Table 4 Reaction of NPRB 1 to major diseases and pests under field conditions

S.No.	Culture/Variety	Yellow mosaic (%)	Root rot (%)	Stemfly (%)	Pod borer (%)
1.	NPRB 1	3.30	15.00	8.82	10.33
2.	Co 5	100.00	42.50	17.36	10.96
3.	KM 1	34.20	78.60	7.69	17.00
4.	T9	50.00	35.00	22.41	18.00

Madras Agric. J. 77 (2): 76-82 Feb. 1990 https://doi.org/10.29321/MAJ.10.A01921

INFLUENCE OF SALINITY ON OSMOTIC PRESSURE OF RICE (ORYZA SATIVA L.)

A. ARJUNAN[1] AND S. CHANDRASEKARAN[2]
College of Agriculture, Annamalai University, Annamalainagar - 608 002.

ABSTRACT

Under Nacl salinity stress, the relatively salt tolerant rice varieties maintained a lower osmotic pressure in their plant parts, than the relatively salt susceptible rice varieties. Higher root-shoot ratios observed in the tolerant rice varieties than the susceptible ones facilitated for higher absorption of water and nutrients.

KEY WORDS: Rice, Salt tolerance, osmotic pressure.

The area under problem soils in India has been reported to be 6.9 million hectares of which 4.0 million hectares are subjected to salinity and alkalinity (Abrol and Bhumbla, 1976). As salt concentrations are injurious to high yielding varieties, the tolerant variety can perform well when compared to the salt susceptible ones (Tajuddin and Chandrasekaran, 1979). Rice, in general is reported as medium tolerant (Bernstein, 1964) and wide variations exist among the varieties for salt tolerance (Pearson, 1959; IRRI, 1967; Hegde and Joshi, 1974; Tajuddin and Chandrasekaran, 1978). Eventhough many explorative studies have been made, there is not much headway in understanding the physiological basis of salt tolerance in rice. Therefore an attempt was made to study certain aspects of the mechanism of salt tolerance in the rice varieties with respect to the osmotic pressure in the cells that is generally associated with the salt tolerance.

MATERIALS AND METHODS

A glass house experiment was conducted during August, 1980 with 11 rice varieties viz., AU 1, Annapoorna, Pokkali, Getu, Dasal, Damodar, Nonabokra (all relatively salt tolerant),TKM 9, Triveni, ADT 31 and Co 13 (all relatively salt susceptible). Water culture technique was adopted as recommended by Yoshiad *et al.* (1976).

The sterilized seeds with 0.1 per cent Mercuric chloride were washed several times with de-ionised water to remove the chemical completely and then soaked for 24 hours in de-ionised water, to avoid contamination of heavy metals and other elements. The germinated seeds were spread uniformly over the acid-washed, broken quart (that passed through 0.5 mm sieve) in the glazed pots of 22 cm depth and 11 cm diameter. Base nutrient (B.N.) solution was utilised. The composition of the B.N. solution was as follows: N,K,Ca and Mg each 40 ppm, P,Mn, Mo,B,Zn, Cu and Fe at 10, 0.5, 0.05, 0.02, 0.01, 0.01 and 5 ppm respectively. B.N. solution was used for the first three days at 1/10th concentration, for next three days at 1/4th concentration, and thereafter at full concentration.

There were three salinity levels, with the osmotic pressure of 0.40, 1.40 and 2.40 atm.and six replications. The saline waters were prepared by adding calculated quantity of sodium chloride salt with the B.N. solution.The pH of the solution was adjusted to 6.4 by addition of 1N NaOH and was maintained constant throughout the experiment. Fourteen-day old seedlings were transferred at two numbers per glazed pot containing different salt solutions as per treatment. Since young seedling stage (3- leaf stage) was more susceptible to salinity (Pearson and Bernstein,1959), fourteen-day old seedlings were taken for the study. Nylon nets were stretched and spread over the pots before transplanting. Dried cocount fibres were thoroughly washed and spread over the nylon nets to support the growing rice plants and also to avoid direct sunlight to the growing roots. The nutrient solutions were drained through the outlets at the sides of the glazed pots and renewed once in three days to maintain a constant pH (6.4) and nutrient composition.

Fifteen days after transplanting the plants were removed at 8.00 a.m., since diurnal variations might bring about changes in the osmotic pressure. The adhering moisture was wiped off with the filter paper. Fully matured green leaves were cut and weighed. The remaining stem and roots were taken and weighed separately. One gram in each of these samples was ground well in a chilled mortar. The extracted cell sap was diluted to 100 ml with distilled water and the E.C. was estimated. The osmotic pressure of the cell sap was calculated by using the following formula and the results were expressed in atmospheres. O.P.of Cell sap in atm. = 0.36 x E.C.(mmhos/cm) x df where. df = dilution factor and 0.36 = factor for converting EC into atm. pressure. and df=known volume of added water – moisture content/g plant material. The dry matter yields were estimated after drying in an over at 68°C for 48 hours.

RESULTS AND DISCUSSION

Data on osmotic pressure of plant parts and dry matter yields (g/pot) are presented in Tables 1 and 2 for the high yielding and low yielding rice varieties respectively. The increase in the osmotic pressure of external growth medium increased the osmotic pressure of plan parts to a greater extent. Also the gradual increase in osmotic pressure from root to leaf through stem was a general phenomenon observed at all salinity levels and in all varieties explaining the prevalence of higher solute concentration in the leaf as compared to other plant parts. The salt tolerant rice varieties, AU 1 and Annapoorna maintained a lower O.P. in their plant parts, leaf in particular leading to lower water stress, as compared to other three salt susceptible rice varieties. The O.P. in AU 1 leaf in-

Table 1. Effect of salinity levels on Osmotic Pressure of plant parts and dry matter yields of five high yielding rice varieties (30 days old).

Osmotic Pressure of external solution (Atmospheres) (Nacl salinity)	Variety	Osmotic Pressure(atm.) Leaf	Stem	Root	Dry matter yields (g/pot) Tops	Root	Total	Root shoot ratio (mg/g)
0.4 (B.N)	AU 1	11.03	4.23	3.20	2.58	0.78	3.36	302
	Anna-poorna	11.11	5.33	4.87	2.56	0.72	3.28	281
	TKM 9	10.63	7.06	5.15	1.78	0.44	2.22	247
	Triveni	10.30	5.01	4.57	2.12	0.54	2.66	255
	ADT 31	11.30	5.36	2.87	1.82	0.44	2.26	242.
1.4 (B.N. + 24 meq/l)	AU 1	12.74	7.01	4.47	1.04	0.42	1.46	404
	Anna-poorna	12.64	6.85	4.53	1.22	0.48	1.70	393
	TKM 9	13.41	8.70	5.48	0.94	0.22	1.16	234
	Triveni	13.60	7.65	4.90	1.02	0.24	1.26	235
	ADT 31	14.75	9.28	5.62	1.02	0.30	1.32	294.
2.4 (B.N. + 48 meq/l)	AU 1	21.20	8.80	5.50	1.14	0.37	1.51	325
	Anna-poorna	21.80	8.22	6.29	1.02	0.34	1.36	333
	TKM 9	26.08	9.73	6.54	0.70	0.18	0.88	257
	Triveni	26.60	8.92	6.57	1.00	0.20	1.20	200
	ADT 31	24.12	9.80	6.60	1.00	0.22	1.22	220.

'r' value : O.P × DM Tolerant varieties = −0.670

Susceptible varieties = −0.718

creased from 11.03 to 21.20 atm. as the external salinity level increased from 0.4 to 2.4 atm. Among the high yielding salt tolerent rice varieties, the increase in O.P. was in the order of 1.7 to 1.9 times at the given highest salinity level. But this range had been 2.2 to 2.6 times in the case of salt susceptible rice varieties. Similar observations were exhibited by other plant parts as well due to the way of treatment with varying degrees. Considering the date on dry matter yields and their root/shoot ratios (Table 1), the growth inhibition was linear with the increase in salinity level. The total dry matter yields were always higher at all salinity levels for the salt tolerant rice varieties, than the salt susceptible varieties. Also the former recorded a higher root/shoot ratios. For example, the salt tolerant rice variety AU 1 recorded a root/shoot ratio of 325, whereas the salt sensitive variety, ADT 31 recorded a root/shoot ratio of 220, at the highest salinity level.

Similar results were obtained for the low yielding rice varieties in increasing the osmotic pressure of plant with the increase in O.P. of external solution (Table 2). The increase in O.P. of leaf in the case of tolerant varieties was in the order of 1.91 to 2.34 times at the highest salinity level, whereas it was 2.51 times in the case of salt susceptible rice variety, CO 13 (from 10.57 to 26.50 atm.).The observation was consistent with the other plant parts also. The dry matter yields were comparatively higher in CO 13, in control (1.63 g) and at 24 meq of Nacl (1.21 g). The standard salt tolerant rice variety, Pokkali registered the highest values for dry matter yields in all treatments (2.14, 1.63 and 1.19 g respectively). The higher osmotic pressure and lower root/shoot ratios observed in CO 13, thus indicated the salt susceptible nature of the variety.

It is a well know fact that for movement of water in plants, the existence of osmotic gradient is essential. For the regular physiological process, there should be a continuous supply of water to plant roots, and in turn to other plant parts viz., the leaf and stem in order to compensate the unaviodable transpiration water loss. In the present studies, salts in general decrease the free energy of water, lower the water potential and hence the decrease the entry of water molecules into the plant roots. The lowered water potential of the growth medium due to salinity is considered to be of importance. Osmotic adjustment is a satisfying design for the maintenance of turgor and of water potential between plant and soil (Hanson and Hitz, 1982). The result finds support from the work of Bidwell (1979) who convincingly proved that flux of water is implicated through the cytoplasm and cell walls. Strongnoy (1964) stated that in crop plants grown under saline conditions, the contraction of protoplasts destroys the intercellular connections in many parts and this brings about a diminition in the exchange of water and nutrients between the cells. This is stressed since the protoplasm contains, on an average, 80 to 90 per cent water. Similarly Greulach (1973) had shown that under saline conditions, the degree of hydration of protoplast and chloroplast was decreased resulting in the alteration of colloidal structure. Hence a reduction in the amount of water in the growing point is felt.

The present study has impressively brought out the maintenance of lower O.P. by the relatively salt tolerant rice varieties to endure saline conditions. The optimum water potential is reported to be −20 to −30 bars. It is clearly evident that poor turgor due to higher osmotic pressure in the salt sisceptible varieties would have resulted in lower dry matter yields under saline conditions. This is true since relative turgidity of over 90 per cent is required for causing irreversible extension growth. Thus lower dry matter yields were obtained in the susceptible varieties due to lower water potential. This amply proves the significance of water retained in plant cells. The evidence for this important physiological manifestation is the higher root/shoot ratios as recorded in the relatively tolerant varieties as a pre-requisite to the plant growth. The observations made by Murty and Janardhan (1971), paricha *et al.*, (1975) and CSSRI (1979) on the lower osmotic pressure in the relatively tolerant varieties lend support for the present findings.

Table 2. Effect of salinity levels on Osmotic Pressure of plant parts and dry matter yields of five high yielding rice varieties (30 days old).

Osmotic Pressure of external solution (Atmospheres) (Nacl salinity)	Variety	Osmotic Pressure (atm.) Leaf	Stem	Root	Dry matter yields (g/pot) Tops	Root	Total	Root shoot ratio (mg/g)
	Pokkali	8.15	4.99	4.68	1.76	0.38	2.14	216
	Getu	9.22	6.50	5.26	1.18	0.24	1.42	203
0.4	Dasal	12.53	8.14	4.98	0.86	0.18	1.04	209
(B.N)	Damodar	10.99	7.93	5.84	1.10	0.20	1.30	182
	Nonabokra	8.22	6.72	4.92	1.35	0.24	1.59	178
	CO 13	10.57	5.62	3.79	1.38	0.25	1.63	181
	Pokkali	11.09	6.87	5.53	1.44	0.30	1.74	208
1.4	Getu	15.73	9.03	6.33	0.79	0.17	0.96	215
(B.N. + 24	Dasal	14.21	8.90	5.75	0.85	0.19	1.04	224
meq/l)	Damodar	15.20	8.58	6.19	0.83	0.19	1.02	229
	Nonabokra	18.03	8.03	5.03	0.83	0.17	1.00	205
	Co 13	19.32	9.19	6.93	1.01	0.20	1.21	198
	Pokkali	15.59	7.46	6.53	0.98	0.21	1.19	214
	Getu	19.86	9.86	7.88	0.69	0.14	0.84	203
2.4	Dasal	16.23	9.07	7.48	0.73	0.17	0.90	234
(B.N. + 48	Damodar	20.16	9.51	7.92	0.53	0.14	0.67	264
meq/l)	Nonabokra	19.23	8.66	5.98	0.80	0.15	0.95	188
	Co 13	26.50	9.97	8.28	0.62	0.11	0.73	177

'r' value : O.P × DM Tolerant varieties = −0.86

Susceptible varieties = −0.99

Further, higher dry matter yields were obtained in the tolerant varieties. The negative correlation between O.P. and dry matter yields for the two groups viz., high yielding-tolerants (-0.67) and susceptibles (-0.72), low yielding-tolerants(-0.86) and susceptibles (-0.99) indicated the similarity of salt tolerance mechanism in these two groups. Variations were displayed in the total dry matter production by these two groups, that is, higher dry matter yields in the high yielding rice varieties due to their fast growth rate and lower dry matter yields in low yielding varieties due to slow growth rate. However, the difference in the salt tolerance mechanism almost remained the same. The evidence could be drawn from the work of Hegde and Joshi(1974) who reported the rice as a 'salt avoidance' type.

The tolerant rice varieties maintained lower O.P. in their plant parts by promoting larger root-growth in order to facilitate greater area of absorption. Bernstein and Hayward(1958) observed that varieties possessing lower O.P. could absorb more water due to the larger root system because of their spread and efficiency.

REFERENCES

Abrol,I.P., and Bhumbla,D.R. 1976. FAO world Soil Resources Report. 47 : 42-51

Bernstein,L.1964. Effects of salinity on mineral composition and growth of plants. plant Anal. Fert.Prob. 4 : 25-45.

Bernstein,L. and Hayward,H.E.1958. Physiology of salt tolerance. Ann.Rev.Plant physiol.9: 25-46.

Bidwell.R.C.S. 1979. Leaves and the atmosphere. In: **Plant Physiology**, Macmillan Co., New York.

CSSRI . 1978 Annual Report of the Central Soil Salinity Research Institute.

Greulach,V.A. 1973. Photosynthesis. In: **Plant Function and Structure.** Macmillan Co., New York.

Hanson, A.D.and Hitz, W.D. 1982. Metabolic responses of mesophytes to plant water deficits. **Ann. Rev. Plant Physiol.** 33.: 163-203.

Hegde,B.A., and Joshi,G.V.1974. Mineral salt absorption in saline rice variety, Kalarata. **Plant and Soil** 41: 421-424.

IRRI.1967. Annual Report of the International Rice Research Insititute, Los Bonos, Philippines.

Murty, K.S. and Janardhan, K.V. 1971. Physiological considerations for selection and breeding of varieties for saline and alkaline tracts. Oryza 2 : 87-92.

Paricha, P. C., Patra, C. J. and Sahoo, P. 1975. Effect of synthetic sea water on growth and chemical composition of rice at different stages of development. **J. Indian Soc. Soil Sci. 23:** 344−348.

Pearson, G.A.1959. Factors influencing salinity of submerged soils and growth of calaro rice. Soil Sci.87: 198-206.

Pearson, G.A. and Bernstein,L.1959. Salinity effects at several growth stages of rice. Agron. J. 51: 654-657.

Strogenov, B.P.1964. Physiological basis of salt tolerance of plants. Publ Acad. Sci USSR. pp. 98-130. Transl. from Russian;Israel Program for Scientific Translocation, Jerusalem.

Tajuddin, E. and Chandrasekaran,S. 1978. Performance of two rice varieties under saline water irrigation. Farm Sci.5: 17-26.

Tajuddin, E. and Chandrasekaran. S. 1979. Effect of borewell saline waters on three rice types. Agrl. Res. J. Kerala. 17 : 160-164.

Yoshida,S., Forno, D.A., Cock,J.H. and Gomez, K.A. 1976. Laboratory manual for physiological studies of rice. International Rice Research Institute, Philippines.