Chapter IV

SUMMARY AND CONCLUSIONS

The normal growth and yeild are greatly affected when plants are subjected to environmental stresses. Stress is an environmental factor capable of inducing a potentially injurious strain in a plant, where the "strain" can be reversible or irreversible. Drought and salt stress are of major concern, because they affect the yield and productivity of several plants all over the world. Water stress is due to unavailability of sufficient amount of water to support normal growth and development of a plant. Soil salinity is another crisis in the modern agriculture, particularly in the arid and semiarid regions of the country. Salinity stress is also described as a physiological drought for the plant because, eventhough, there is plenty of water available in the soil medium, it is not available for the plants because of excessive dissolutin of various types of salts in the water.

Loss of water from the plant tissue leads to a reduction in hydrostatic pressure inside the cell, the concentration of macromolecules and solutes of low molecular weight is increased, the spatial relations of cellular membranes are altered and the chemical potential activity of plant water is reduced. All these effects influence the metabolic processes. Exposure of plant to even mild water stress can affect growth and lead to the disruption of metabollic processes and depending upon their severity, these effects can reduce the ability of the plant to survive and reproduce.

The response shown by the plants to water stress varies from plant to plant and species to species. There are number of drought resistant plants. Drought resistance is the generic term used to cover a range of mechanisms whereby plants withstand periods of dry weather. Ability of a plant to complete its life cycle before a serious plant water deficit develops, development of plasticity, increased rooting, increased hydraulic conductance, reduction in absorbed radiation, reduction in evaporative surface, maintenance of turgor by solute accumulation and increase in elasticity are some of the well known mechanisms of drought resistance in plants.

Soil salinity, another crisis in present day agriculture, is due to excessive accumulation of sodium salts or salts of Mg in the metabollic environment of the plant. Millions of hectares of land throughout the world are too saline to produce economic yields of crop plants and more and more land is becoming non-productive every year. In India, more than 12 million hectares of land is saline. Soil salinity puts various problems to the plant. Plants suffering from salt stress are typically stunted with symptoms of wilting. Marked differences in salt tolerance have been observed among several plant species. Plants can be roughly classified as salt tolerant, moderately salt tolerant and salt sensitive species. Various mechanisms of salt tolerance have been put forth. Compartmentation of inorganic ions protecting the cytoplasm against too high concentration of sodium, reabsorption of sodium from the xylem vessels in the basal part of the roots, salt accumulation in the leaves, ability to secrete the excess of ions into the vacuole than the overall salt content of leaves and accumulation of organic solutes in the cytoplasm (accumulation of glycine-betaine, proline and soluble sugars), are some of the known mechanisms of salt tolerance in plants.

Inspite of several attempts to understand the mechanism of stress tolerance in plants, the exact picture is not yet clear. Therefore, to understand the exact nature of mechanism of stress tolerance in plants, studies in physiology of plant species are essential. Further, there are almost no efforts to compare the physiology of drought resistance and that of salt tolerance in a single plant species. Keeping this view in mind, in the present investigation, an attempt has been made to study the effect of water stress and NaCl salinity on the physiology of Dodonaea viscosa L, a well known highly drought resistant hedge plants to throw some light on the mechanisms of tolerance to both drought and salinity stresses.

For the study, the plants were raised in pot soil culture. Water stress was given by withholding water from the pots for a variety of durations. Salt treatments were also given separately to the plants by supplying NaCl salt at various concentrations to the rooting medium. At the end of the treatments the plants (about 60 days old) were analysed for growth and development, mineral uptake and some organic constituents and enzyme systems.

The significant findings of the present investigation can be summarised as follows,

1. Drought has almost a negligible effect on the linear growth of Dodonaea viscosa L. Root:Shoot ratio, however, is affected due to drought indicating the adverse effect of water stress on the root growth. The number of leaves $plant^{-1}$ decreases with increasing the intensity of drought. NaCl salinity appears to be more detrimental to the growth of D. viscosa L.. There is almost 50% reduction in the total length of the plant when grown under saline conditions at 100 and 200 mM NaCl. The root:shoot ratio is slightly affected upto 50 mM NaCl level. However, the higher salinity level strongly affects this ratio. Root growth in this species seems to be sensitive to saline conditions as compared to that under drought.

The biomass (fresh as well as dry wt) production is considerably affected by water stress. Dry matter production seems to be sensitive to salinity stress. It is suggested that D. viscosa L. can be considered as a drought resistant as well as a moderately salt tolerant species

2. The moisture content of the plants at the end of the water deficit treatments suggested that *D. viscosa* L. is able to conserve sufficient amount of water during drought, which may be considered as an adaptive feature of the species towards drought . Similarly high level of moisture in the plants grown under saline conditions may serve as an adaptation of the species towards salinity tolerance.
3. The acidity status (TAN and pH) of the leaf tissue increases significantly and linearly with the dessication of the plant. Similar type of increase in the acidity status has also been observed under saline conditions,but only upto 50 mM NaCl concentration. Higher salt concentrations cause to decrease the acidity status of the leaves. It is suggested that the organic acids by virtue of their accumulation in the dessicated tissue may play a primary role in the drought resistance of the species.
4. Total chlorophyll content of the leaves of *D. viscosa* L. increases due to water stress. It is probably due to more synthesis of chlorophyll 'a' under drought. Almost similar trend has been observed in the plants exposed to salinity stress.It appears that *D. viscosa* L. has a well developed capacity to retain chlorophyll under stress conditions. The plant shows relatively a better tolerance to salinity as far as the response of photosynthetic pigments is concerned and the mechanism seems to be almost common for drought resistance and salt tolerance.
5. The total carbohydrate content of the leaves of *D. viscosa* L. increases with the intensity of water stress. Starch is accumulated nainly due to intense drought. However, the level of reducing sugars and total soluble sugars is decreased under water deficit. It is observed that the carbohydrate content of the leaves decreases due to salinity at 25 mM NaCl. However, at higher salt concentrations there is some

measurable increase in them. Starch is accumulated significantly in the leaves at 25 and 50 mM NaC1 salinity. The level of total soluble sugars however, declines due to salinity at all salt concentrations. It is suggested that the carbohydrates in D. viscosa L. seem to play a minor role in the adaptation to stress.

6. Total polyphenol content of the leaves increases due to water stress while NaC1 salinity has shown almost no effect on the phenolic content of the plant. It is suggested that the polyphenol level which is basically very high in D. viscosa L., may play a protective role against dessication.

7. It is observed that a linear and gradual accumulation of free proline takes place in the leaves of D. viscosa L. exposed to water stress. The highest level of proline is accumulated in the 12 days water stressed plants. Free proline accumulation takes place in the plants under saline conditions also. However, this accumulation is insignificant and hence, it appears that proline has to play a minor role in salinity tolerance in the species.

8. The electrical conductivity of leaf cell sap remarkably increases due to NaC1 salinity. It is almost doubled at 100 mM NaC1 level. The electrical conductivity of root cell sap, however, is unaffected by salinity. Increased electrical conductivity of leaf cell sap may lead to the osmotic adjustment of the tissue as a mechanism towards salt tolerance.

9. Activity of root peroxidase in D. viscosa L. increases due to 8 days water stress. However, further dessication strongly affected it. This inhibition can be attributed to the probable denaturation of enzyme protein due to water deficit. Activity of enzyme catalase in the leaves increases markedly after 12 days water stress. NaC1 salinity upto 50 mM NaC1 slightly depresses the activity of enzyme peroxidase in the leaves. However, higher salt concentrations (100 and 200 mM NaC1) cause

a dramatic increase in the activity of this enzyme. Enzyme catalase from the leaves as well as roots has registered a remarkable resistance to salinity. Augmentation of activity of enzyme catalase in the species under water stress and salinity stress indicates the presence of protective mechanism for stress tolerance in D. viscosa L.

10. Acid phosphatase from leaf as well as roots of D. viscosa L. is stimulated by water stress. However, NaCl salinity has an adverse effect on this enzyme in both the plant parts. The differential response to stress shown by acid phosphatase indicates a diversity in the mechanisms of stress tolerance in D. viscosa L. as far as phosphate metabolism is concerned.

11. Nitrate reductase in the leaf is slightly affected by water stress. This enzyme responds rather negatively to the increasing intensity of drought. Contrary to this, activity of the enzyme records remarkable stimulation in the leaves and roots under saline conditions.

12. Sodium is slightly accumulated in the roots of D. viscosa L. exposed to 8 to 12 days water stress. The sodium content of the stem remains unchanged while, this monovalent cation accumulates in the leaves when the plants were exposed to even a mild water stress. It appears that sodium has no role to play in the osmotic adjustments through solute accumulation in the cell sap exposed to dessication. It is no wonder that the level of sodium in all parts of the plant increases due to salinity.

13. The potassium content of the roots of D. viscosa L. increases with increasing the intensity of drought. In the leaf tissue however, its level declines due to water stress. The stem potassium remains unaffected. It is suggested that probably, not the uptake but the translocation of potassium is affected by water stress. The potassium nutrition of the plant under saline conditions, however, has shown an opposite

trend. It is found that the uptake as well as translocation of potassium are affected by NaCl salinity. K:Na ratio in different parts of *D. viscosa* L. decreases due to salinity.

14. The uptake of calcium is not affected but its translocation is affected by drought conditions. However, calcium is found to be accumulated in the leaf tissue due to salinity. It appears that, under saline conditions, *D. viscosa* L. has a good capacity to absorb and translocate calcium to the shoot parts. Thus *D. viscosa* L. is able to maintain a balance between Na^+ and Ca^{2+} to avoid probable toxicity due to high concentration of sodium.
15. The phosphorus content of all plant parts increases remarkably, under drought conditions. The phosphorus uptake, therefore, appears to be stimulated in *D. viscosa* L. under drought conditions. The phosphorus content of root and stem tissues decreases linearly with increase in salt concentration in the medium. Leaf phosphorus, however, shows a slight decline in its content due to salinity. It appears that NaCl salinity affects both uptake as well as translocation of phosphorus from the root to the foliage. Thus, phosphorus metabolism seems to respond differently to water stress and salinity stress.
16. Magnesium uptake and translocation is only slightly influenced by water stress. However, the magnesium content of leaves of *D. viscosa* L. is not only maintained but also increased slightly under saline conditions. Thus magnesium metabolism in *D. viscosa* L. is less sensitive to salinity stress.
17. Iron is accumulated in the roots of *D. viscosa* L., water stressed for 4 days. However, water deficit of prolonged period causes a decrease in the level of iron in the roots. The iron content of stem and leaves follows almost the same trend. Thus, the iron uptake in *D. viscosa* L. is affected by water stress. The iron

metabolism in the plant follows a different trend towards saline conditions. It is observed that iron gets accumulated in the leaf tissue with a slight increase in its level in the stem and root tissues. It is suggested that the uptake and translocation of iron are stimulated by salinity in D. viscosa L.

18. There is no significant effect of water stress on manganese nutrition of D. viscosa L. The manganese content of the leaf tissue increases remakably under saline conditions. It appears that the uptake and translocation of manganese in D. viscosa L. is improved under salinity stress resulting in decrease in the level of manganese both in roots as well as in the stem.

19. Water stress stimulates the uptake of cobalt which is heavily accumulated in the leaf tissue. However, the cobalt content of leaf as well as stem decreases under saline conditins.

20. Water stress does not affect the copper nutrition of D. viscosa L. However, the copper content of all the parts of D. viscosa L. increases due to NaC1 salinity. Increased level of copper in the tissue, however, is not toxic because the uptake and translocation of iron and manganese are not affected by salinity.

21. The level of zinc in different parts of D. viscosa L. is increased under both water and salinity stress. It appears that there is more uptake and translocation followed by accumulation of zinc under stress conditions. In D. viscosa L. zinc may be playing a protective role under stress conditions.