BIOLOGIA PLANTARUM 39 (2): 257-262, 1997

Sodium chloride induced changes in leaf growth, and pigment and protein contents in two rice cultivars

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Abstract

Rice (*Oryza sativa* L.) seedlings were grown under NaCl stress. The leaf growth of resistant cv. Damodar was less affected than that of the susceptible cv. Jaya. The leaf protein content showed no distinct cultivar or age dependent differences under NaCl salinity. There was a significant increase in chlorophyll (Chl) and carotenoid (Car) contents of 25-d-old seedlings of both cv. Jaya and cv. Damodar. However, Chl and Car content of 15-d-old seedlings of cv. Jaya decreased and that of cv. Damodar increased, under NaCl stress.

Additional key words: carotenoid, chlorophyll, *Oryza sativa* L., salinity

Introduction

Photosynthesis is often reduced by salt stress, irrespective of the type of salts used. Chlorophyll *a* and *b*, carotenoid and protein content decreased in most of the plant species (*e.g.* Abdullah and Ahmed 1970, Aspinall 1986, Eder *et al.* 1977, Greenway and Munns 1983, Lapina and Popov 1970, Rao and Rao 1981, Reddy and Vora 1986, Seemann and Critchley 1985, Shinde and Bhosale 1985), but in some cases an increase in the pigment and protein content was reported (Abd El-Samad 1993a,b, Aldesuquy and Gaber 1993, Joshi 1987, Venkatesalu and Chellapan 1993). Recently, our group showed that these changes are NaCl concentration dependent in Indian mustard leaves and cotyledons (Misra *et al.* 1995). In the present study, we report changes in the leaf pigment and protein content of a susceptible and a resistant genotypes of rice.

Received 19 January 1996, *accepted* 1 April 1996.
Acknowledgement: This work was supported by a grant No. 38(0869)/94/EMR-II to ANM from the Council of Scientific and Industrial Research, India. The authors are thankful to the Head, Department of Botany for providing necessary laboratory facilities.

Materials and methods

The experiment was conducted in the Botanical Garden. Rice (*Oryza sativa* L.) cv. Jaya (salt susceptible) and cv. Damodar (salt resistant) seeds were obtained from Central Rice Research Institute, ICAR, Cuttack. Seedlings were grown in earthen pots filled with soil and organic manure. During the experimental period the temperature was 26 ± 2 °C and the weather was mostly cloudy. Pots were irrigated at one day intervals. Leaf pigment and protein contents of fully expanded leaves were estimated by spectrophotometry (for details see Misra *et al.* 1995).

Results

The leaf length, fresh mass and dry mass of salt susceptible cv. Jaya decreased gradually with salinity, except with that for leaf fresh mass at 25 d. On the contrary, there was a stimulation in the leaf growth of salt resistant cv. Damodar at 0.5 % (m/v) NaCl treatments (Table 1). The change in the leaf growth under 3 % (m/v) NaCl was also not significant. Taking into consideration of these growth differences it was postulated that the over-all metabolism of these two cultivars might vary.

Table 1. Salinity induced changes in the leaf growth of rice seedlings (mean ± S.E., $n = 3$).

Cultivar	NaCl [%]	Leaf length [cm]		Leaf fresh mass [g]		Leaf dry mass [mg]	
		15 d	25 d	15 d	25 d	15 d	25 d
Jaya	0	15.5±0.5	25.6±1.1	0.57±0.04	1.53±0.05	88±7	480±41
	0.5	15.2±1.0	23.0±2.5	0.55±0.05	1.49±0.36	85±11	423±92
	1.0	13.5±0.9	24.1±1.1	0.48±0.08	1.64±0.21	74±9	412±51
	2.0	13.0±0.6	23.2±0.7	0.49±0.04	1.58±0.03	59±5	388±50
	3.0	14.1±0.7	23.1±1.5	0.45±0.03	1.63±0.23	70±5	414±75
Damodar	0	16.7±0.2	28.4±0.1	0.51±0.02	1.28±0.06	72±3	370±9
	0.5	17.7±0.4	32.6±1.3	0.58±0.03	1.85±0.17	82±5	490±47
	1.0	17.3±0.4	28.3±0.7	0.49±0.04	1.63±0.16	69±6	400±45
	2.0	17.7±0.8	26.7±1.0	0.49±0.03	1.34±0.08	70±4	360±26
	3.0	16.1±1.2	16.1±1.5	0.45±0.08	1.45±0.09	68±4	380±37

In cv. Jaya, Chl and Car contents of 15-d-old seedlings decreased under salinity (Fig. 1). However, these pigment contents increased gradually with an increase in NaCl concentration in 25-d-old seedlings. On the other hand, salt resistant cv. Damodar showed a salinity induced increase in the amount of Chl and Car content at 15 d and 25 d stage (Fig. 2). The enhancement of the pigment content was maximum with 0.5 % NaCl after 15 d and 1 % NaCl after 25 d.

The Chl *a*/*b* ratio increased with saline treatments in both the susceptible and resistant cultivars at 15 d and 25 d (Table 2). The Chl/Car ratio showed no significant change with salinity in cv. Jaya unlike a decrease with NaCl treatments at 15 d and an increase at 25 d in cv. Damodar (Table 2).

The protein content of 15 d seedlings of cv. Jaya showed a transient increase with a moderate increase in salinity (0.5 % NaCl). However, the protein content gradually decreased and at 3 % NaCl it was similar with the control values (Fig. 3).

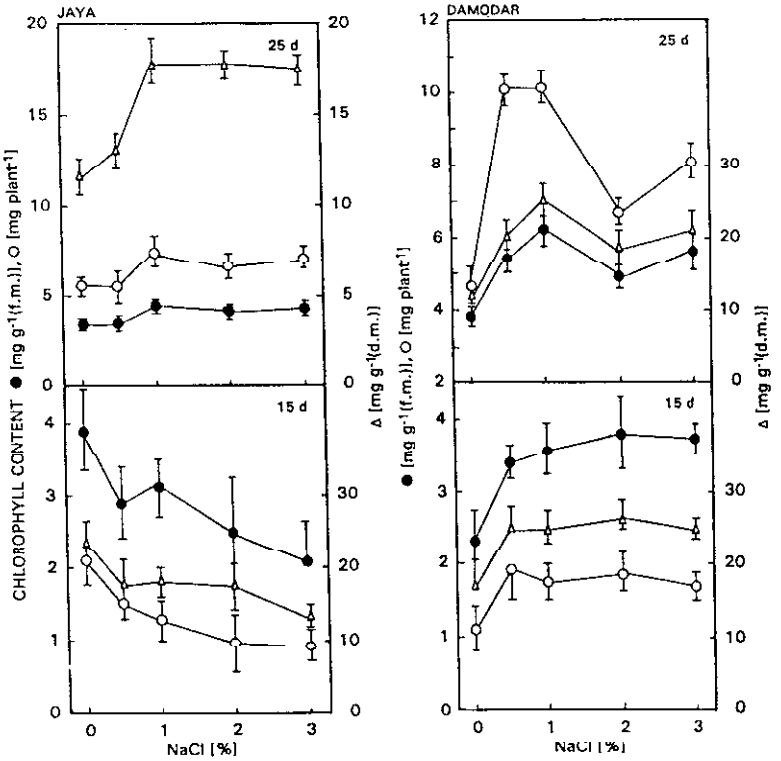

Fig. 1. Changes in chlorophyll content of rice leaves of susceptible cv. Jaya and resistant cv. Damodar grown under different NaCl concentrations. The data are means of three separate experiments. The bars represents S.E. Pigment content was expressed per fresh mass unit (*closed circles*), per dry mass unit (*triangles*) and per plant (*open circles*).

Table 2. Salinity induced changes in the pigment ratios of rice seedlings (mean ± S.E., $n = 3$).

Cultivar	NaCl [%]	Chl *a/b*		Chl/Car	
		15 d	25 d	15 d	25 d
Jaya	0	1.92±0.03	2.44±0.17	3.88±0.48	3.45±0.06
	0.5	2.33±0.08	2.01±0.09	3.97±0.09	2.86±0.19
	1.0	2.63±0.13	2.66±0.17	4.03±0.11	3.50±0.20
	2.0	2.18±0.20	2.57±0.11	3.91±0.14	3.30±0.17
	3.0	2.48±0.46	2.63±0.30	3.66±0.02	3.35±0.13
Damadar	0	2.30±0.07	2.42±0.08	4.13±0.38	3.22±0.33
	0.5	2.55±0.01	2.79±0.162	3.70±0.05	3.42±0.26
	1.0	2.58±0.20	2.75±0.18	3.60±0.03	3.56±0.28
	2.0	2.20±0.11	2.66±0.07	3.80±0.12	3.68±0.27
	3.0	2.50±0.11	2.71±0.10	3.80±0.10	3.72±0.28

The protein content of 25 d seedlings of cv. Jaya decreased gradually with an increase in salinity (Fig. 3). Similar decrease in protein content of cv. Damodar was observed when expressed per fresh mass unit. However, there was an increase in the protein content of cv. Damodar per plant or per dry mass unit with 0.5 % NaCl treatment at 25 d, and with the NaCl concentrations of 2-3 % the protein content was similar as in the control (Fig. 3). On the contrary, the protein content increased gradually with an increase in NaCl concentration at 15 d in the seedlings of cv. Damodar (Fig. 3).

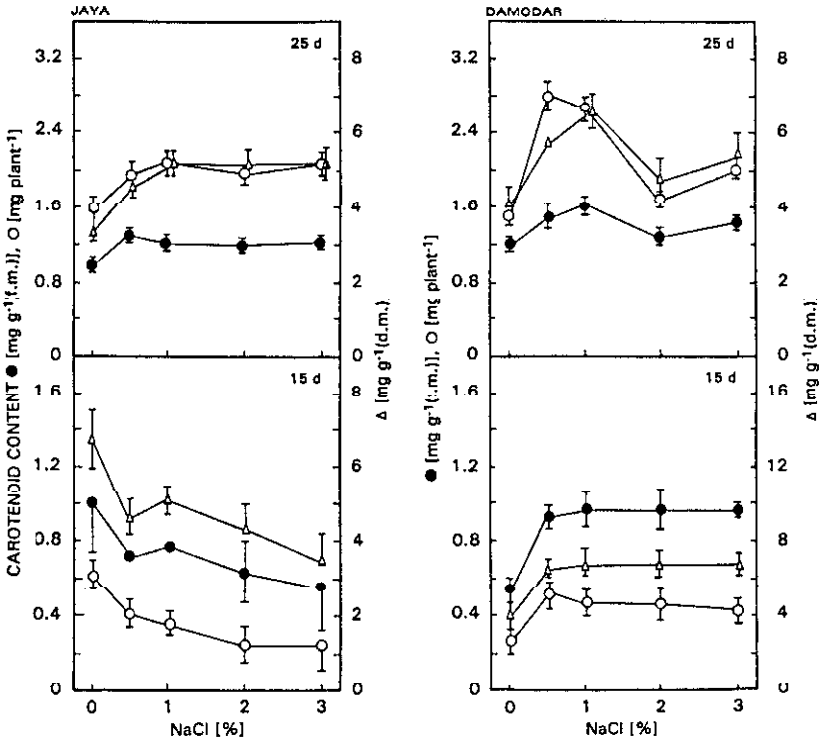

Fig. 2. Changes in carotenoid content of leaves of cv. Jaya and cv. Damodar grown under different NaCl concentrations. Otherwise as in Fig.1.

Discussion

Rice is a moderately salt tolerant crop (Roy *et al.* 1993). The salt susceptible cultivar showed growth reduction with salinity treatment in contrast to a stimulation in leaf growth at low NaCl level or a marginal change at higher salinity levels in the resistant cultivar.

Salinity induced decrease in Chl and protein contents was reported in halophytes like *Aegiceros corniculatum* (Shinde and Bhosale 1985), salt tolerant crops like barley, wheat, pearl millet and mustard (Lapina and Popov 1970, Misra *et al.* 1995, Reddy and Vora 1986, Singh *et al.* 1990), medium tolerant crop potato (Abdullah

and Ahmed 1970) and susceptible crops like bean (Lapine and Popov 1970, Seemann and Critchley 1985). On the contrary, leaf pigment contents were reported to increase in wheat (Abd El-Samad 1993a), broad bean (Abd El-Samad 1993b, Aldesuquy and Gaber 1993), *Sesuvium portulacastrum* L. (Venkatesalu and Chellapan 1993) and in Indian mustard under low salinity levels (Misra *et al.* 1995).

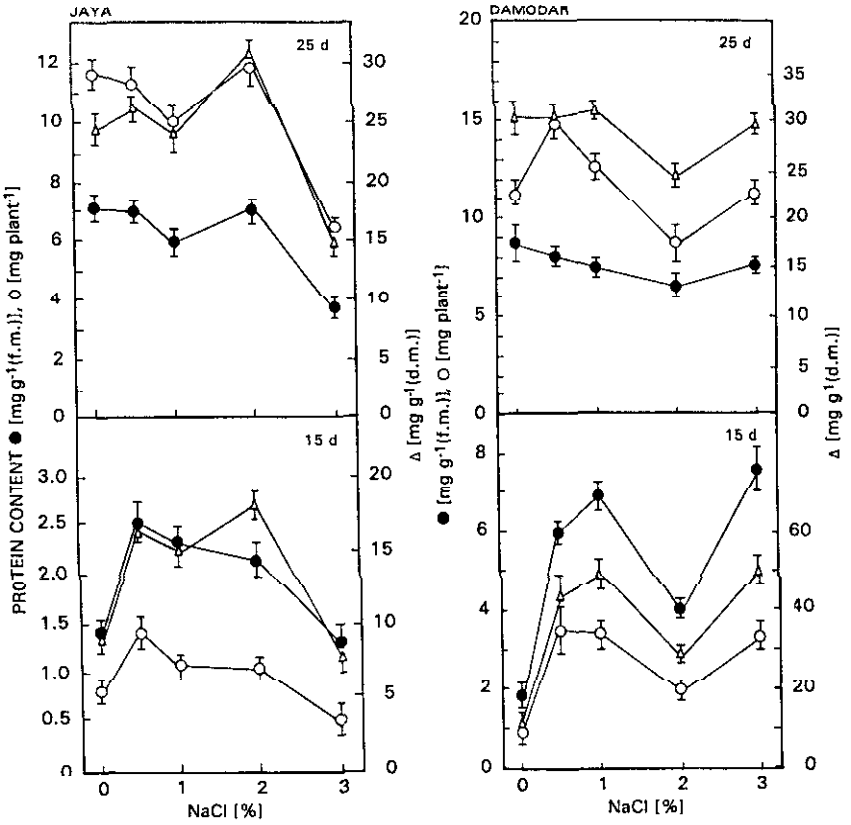

Fig. 3. Leaf protein content of rice seedlings grown under NaCl salinity. Otherwise as in Fig. 1.

These authors reported a preferential increase in Chl *a* but no significant change in Chl *b* content. The Chl and Car contents decreased under salinity in 15-d-old seedlings of cv. Jaya, suggesting either salt induced retardation of synthesis and/or acceleration of pigment degradation. Salinity was reported to enhance chlorophyllase activity (Rao and Rao 1981). In the later developmental stage (25 d), pigment contents increased under NaCl treatments in both the cultivars (Fig. 1, 2). The salt stress induced increase in pigment contents of resistant cv. Damodar at 15 d and 25 d could be due to an increase in the number of chloroplasts in stressed leaves (Aldesuquy and Gaber 1993).

The protein content increased at 15 d and decreased at 25 d in both susceptible and resistant cultivars. This is in contradiction to the findings of Abd El-Samad

(1993 a,b) that leaf pigments increased and protein content decreased in salt stressed wheat and broad bean.

It is concluded that there is a contrasting pigment (Chl and Car) accumulation pattern in the susceptible and the resistant cultivars of rice at early seedling growth stage (15 d).

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