Chapter I

INTRODUCTION

The normal growth and yield are greatly affected when crop plants are subjected to environmental stresses. Stress has been defined by Levitt (1980), as "Any environmental factor capable of inducing a potentially injurious strain in plant", where the "strain" can be reversible or irreversible. Thermal, freezing, moisture or water, salt and aging are some of the well known stresses to which number of crop plants are exposed. Among these, the water and salt stress are of prime importance, because, they affect the yield and productivity of food grains adversely, all over the world. Water stress is the result of unavailability of sufficient amount of water to support normal growth and development of plants. It is also described as physical drought. Drought is sporadic phenomenon, however, occurring mostly in arid and semiarid regions of the world. Salinity is another crisis in agriculture in these regions. Now a days it has become a threatening problem to the modern agriculture all over the world. Salinity stress is also described as a physiological drought for the plant, because, eventhough, there is plenty of water available in the soil medium , due to excessive dissolution of various types of salts in soil water, it becomes unavailable to the plants.

"Drought" is defined in both the Concise Oxford Dictionary and Webster's New World Dictionary as "Prolonged dry weather". This definition highlights the fact that drought is a meteorological term involving a rainfall deficit. For a period of dry weather to affect a plant community, the rainfall deficits must lead to a soil water deficit and ultimately to a plant water deficits. Water loss from plant tissues may cause a number of effects. It can lead to a reduction in hydrostatic pressure inside the cells. It can result in an increase in the concentration of macromolecules and solutes of low molecular weight. The spatial relations of cellular membranes may be altered. In addition, a reduction in the chemical potential activity of plant water, occurs. All these effects can influence the metabolic processes. It may occur when only small changes in plant water status are involved. In reviewing the effect of water stress on plant growth and function, Hsiao (1973) found it convenient to use three, rather loosely defined, degrees of water stress, in relation to a "typical mesophytes."

1. Mild Stress : Water potential of the cell slightly lowered, typically down to -0.5 MPa at most.
2. Moderate stress : Water potential of the cell lowered to values in the range - 0.5 to -1.2 or - 1.5 MPa.
3. Severe stress ; Water potential of the cell below -1.5 MPa.

Exposure of plant to even mild water stress can affect growth, and lead to the disruption of metabolic processes. Depending upon their severity, these effects can reduce the ability of the plant to survive and reproduce. Water stress can bring about very different physiological effects. In an excellent review on plant response to water stress, Hsiao (1973) has suggested a very tentative scheme of development of these effects in tissues with water stress. The first change suggested is the reduction in shoot and root growth brought about by reduced water potential. This is followed very closely by a decrease in cell wall and protein synthesis in tissues with high growth potential. Cell division may decline with a further decrease in water potential and the level of some enzymes such as nitrate reductase may decrease. Stomata may then be closed with consequent reduction in transpiration and CO_2 assimilation. At this stage the rate of respiration and translocation of photosynthates is declined. Later, accumulation of sugars and proline can be observed. These physiological effects are accompanied by anatomical changes including cavitation of xylem and blockage by vapour space. Older leaves become senescent and shade as the process continuous and finally the plant dies. The influence of water stress varies from plant to plant and species to species. Number of drought resistant species are identified.

It is the degree to which the plant can withstand the water deficit, that constitutes its drought resistance. Drought resistance is the generic term used to cover a range of mechanisms whereby plants withstand periods of dry weather. Drought escape, drought tolerance at high tissue water potential and drought tolerance at low tissue water potential are the three primary types of drought resistance (May and Milthorpe, 1962; Turner, 1979). Within these three types of drought resistance there are a number of mechanisms that enable plants to resist drought. 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.

The saline environment is mainly due to excessive accumulation of sodiun 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 and more land is becoming non-productive every year. In India, about 12 million hectares of land is saline which has considerably influenced the grain production (Sharma and Gupta, 1986).

In general the presence of soluble salts in the nutrient medium can affect plant growth in two ways. Firstly, high concentration of specific ions can be toxic and induce physiological disorders and secondly, soluble salts depress the water potential of the nutrient medium and hence restrict the entry of water into the plant roots. The higher salt concentration in the nutrient medium leads to increase the rate of ion uptake. This lowers the water potential in the plant root and stimulates water uptake, which raises the cell turgor and turgidity of plant tissues. This is called an osmotic adjustment.

Plants suffering from salt stress are typically stunted with small and dull bluish-green leaves. Wilting symptoms are seldom observed. Marked differences in salt tolerance have been observed among the plant species. Greenway and Munns (1980), while reviewing the mechanisms of salt tolerance in non-halophytes, have categoried the plants into three groups. The first group being that of halophytes which continue to grow rapidly at 200 to 500 mM NaC1, includes the plants such as Sueda maritima, Atriplex numularia, A. hastata, Spartina townsendie and sugar beet. The second one of both halophytes and non-halophytes, which grow very slowly above 200 mM Nacl, includes halophytic monocotyledons, cotton, barley and tomatoes. The third group comprises of very salt sensitive non-halophytes and includes fruit trees such as citrus, avocado, stone fruit etc. Various mechanisms of salt tolerance have been putforth. 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 number of attempts to understand the mechanism of drought resistance and that of salt tolerance in plants, the picture is not yet clear. 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, therefore, 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 plant, to throw some light on the mechanisms of tolerance to both drought and salinity stresses. The water stress was given by withholding water from the soil pot culture, while, salinity stress was imposed by treating the plants with NaCl salt solution. The effect of stress on growth and biomass production, some organic and inorganic constituents and some enzyme systems in D. viscosa L. has been investigated.

For the study, the most recent and advanced techniques and methods have been employed. UV-VIS spectrophotometry and atomic absorption spectrophotometry have also been extensively used.

The thesis has been divided in different parts. A brief idea behind the present investigation has been given in this I part of the thesis. Chapter II (Materials and Methods), the second part of the thesis, describes the techniques and methodology employed for various analytical studies. The observations made and the results obtained out of the present investigation have been given and critically discussed in the light of upto date literature, relevant to the subject, in the third part of the thesis, Chapter III, "Results and Discussion". The background, the purpose and highlights of the significant findings have all been summarised in the chapter IV, " Summary and Conclusions".The research papers, reviews, monographs and the books, extensively used for the discussions have been properly listed in the last part of the thesis "Literature cited".