Chapter 1

Introduction
1.1 Introduction

Salinity is one of the major abiotic stresses that affect crop growth and productivity. Various factors such as sea water, mineral weathering and irrigation increase the soil salinity. Although irrigation is important for the crop growth and yield, excess irrigation leads to accumulation of salts in the soil. Increased soil salinity results in deterioration of soil strength affecting availability of water and nutrients to the plants. In general, salt stress interferes with the plant nutrient uptake, decreases the photosynthesis and respiration rate resulting in reduced growth and yield. High salt leads to cellular dehydration which results in the damage of proteins and cellular membranes. The decrease in photosynthetic efficiency of plants results in decreased plant growth and yield owing to reduction in central metabolic activities. Due to ever growing population, it is increasingly becoming difficult to meet the food supply. Therefore, it is necessary to develop crop varieties which can sustain and set seeds under high salt concentrations. In order to develop salt stress tolerant crop plant, it is vital to understand the plant adaption mechanism to salt stress. Plants respond to salt stress by various mechanisms and these vary amongst different species. The adaptation mechanisms include the mechanisms like control of ion uptake by roots and transport into leaves, selective accumulation or exclusion of ions, compartmentalization of ions, change in photosynthetic pathway, osmoregulation involving synthesis of compatible solutes, induction of antioxidative enzymes/plant hormones and alteration in membrane structure (Parida AK and Das AB, 2005).

Most plants adapt to low or moderate salinities, however their growth is severely limited above 200mM NaCl (Hasegawa et al., 2000). The response of plants to salt stress has previously been studied in model plant species such as Arabidopsis and rice. Differential genomic screens carried out in Arabidopsis and rice have shown that plants respond to salt stress by up-regulation of a large number of genes involved in diverse physiological functions (Kawasaki et al., 2001; Kreps et al., 2002), however these species are not well adapted to high salinity conditions. In this context halophytic organisms may serve as valuable model(s) for identification of basic mechanisms of salinity tolerance (Glenn et al., 1999). A special example of adaptation to hypersaline conditions is the unicellular algae Dunaliella, a
dominant photosynthetic organism are exceptional in the plant kingdom in their ability to proliferate over practically the entire range of salinities. The algae grow in NaCl media with concentrations ranging from 0.1 M to near saturation while maintaining a low intracellular ionic concentration (Avron M and Ben-Amotz A, 1992). *Dunaliella* responds to salt stress by massive accumulation of glycerol (an internal osmolyte), enhanced elimination of Na$^+$ ions, and accumulation of specific proteins (Pick, 2002). Thus overcomes external osmotic variations by adjusting intracellular levels of glycerol concentrations balancing the external osmotic pressure. Therefore, the cells maintain a constant volume independent of the external salinity (Avron, 1986; Sadka et al., 1991). Mechanisms governing ionic homeostasis and other aspects of salt tolerance of *D. salina* still remain largely unknown. In addition to its ability to survive in extreme environments of salt, it accumulates massive amounts of carotenoids under appropriate growth conditions. Natural carotenoids found in *Dunaliella salina* are among nature's best antioxidants, containing a variety of carotenoids including beta carotene, alpha carotene and xanthophylls like zeaxanthin, cryptoxanthin and lutein (Ben-Amotz, 1982). These carotenoids could be useful in combating oxidative stress and other abiotic stresses. Thus it serves as an excellent model organism to understand the molecular basis of adaptation to extreme salinity and abiotic stress. On the other hand, glyophillic algae *Chlorella* serves as an excellent photosynthetic model for plant systems and it was used to study salt stress mechanisms (Barry and David 1980; Ley and Mauzerall 1982; Sheekh and Demeter 1993). Comparing responses in terms of proteomic changes of these two systems to salt stress would perhaps provide molecular insight of adaptation mechanisms to salt stress. Identifying genes and proteins that enable survival at hyper-saline condition is of great importance for developing salt tolerant plants. Expression of such genes in higher plants may lead to generation of transgenic plants with improved salt-tolerance.
1.2 Objectives of the proposed project

- Isolation and characterization of a marine algae for salinity tolerance study
- To study the proteomic profile of *Dunaliella* (isolated marine algae) under different salinity conditions
- Comparative proteomic study of *Dunaliella* and *Chlorella* (a fresh water algae) to understand their salt tolerance mechanisms

1.3 Outline of the Thesis

Chapter 1: Introduction

Chapter 2: Literature Review

Chapter 3: Materials and Methods

Chapter 4: Results

Chapter 5: Discussion

Chapter 6: Summary