CHAPTER V

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Nine rice varieties namely AU1, Co36, Co43, CSC1, CSC2, GR3, IR20, TKM4 and TKM9 were selected for the present study and screened for their resistance to salinity using different criteria based on the seedling and preflowering vegetative growth, yield, physiological and biochemical parameters by exposing them to sodium chloride salinity. The salient findings of the present work can be summarised as follows.

Dry weight of shoot was measured in three salinity levels at ten day seedlings. Low salinity level of EC 5 m mhos/cm did not considerably affect any of the varieties. But the dry matter accumulation of shoot was inhibited in all the varieties with EC10 m mhos/cm salinity level. The inhibition was less in Co43, IR20 and TKM4 than the others. Varieties CSC2 and IR20 were more resistant in terms of shoot dry matter production at the highest salinity level of EC 15 m mhos/cm, while AU1, Co36 and CSC1 showed 50 per cent inhibition of shoot dry weight over the control.

Possible effects of sodium chloride absorption on the seedling growth and metabolic tolerance mechanism involving within the nitrogen metabolism of five rice varieties were investigated upto 30 days after initial salinization by growing the seedlings in nutrient solution containing 100 mM NaCl. Co43 and TKM9 were highly resistant in their shoot and root length and fresh and dry matter production to saline treatment. TKM4 was more sensitive towards vegetative growth production to salinity at the first month of its growth.

There was a marked varietal difference in the behaviour of Na^+, K^+ and Cl^- accumulation in the shoot and root systems of rice varieties during 30 days of salinization. Co43 and TKM9 accumulated high level of sodium, while CSC2 accumulated less sodium in their shoot and root systems to salinization. High chloride content was found in the shoots of CSC2 and TKM4 at the end of salinization. In varieties TKM4, CSCl and CSC2 there was a steady increase in the Na^+ and K^+ levels as the duration of salinization increased. NaCl treatment lowered the K^+ in TKM4, TKM9 and Co43. Interestingly the CSCl and CSC2 maintained higher level of K^+ than the Na^+ as compared to their control.

Free amino acids were found to increase in response to NaCl during the seedling stage of all the varieties. In

TKM4, CSC1 and CSC2 steady increase in the free amino acids was noticed with increasing days of salinization. Shoot free amino acid content always exceeded the root content in all the varieties. Co43 maintained the higher level of proline than others in the shoots during 23 days of salinization. On the contrary, the TKM4 was less capable maintaining high level of free amino acids in response to salinity. Saline treatment did not affect the protein-bound-proline level in the shoots of CSC1. But the protein-bound-proline content was increased in the shoots of CSC2, Co43, TKM4 and TKM9 and in roots of CSC1, CSC2 and TKM4 to salinity during seedling stage.

Generally, salinization brought about an increase in the levels of soluble protein and decrease in insoluble protein levels during the seedling growth of all the varieties. The high level of soluble protein content was noticed in the CSC1 while comparing others. The Co43 seemed to be less capable in accumulating higher level of soluble protein than the others to salt treatment. All the varieties showed fluctuating levels of total protein upto 14 days of salinity with subsequent increase thereafter. CSC1 and Co43 increased the maximum level of total protein in the roots than the others.

Salinization significantly increased the total nitrogen in both shoots and roots of TKM4 and TKM9 but

decreased it in other varieties in all the stages of investigation. The total nitrogen content increased steadily in both non-salinized and salinized plants of CSC1 and CSC2. At the time of final harvest high concentration of total nitrogen in the roots than the shoots was present in TKM4.

All the nine rice varieties were subjected to pot culture experiments for studies on the growth, inorganic and organic constituents of shoot portion at 2, 4 and 6 weeks after initial salinization and final yield components. Varieties AU1, Co43 and CSC1 exhibited less reduction of shoot height, fresh and dry weight of shoot system, height of tillers, fresh and dry matter content of tillers and total leaf area than the other varieties under saline treatment. Generally, Co36, IR20 and TKM4 were more susceptible in their vegetative growth production to salinization. Varieties CSC2, IR20 and TKM4 were resistant in their vegetative growth production to salinity during seedling stage and became sensitive in the preflowering vegetative growth stage. The AU1 and CSC1 were highly sensitive in the dry matter accumulation of shoot to salinity during ten day old seedling stage but was highly resistant in the preflowering vegetative growth stage. Sodium chloride treatment brought about a less mortality rate in AU1, CSC1 and Co43, and high mortality rate in CSC2 and TKM4 at the end of saline treatment.

Varieties Co36 and CSC2 accumulated a high level of sodium and chloride than the others in their shoot system after saline treatment. But AU1 always maintained lower sodium content in the shoot system. Sodium chloride treatment increased the potassium, calcium and magnesium levels in the shoot while decreasing it in other varieties.

Sodium chloride treatment increased the free amino acid levels in the third leaf of all the varieties during preflowering vegetative growth stage. The free amino acid pool was gradually increased over the duration of salinization in Co36, CSC2, GR3 and TKM4. The maximum of 1 to 3 fold increase in free proline content was evident in varieties AU1, Co43 and CSC1 as compared to their controls at the end of salinization. Co36, CSC2, IR20 and TKM4 were less able to maintain a high level of proline in their leaf to saline treatment.

Salinity decreased the RNA content of shoot in all the varieties. In AU1, Co43, CSC1 and IR20 less degree of reduction in RNA content was observed whereas it was more in other varieties. Interestingly, AU1, Co43, and CSC1 exhibited a steady increase of DNA content of shoot while in other varieties it decreased over the control from two weeks of saline treatment.

Generally, salinization increased the soluble protein content of leaf in all the varieties. There was a constant increase of insoluble protein and total protein levels in AU1, Co43 and CSC1 towards salinity. But in Co36, CSC2, GR3, IR20, TKM4 and TKM9, four weeks of salinization decreased the insoluble and total proetin content over their control.

Salinity considerably increased the total nitrogen content of shoot in AU1, Co43 and CSC1, and decreased it in Co36, CSC2, IR20, TKM4 and TKM9 as compared to their respective controls.

Salinization resulted the accelerated accumulation of reducing, non-reducing and total soluble sugars and total carbohydrate in AU1, Co43 and CSC1, whereas it decelerated in other varieties in their shoot system. There was a general reduction of starch content in the shoots of all the varieties to salinity. AU1, Co43 and CSC1 were much less affected regarding the reduced starch content than the others to salinization.

Ascorbic acid content of leaves was generally increased in all the varieties to salinity. Varieties AU1, Co43 and CSC1 accumulated higher levels of ascorbic acid than the others at the end of saline treatment. Titrable acid number was increased in the leaf of all the

varieties to salinization. AU1, Co43 and CSCl showed the maximum level of titrable acid number than the others to salinity at the time of final harvest. The varieties rich in ascorbic acid and titrable acid number, and with more efficient mechanism for maintaining ascorbic acid level and titrable acid number were more resistant than the varieties with low or high fluctuation in ascorbic acid level and titrable acid number in response to salt treatment.

Significantly salinization increased the chlorophyll 'a' and chlorophyll 'b' levels in the leaves of AU1, Co43 and CSCl upto four weeks and decreased in the subsequent week of salinization. There was a constant decrease of chlorophyll levels in other varieties in response to salinity. AU1, Co43 and CSCl showed less reduction of chlorophyll than the others at the end of saline treatment.

NaCl treatment stimulated the peroxidase, polyphenolase, ascorbic acid oxidase, protease, acid phosphatase, membrane-bound ATPase, amylase, invertase, phosphorylase, α-Ketolutaric dehydrogenase, succinic dehydrogenase and pyruvic dehydrogenase enzymes activity of leaf in all the varieties in varying degrees. A substantial increase in nitrate reductase acitivity was evident in the leaf of AU1, Co43 and CSCl, while it decreased in others in response to salinity. Transaminase enzymes GOT and GPT

were stimulated in the leaf of AU1, Co43 and CSC1 and suppressed in other varieties by NaCl treatment.

NaCl treatment delayed the flowering from 11 to 15 days in the Co36, IR20, CSC2 and TKM4 and 6 to 9 days in Co43, AU1, CSC1 and TKM9. Interestingly, GR3 showed 10 days early flowering in comparison to the control. The yield components were assessed using different parameters such as panicle length, number of panicle per plant, number of spikelets per panicle, number of filled grain per panicle, number of unfilled grain per pancile, fresh weight of filled and unfilled grain per panicle, dry weight of filled and unfilled grain per panicle, 100 grain weight, net grain yield per plant, straw yield per plant, biological yield and harvest index. Comparing the final yield of the rice varieties under saline conditions, the degree of reduction in AU1, Co43 and CSC1 was less compared to TKM4 and IR20. The Co43, CSC1 and AU1 showed less reduction of grain yield per plant upto 50 per cent and high reduction of grain yield per plant upto 95 per cent was recorded in TKM4 and CSC2 in response to salinity.

Sodium chloride treatment increased the K^+, Ca^{2+} and Mg^{2+} levels with the increase in Na^+ and Cl^- in the straw and filled and unfilled grains of AU1, Co43 and CSC1 as compared to their control. On the contrary to this,

the sodium chloride treatment decreased the K^+, Ca^{2+} and Mg^{2+} levels in the straw and filled and unfilled grains of Co36, CSC2, GR3, IR20, TKM4 and TKM9 with increasing concentration of Na^+ and Cl^- when compared to their respective control. AU1, Co43,GR3 and TKM9 accumulated less sodium, whereas Co36, CSC2 and IR20 accumulated higher level of chloride in their straw than the others when compared to their control.

Salinity decreased the reducing, non-reducing and total soluble sugar contents in the grains of all the varieties expect AU1, Co43 and CSC1 which maintained increased levels of sugar in their shoot system as a result of saline exposure. Starch and total carbohydrate levels were generally decreased in the grains of all the varieties to salinization. Varieties AU1, Co43 and CSC1 could be called to be more resistant as the degree of reduction of starch and total carbohydrate content was low but as compared to the more sensitive varieties like CSC2 and TKM4 with a high reduction of starch and total carbohydrate content of grain when exposed to salinity. There was no marked change in the amino acid levels in AU1, Co43, and CSC1, but it increased considerably in other varieties due to exposure to saline treatment. Reduction in the total protein and total nitrogen content of grains was noticed in all the varieties in response to

salinity, but the degree of reduction was quite less in AU1, Co43 and CSC1 when compared to others. When comparing the grain analysis of all the varieties, AU1, Co43 and CSC1 could produce better quality of grain than the other varieties to NaCl treatment.

The harvested grains were subjected to germination and analysed for growth parameters. Inhibition in the percentage of germination was upto 20 per cent in AU1, Co43 and CSC1, whereas in other varieties it was upto 40 per cent over the control at the tenth day of germination. While comparing the length and its fresh and dry weight of the shoots and roots of the grains harvested from saline exposed crops, the AU1, Co43 and CSC1 exhibited less reduction of vegetative growth against the other varieties. This character could be considered as one of its resistance mechanism. TKM4 and CSC2 were highly sensitive to saline exposure and showed the maximum reduction in the dry matter accumulation of shoots and roots.

An attempt has been made to assess the rice varieties for their nature of resistance to salinity using the criteria based on the decreased and/or increased percentage of growth, yield, physiological and biochemical parameters totally amounting to 85. From this, it can be concluded that AU1, Co43 and CSC1 are more resistant than others to sodium chloride treatment. However, GR3 can be

considered very close to the above varieties in its net grain yield performance on exposure to salinity.

Therefore, among nine rice varieties investigated in the present study, it was concluded that AU1, Co43 and CSC1 exhibited best resistance characters to saline treatment and they are suitable to grow in the saline substrate upto EC 7.95 m mhos/cm and 13 ESP level.

The results obtained in the above work opens avenues for further research in the following lines as given below:

1. To investigate whether the resistant varieties can tolerate salinity higher than the EC 7.95 m mhos/cm and 13 ESP level upto maturity.
2. In addition to this, screening of more varieties for resistance to salinity will be desirable.
3. Field trials to be conducted to check the resistance characters of the above varieties to saline conditions existing in the areas of Gujarat State.
4. Testing for improved yield by manipulating the application of fertilizers.