroplast by impairing the generation of reduction pool, electron transport and ATP synthesis in the thylakoid (Krause and Weis 1991, Adams *et al*. 1992).

Unlike other characters salinity, however, stimulated the LAR in all and RGR and NAR in 33 genotypes (Table 3), the relatively higher stimulatory effect was being observed in BR3 for these three characters and that was followed by BR19 but the highest inhibition i.e. lowest values for NAR and RGR were noted in BR 14. Cachorro *et al.* (1993) reported that NaCl concentration of 25 mM did not affect RGR, although decreased plant wt. However, Tattini (1994) noted inhibitory effect of salt on RGR of olive. Similarly, Colmer *et al.* (1995) observed small percentage of reduction of RGR in wheat at 20 mM NaCl stress, but higher salt tolerance efficiency was in amphiploid wheat than in Chinese spring.

On the basis of the tolerance index (TI) score for leaf characters and leaf dry wt. there were generally four tolerance categories. Compared to others the LAR of all genotypes was less affected and was under T and had 100-80 % growth efficiency under stress. For NAR about 22 genotypes were under T, 5 under moderately tolerant (MT), 4 under MS and 2 under S and for RGR about 23 genotypes belonged to T group, 5 to MT, 3 to MS and 2 to S. However, for almost all leaf growth characters the number of T genotypes was lower than the MT genotypes. Fageria also observed similar trend in the strength of varietal number showing high tolerance activity. He also noted a significant varietal difference in salinity tolerance of rice in leaf dry matter yield which corroborates with the findings of the present work. Similar varietal difference both at intra- and intervarietal levels for salt stress was reported in rice (Yeo and Flowers 1983, Yeo *et al*. 1990, Misra *et al.* 1997).

It is evident from the results of the present work on the tolerance index that for most of the leaf growth characters BINA-5-153-8-163, Birpala, Borobalamdhan, BR 14, BR 15, Canning-7, Deshipajam, Raildhan, and Zorabati at tillering stage and Birpala, Borobalamdhan, BR 9, BR 15, Canning-7, Kalobini, MC-12, Pokkali, Rashiraj and Zorabati were tolerant at booting stage of growth. Among them five genotypes (e.g., Bipala, Borobalamdhan, BR 15, Canning-7, Zorabati) were tolerant at both the growth stages. Besides, for LAR, NAR, and RGR under stress averages good performances were observed with Birpala, BR 1, BR 3, BR 9, BR 18, BR 19, Kalojira, Pokkali and Rashiraj. Germplasms with an average good leaf growth characters and physiological growth attributes may be considered important for salt tolerance efficiencies.

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(Manuscript received on 3 September, 2005; revised on 17 July, 2006)