CHAPTER-IV

Summary & Conclusions

Increasing salinity of the soil has threatened the modern agriculture especially in arid and semi-arid regions. The problem is becoming more severe because every year more and more agricultural land is becoming saline. The problem is more serious in our country because one third of the land is arid or semi-arid and secondly the rainfall is erratic and scanty. About 12 million hectares of land in our country has been affected by salinity and alkalinity. In Maharashtra also about 1.4 million hectares of agricultural land is saline, besides coastal soils. Secondary salinity is also developing particularly in areas under sugarcane cultivation.

The normal growth and metabolism of the plants is considerably affected by the salt stress. However, a great variation is observed among the plant species with respect to salt tolerance potential, e.g. halophytes can grow well under saline conditions but glycophytes cannot. Eventhough most of the crops are glycophytes and hence considered as salt sensitive, they may have some degree of salt tolerance. Such crops can be cultivated in saline soils (salt concentration 0.2 to 0.5 %) and to give some yield and this is one of the most important means to overcome such soil salinity problem. Hence, it has become essential to test salt tolerance potential of various crops and their varieties.

The accumulated salts in such soil exert various harmful effects on the normal growth and development of the plant, even the very existance of the crop plants. The various changes occuring under salt stress include anatomical, morphological and physiological (metabolic) changes, resulting in growth-reduction and subsequent decrease in yield. Sensitive plants show drastic chages under saline conditions, while tolerant plants can tolerate salinity at least to some extent and show a better growth performance. In order to understand the mechanism of salt tolerance in such plants, it is necessary to study physiological changes in the plants under saline habitat. Such studies also provide a key to induce salt tolerance potential in crop plants.

Millets are generally considered as hardy, drought tolerant cereals. They are especially cultivated in tropical and sub-tropical regions and form a staple food in developing countries. They have good nutritive value and especially rich in proteins and minerals. They possess a good tolerance capacity to adverse conditions like drought, high temperature, infertile soils etc. Comparatively they have few insect pests and diseases and even they require less ideal conditions for development. Eventhough they possess such good qualities, adaptive features and general tolerance very little attention has been paid to their physiology. Study of salt tolerance in millets may be helpful for the application of millets in modern agriculture. Among the millets, Setaria is the most neglected genus and hence present study is undertaken.

In present investigation two cultivars of Setaria italica SIC-1 and CO-5, which have been identified as sensitive and moderately tolerant in the earlier salt tolerance screening programme of millets (at germination state) were exposed to salt stress. The effect of NaCl treatment on the germination behaviour, growth organic constituents and some important enzyme systems of nitrogen metabolism have been studied. It is generally considered that most of the salt injuries mainly occur through the changes in nitrogen metabolism. Hence in the present study an attempt has been made to study the effect of salt stress on nitrogen metabolism. The organic constituents include chlorophylls, carotenoids, polyphenols, nitrogen fractions and proline content. While the enzymes studied are nitrate reductase, nitrite reductase, glutamate oxaloacetate transaminase, alanine amino transferase, glutamine synthatase and glutamate dehydrogenase. The significant findings of the significant findings of the present study are listed as follows :

1) NaCl salinity considerably inhibits germination process even at the lower salt concentrations in CV SIC-1 while in CV CO-5

it is inhibited only at the highest salt concentration that is 300 mM NaCl. This clearly indicates the varietal response given to salt stress and CV CO-5 appears to be tolerant to salt at germination stage.

2) Salt stress causes a decrease in biomass production at 120 h seedling growth in both the cultivars. However, in CV CO-5 the biomass production appears to be insignificantly influenced by salt and decreases by 25% only and that at the 100 mM NaCl. CV SIC-1, however, shows about 25% reduction even at the low salt concentrations. On this basis also CV CO-5 appears to be more tolerant than CV SIC-1.

3) The <u>in vivo</u> activity of NR in the seedling (120 h growth) decreases due to salt stress in SIC-1 while it is stimulated in CV CO-5. The decrease in NR activity in SIC-1 may be probably due to decrease in synthesis of enzyme protein or partial dissociation of the enzyme. Increased NR activity is an indication of successful osmotic adjustment, better protein content and better uptake of NO_3-N by the enzyme. On this basis also CV CO-5 appears to be more salt tolerant than SIC-1.

4) NaCl salinity causes inhibition of <u>in vivo</u> NiR activity in the seedlings of both the cultivars. The reduction in activity is probably due to inhibitory effect of NaCl on enzyme itself or salinity may be affecting the relationship between NiR and ferridoxin.

5) In soil culture studies it is found that salinity affects biomass production (fresh weight) in SIC-1 at the low salt concentrations while in CV CO-5 salinity causes to increase the fresh weight of plants. From this, it appears that both the cultivars are rather tolerant to salt, however, CO-5 appears to be more tolerant as far as fresh weight is considered.

Dry weight in SIC-1 decreases with salinity except a sudden increase at 200 mM NaCl. Moisture content (% control) in this cultivar increases with salinity. In CV CO-5, however, dry weight decreases under saline conditions along with an increase in moisture content. The increase in moisture content in both the cultivars may be as a result of accumulation of Na^+ and Cl^- which is considered as a halophytic or succulent character and as an adaptive feature.

6) Under salt stress the chlorophyll content in young leaves of SIC-1 decreases while mature leaves are able to retain it. Thus young leaves of SIC-1 are more sensitive to salt. In CV CO-5 young leaves are more stable under salt stress and a stimulation of chlorophyll synthesis is observed in both young and mature leaves. Accumulation of chlorophylls suggests stability of pigment protein - lipid complex in CV CO-5, while that decrease in cultivar SIC-1 may be associated with increase in chlorophyllase activity or changes in pigment - protein - lipid complex. On this basis also CO-5 appears to be more salt tolerant.

7) Carotenoid content of leaves is decreased in SIC-1 due to NaCl salinity except an increase in that in mature leaves at higher salt concentration. On the other hand in CV CO-5 the carotenoid content increases with salinity. However, neither the decrease nor the increase is significant.

8) NaCl salinity did not induce considerable changes in the polyphenol content of both the cultivars. In CV SIC-1, the level of polyphenols increases with salinity in both young and mature leaves, while in CV CO-5 it decreases slightly in young leaves and no change is observed in the mature leaves. Insignificant effect of salinity on polyphenols is suggestive of stability of both the cultivars under saline conditions.

9) The salt stress increases the NO_3-N content in all the plant parts of both the cultivars. It appears that the salt does not affect the uptake of NO_3^- in both the cultivars; however, its utilisation is affected by salinity. Accumulation of NO_3-N in roots under saline conditions is indicative of affected translocation and distribution of NO_3^-. In CV SIC-1 maximum accumulation is recorded in the young leaves indicating that they are more sensitive to salt. However, in CV CO-5 more accumulation is observed in mature leaves.

The values obtained for NO_2-N in both the cultivars under saline conditions as well as non-saline conditions are very low. NO_2-N accumulates in all parts of SIC-1 under saline conditions which indicates incomplete utilisation of NO_2-N. In CO-5 the level of NO_2-N decreases at all the salinity levels in all parts indicating that utilisation of NO_2-N in this cultivar is not affected by salinity.

The protein-N content decreases under salt stress in both the cultivars, probably due to inhibition of protein synthesis. However, the decrease is not much significant and both the cultivars are able to retain protein level at least to some extent during salt stress.

The insoluble-nitrogen content of young and mature leaves of SIC-1 and CO-5 decreases with salinity while it increases in roots of both the cultivars. This indicates that the translocation of nitrogen is affected by salinity. In CV CO-5 the insoluble nitrogen in stem remains somewhat constant while in stems of SIC-1 it decreases with salinity. By comparing the results, it appears that the effects are more pronounced in SIC-1.

10) Salinity increases proline content in young leaves and roots of SIC-1, while mature leaves did not show any definite pattern. In CV CO-5 it increases sharply in young leaves at 50 mM NaCl treatment and then decreases. Proline content in mature leaves and roots also shows a decrease due to salinity.

11) The NR activity decreases in the leaves of SIC-1 while the roots show a stimulation of NR activity due to salinity. Low salt level, however, enhances NR activity in the leaves.

In CO-5 the activity increases in young leaves while decreases in mature leaves and roots. The inhibition is probably due to partial dissociation of enzyme or decrease in supply of reducing power. Stimulation observed in roots of SIC-1 and young leaves of CO-5 may be probably due to induction of enzyme synthesis. In general it can be said that NO_3^- reduction process is not much affected by salt especially in CV CO-5.

12) In SIC-1 the activity of NiR increases in young leaves and roots while in CO-5, it appears to be stable under saline conditions, while in mature leaves it decreases with salinity. The increases observed in SIC-1 may be associated with increased activity of NR. The decrease in activity of NiR in mature leaves did not have any definite pattern and is probably related to substrate available . The root NiR and leaf NiR appear to be somewhat stable. Thus NiR from both the cultivars appears to be insensitive to salt.

13) The activity of GOT is decreased in the roots and leaves of SIC-1 while it increases in the leaves of CO-5 due to salt stress. In roots of CO-5, however, the activity decreases at all the salt levels. The increase in GOT activity in the leaves of CO-5 may be due to more and more availability of keto acid and amino acids. The increased activity of GOT may help for the accumulation of amino acids for osmotic adjustment.

14) The activity of AAT is increased in leaves and roots of

SIC-1 while it is decreased in both, leaves and roots of CO-5 due to salt treatment. The increased AAT activity may be related to amino acid synthesis in SIC-1 for osmotic adjustment.

15) Salinity decreases the activity of GS in the young leaves of SIC-1 at low salinity levels while it increases at the higher levels and in mature leaves also. However, in CV CO-5 the activity is stimulated by low salt concentrations and high salt concentration inhibits it both in young and mature leaves.

16) The activity of GDH is stimulated by salinity in SIC-1 while it is inhibited in CO-5.