Chapter-V
SUMMARY AND CONCLUSIONS

The normal growth and yield are greatly affected when crop plants are subjected to environmental stresses. Among these the water and salt stress are of prime importance as they affect a very large area of the surface of the earth. The saline environment is mainly due to excessive accumulation of Na salts or salts of Mg in the metabolic environment of the plant. Millions of hectares of land throughout the world are too saline to produce economic yields of crop plants and more land is becoming non-productive every year. In India about 11 million hectares of saline and salinized soils are present and they have considerably influenced on the grain production.

Plant species differ greatly in their tolerance to salinity. It is well known that most of the crops do not show optimum growth under saline conditions. Salinity affects several facetes of metabolisms of plant and thereby induces changes in anatomy as well as morphology. Salinity influences metabolic activities of different processes like mineral nutrition, uptake of nitrogen and photosynthesis. According to Epstein et al., (1980) besides an engineering approach the development of crops tolerant to salinity is a better strategy for meeting the chalange of salinity problem.

Pulse crops accupy a unique place in agriculture. They also have high protein content which is helpful for nourishment of human beings. Among the pulses Phaseolus aconitifolius (Jacq.)

is an important crop. It has a high nutritious value, usually it is a Kharif pulse crop growing in different regions of India. Generally arid and semi-arid, light sandy soils are suitable for the growth of P.aconitifolius. In spite of these qualities this crop is one of the most neglected crops. The improvement programmes with respect to disease resistance and the qualities are very scanty. Almost no physiological work has been carried out in this plant in relation to its adaptation to environmental stress. Keeping this view in mind in the present investigation an attempt has been made to study the process of growth and development thoroughly and to correlate it with organic and inorganic metabolism. The effect of NaCl salinity on growth and metabolism of this plant has also been investigated. A priliminary attempt to study the response of this plant to different methods of salt application has also been made.

Some of the significant findings of the present investigation can be listed as follows :

1. There is considerable decrease in growth in terms of average plant height, number of leaves plant^{-1}, total leaf area plant^{-1}, biomass produced plant^{-1} (dry matter), leaf dry matter, root dry matter, number of pods plant^{-1} and their dry weight only at the highest salinity level i.e. 100 mM NaCl. Inhibitary effect of salt is mainly on shoot growth.

As concentration of NaCl increases upto 50 mM NaCl there is linear increase in almost all the growth parameters. RGR is maximum at 50 mM NaCl while LAR and NAR are maximum at 25 mM NaCl. From the above observations it is suggested that P.aconitifolius may be considered as moderately salt tolerant crop.

2. There is increase in total chlorophyll content of mature leaves upto 25 mM NaCl while in case of young leaves there is increase in chlorophyll content upto lower salinity level i.e. 10 mM NaCl. From the results and chlorophyll a : b ratio it is apparent that chlorophyll 'a' is degraded more in both type of leaves due to salinity. It appears that P.aconitifolius has got a good chlorophyll retaining capacity at the intermediate levels of salinity (25 mM to 50 mM NaCl concentrations.)

3. Polyphenol content of leaves increases upto 50 mM NaCl concentration. Accumulation of polyphenol in young leaves may be an adaptive feature as they are growing parts of the plant.

4. There is continuous accumulation of both soluble sugars and starch with the advancement of developmental stage this is quite significant in the plants grown in non-saline conditions and low salinity levels. At the beginning there is continuous increase in level of soluble sugars and starch in the leaves

and pods with increasing salt concentration in the medium. However, during later stages it goes down consideraly. At the lower concentrations it appears that the synthesis or accumulation of carbohydrates in leaves and pods is stimulated, which indicates that the soluble sugars play a role in the early stages of growth under saline conditions.

5. It is observed that maximum amount of total nitrogen and protein content is present at vegetative (IInd) and maturity (Vth) stages of growth in the leaves and stem of P.aconitifolius. It appears that the leaves and the stem are the sink of nitrogen at the vegetative stage of growth. During flowering and pod formation stage probably the leaves become the source of nitrogen. It is found out that with increasing salinity there is slight decrease in the level of total nitrogen and protein content of the leaves and roots during the vegetative phase (IInd stage). During the flowering and pod development stage it increases in the leaves and the stem while falls down in the roots. No definate pattern of total nitrogen and protein content is observed in leaf, stem, roots and pods at the final or maturity stage. The nitrogen content of the pods at maturity is slightly influenced at the lower concentrations of salt while there is dramatic increase in the total nitrogen content of the mature pods. It appears that due to salinity there is stimulation of

translocation of nitrogen compounds from roots to the developing parts through both stem as well as leaf. Thus it appears that the overall nitrogen uptake and its translocation is slightly stimulated by salt stress.

6. Due to salinity there is increase in the level of proline in the leaves during vegetative stage while it decreases in stem during the later stages of growth and development. The accumulation of proline is stimulated further by salt stress. It appears that accumulation of proline in both leaves and stem may be one of the mechanisms of salt tolerance in <u>P.aconitifolius</u>.

7. In the leaves peroxidase activity is inhibited only at the highest level (100 mM NaCl) while it is stimulatory in the roots at lowest level of salinity (10 mM NaCl). The higher concentrations, however, are strong inhibitors. In the present investigation it is indicated that in <u>P.aconitifolius</u> there is slight increase in the activity of peroxidase. Decreased level of peroxidase at the highest NaCl concentration indicates probability of imbalance in hormone level affecting growth of plants.

8. Activity of catalase in roots decreases with increasing salinity level while the role of catalase is not definite in the leaves. It is suggested that probably there is

decrease in the rate of root respiration due to salt stress. However, it is difficult to conclude in case of leaves.

9. An increase in acid phosphatase in the leaves of P.aconitifolius subjected to salt stress reflects an increase in metabolic activities which may indicate rapid turnover of P in shoot parts of the plant. Eventhough there is inhibition of this enzyme in roots which may not be sufficient to bring about any disturbances in phosphorus metabolism of plants.

10. Uptake and distribution of nitrogen in P.aconitifolius is slightly affected producing low level of nitrogen in plants which can be attributed to lowered NR activity under saline conditions. Higher concentrations are strong inhibitors for this enzyme both in the leaves and roots.

11. It is clear from the results that Na^+ and Cl^- are equally distributed in leaf, stem and root parts of the plant. Na:Cl ratio shows relatively more accumulation of Na^+ than Cl^- in plants under saline conditions. However, leaves are kept away from to toxic accumulation of this element. Thus, the selective absorption of these elements in P.aconitifolius seems to be an adaptive feature for its moderate salt tolerance na ture.

12. K^+ content of all parts of the plant is relatively high during the vegetative (II) and the pod formation stage (IV) and falls down at maturity. It appears that P.aconitifolius is rather moderately salt tolerant as values of K^+ recorded for different parts are not comparable to these for mangroves but are intermediate and the K^+ conent does not fall below the optimum even under saline conditions.

13. In the leaves of P.aconitifolius Ca content increases linearly with the advancement of growth while it is on decrease in stem and roots. The Ca level in stem is rather low due to salinity. It appears that in P.aconitifolius Ca supresses Na uptake and probably contributes to ionic balance with chloride ions. Thus, Ca may add to the mechanism of salt tolerance in this plant.

14. With increasing salinity there is accumulation of P in the leaves, no definate pattern in the stem, while comparatively it is high in the roots. It appears that the uptake and distribution of P is slightly affected due to salinity in P.aconitifolius.

15. Leaves of P.aconitifolius show the presence of maximum amount of Mg, that least being in roots. Mg content of all plant parts is not changing during different stages of growth. Uptake and distribution of this element is less

affected due to salinity. It is suggested that an increment of Mg particularly in the leaves under saline conditions is certainly beneficial in view of essentiality of this element in various biochemical processes.

16. The translocation of iron and its accumulation in the leaves is notably high only in plants grown at 100 mM NaCl level. This iorn concentration may be toxic and hence there is retardation of growth at this salinity level.

From the foregoing discussion it can be suggested that P.aconitifolius has got well developed selective ion absorption properly with respect to uptake of K, P, Ca and Mg. It has an ability towards regulation of Na uptake. These properties are more pronouncing at the lower salinity levels. This clearly indicates the moderately salt tolerant nature of this plant.

18. There is inhibition of K^+ uptake when NaCl alone is applied and when there is shock treatment. But when there is slow treatment the K uptake is normal. This indicates that the plant gets adapted to the saline environment due to slow treatment. Addition of $CaCl_2$ with NaCl salt upto 50 mM concentration stimulates the K uptake and distribution.

19. P^{5+} content of young and mature leaves is affected where mostly there is increase in it at higher salinity levels.

At higher concentrations the accumulation of P almost in all parts of the plant is probably the indication of P induced secondary salt tolerance mechanism. This mechanism seems to be more pronounced when the salt applied as alone with slow treatment and mixed with $CaCl_2$.

From the foregoing discussion it appears that P.aconitifolius responds differently to the different methods of salt application. However, it has got the ability to overcome the salt injury to certain extent. It is suggested, therefore, that P.aconitifolius is moderately salt tolerant plant.

...

17. It is evident that Na^+, K^+ and P^{5+} uptake is more in the plants grown in sand culture while Ca^{2+}, Mg^{2+}, Fe^{3+} and Mn^{2+} are absorbed less. Thus it appears that the method of culture has a profound influence on ion uptake and other processes.