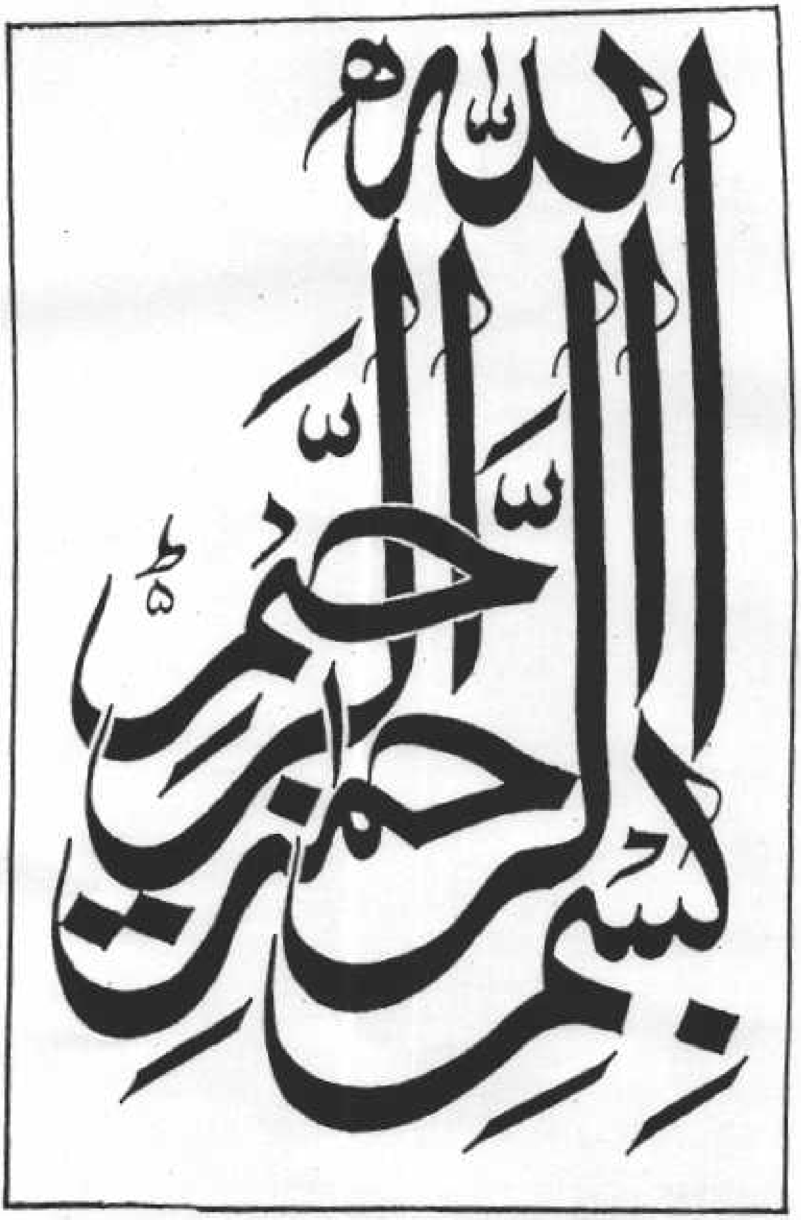
بسم الله الرحمن الرحيم

EVALUATION OF INDIGENOUS WHEAT GERMPLASM UNDER NaCl SALINITY

Muhammad Akram
M.Phil (Botany)

A thesis submitted in partial fulfilment of the requirement for the degree of

DOCTOR OF PHILOSOPHY

in

BOTANY

Department of Botany
Faculty of Sciences
University of Agriculture, Faisalabad
Pakistan

2001

Plants Speak To Men But Only In Whisper! Their Voice Can Be Heard Only By Those Who Remain Close To Them.

Norman E. Borlogue

Chairman;
Department of Botany,
U. A. Faisalabad.

Dean,
Faculty of Sciences,
University of Agriculture,
FAISALABAD

To
The Controller of Examinations
University of Agriculture,
Faisalabad.

We, the Supervisory Committee, certify that the contents and form of thesis submitted by **Mr. Muhammad Akram** have been found satisfactory and recommend that it be processed for evaluation by external examiner(s) for the award of degree.

Chairman : ______________________
(Dr. Ejaz Rasul)

Member : ______________________
(Dr. Mumtaz Hussain)

Member : ______________________
(Dr. Nazir Ahmad)

DEDICATED

To

My Loving

Parents

And

Uncle Wali Muhammad (Late)

ACKNOWLEDGMENTS

I am highly thankful to **Almighty Allah** whose bounteous blessing enabled me to complete this research project as well as to write this dissertation. I offer my humblest and sincerest words of thanks to **Holy Prophet Muhammad** (Peace be upon Him) Who is forever a torch of guidance and knowledge of humanity.

The author wishes to express his profound gratitude and appreciation to the following:

I take this opportunity to express my thanks and deep sense of profound gratitude and indebtedness to my supervisor ***Dr. Ejaz Rasul***, Professor & Chairman, Department of Botany, University of Agriculture, Faisalabad for his affectionate supervision, useful suggestions, constructive criticism, inspiring guidance and consistent encouragement in writing this manuscript.

Dr. Mumtaz Hussain, Assistant Professor, Department of Botany, University of Agriculture, Faisalabad and ***Dr. Nazir Ahmad,*** Professor and Chairman, Department of Crop Physiology, University of Agriculture, Faisalabad for their generous help, encouraging during the time of depressions and healthy criticism during the course of studies.

I am extremely pleased in extending my sincere thanks and deep gratitude to:

Dr. Abdul Wahid, Assistant Professor, Department of Botany, University of Agriculture, Faisalabad for his unforgetable cooperation and valuable suggestions for analysis and writing up this manuscript.

Dr. Altaf-ur-Rehman Rao (late), may his soul rest in eternal peace (Ameen), for his affectionate supervision, valuable advice, help in planning for my Ph.D. studies.

Mr. Abid Nisar Ahmad, Associate Professor, Department of Botany, University of Agriculture, Faisalabad for his encouragement.

Special thanks to my friends ***Dr. Shamshad Akhtar***, ***Iftifikhar Ahmad***, ***Dr. Intishar-ul-Haq Javed***, ***Farrukh Javed*** and ***Mansoor Hameed*** for their assistance and moral encouragement during these studies.

I am greatful to ***Mr. Sohail Ahmad***, consultant **MAS** computers, Press Market, Faisalabad, for his cooperation in data analysis and manuscript writing.

Finally, I wish to thank my Dear mother, father, other family members and my spouse who offered countless prayers for my success and my children *Ehsan* and *Nida* who missed me every evening during these studies.

MUHAMMAD AKRAM

CONTENTS

Chapter 1

INTRODUCTION

Pakistan is situated in the arid and semi arid region, where evapotranspiration exceeds precipitation resulting in the development of salinity and sodicity under irrigated conditions (Sandhu and Qureshi, 1986). Salinity is currently the most wide spread problem affecting crop production on irrigated lands of the world. Salt affected areas usually have associated problem of water logging and the wheat crop typically suffers a dual stress of hypoxia and moderate salinity.

Salt affected soils generally have very low productivity because of dominance of the soluble salts (salinity) and /or exchangeable Na^+ ions. Salt affected area over the world is about 955 Mha (Szabolcs, 1991) out of which about 6.3 Mha falls in Pakistan (Khan, 1993). Pakistan occupies a total geographical area of 79.60 Mha out of which 32.95 Mha is considered suitable for cultivation while only 20.36 Mha ha are actually under cultivation. An area of 16.23 Mha is irrigated through canals and tubewells and remaining 4.13 Mha is rainfed (Rafiq, 1990). Apart from a few localized areas, salt affected soils are generally confined to the Indus plain. The economic importance of salinity is strongly realized from the 10% increase of saline areas all over the world on yearly basis (Ponnamperuma, 1984).

The problem of salinity can be tackled by different techniques. Rehabilitation of the salt affected waste land can be accomplished by adopting reclamation measures involving physical, chemical and hydrological approaches. Since, many of these soils are beyond the reach of conventional reclamation techniques, either for economic reason or for lack of fresh water. A major scientific thrust has been aimed at developing suitable salt tolerant crops to bring these lands under agricultural use (Hollaender, 1979). This approach has special relevance to the countries like Pakistan.

Salt tolerance is difficult to measure because it depends upon many plant, soil, water, and environmental factors. Plant may tolerate a given level of salinity under one set of conditions and yet show considerable sign of salt stress under the other. Nevertheless, some crops are more tolerant than the others (Maas and Hoffman, 1977). In a saline environment, plant may suffer multiple stresses such as:

(i) Water stress due to low osmotic potential in the root zone.

(ii) Ionic stress from high concentration of ions such as Na^+, Cl^-, SO_4^{2-} and Mg^{2+} etc.

(iii) Nutrient/ionic imbalance resulting from high level of Na^+ and Cl^- which reduces the uptake of K^+, NO_3^-, PO_4^{3-}, etc (Wyn Jones, 1985).

Large quantities of toxic salts such as NaCl in the root environment may interfere with nutritional status of the plant. Uptake and translocation of nutrient ions like K^+ and Ca^{2+} are greatly reduced by salinity stress

There is, however, a great diversity in plants. They have evolved a variety of mechanisms for successful growth and development under high saline conditions. There is still no agreement on a unique mechanism which enables the salt tolerant plants to survive in the environment lethal to the salt sensitive plants (Gorham *et al.*, 1985; Shabala *et al.*, 1998). Many investigators have explored diverse responses of plants to salinity (Greenway and Munns, 1980, Flowers, 1985; Isla *et al.*, 1998).

Salinity exerts a number of effects on plant growth and metabolism. It generally decreases plant growth and yield at low concentration (Kingsbury and Epstein, 1986; Zahid *et al.*, 1986; Maas and Grieve, 1990; Grieve *et al.*, 1992; Knight *et al.*, 1992; Maas *et al.*, 1994 and Shannon *et al.*, 1998; Akhtar *et al.*, 2001a,b).

Salt affected plants appear dark green and are stunted, have shorter and fewer internodes, or may develop succulence or a rosette growth habit (Shannon *et al.*, 1993). Chlorophyll contents also decrease due to NaCl treatment (Lutts *et al.*, 1996). Second strategy of plants to cope with salinity stress is to synthesize compatible solutes such as proline, betaine, polyalcohols etc. to maintain osmotic balance between the plant cell cytoplasm and its vacuoles (Wyn Jones, 1981). The latter can accommodate higher concentration of ions e.g. Na^+ and Cl^- etc. (Gorham *et al.*, 1985). The enhancement of proline synthesis by about 50 fold in root tip has been reported (Colmer *et al.*, 1996).

Glycophytes (native to non-saline or marginally saline habitat) as well as halophytes (native to saline habitat) seem to depend on morphological, anatomical and physiological mechanisms which enable them to survive in saline habitats (Maas and Nieman, 1978; Cheesman, 1988; Lauchli and Epstein, 1990; Shannon, 1997; Isla *et al.*, 1998). Among the physiological mechanisms, two contrasting types of salt tolerance mechanisms can be recognized (Munns *et al.*, 1983). These are a) substantial salt uptake, accompanied by efficient compartmentation of salts into large vacuoles b) salt exclusion from the shoot, with accumulation of sugars to reduce leaf water potential (Gorham and Wyn Jones, 1993).

The intervarietal differences for salt tolerance in plants are important factors in controlling salinity tolerance (Aslam *et al.*, 1990). Salt tolerance is a complex phenomenon and is controlled by many genes (Akbar and Senadhira, 1985, Epstein and Rains 1987) which cooperate to bestow tolerance at different stages of plant growth Investigation into the mechanism of salinity tolerance is a crucially important and urgently needed field of research. An immediate and highly rewarding approach to combat the problem of salinity is the mass screening of existing genepool. This approach may be more useful in wheat and oilseed crops because of high amount of genetic variability in them (Schachtman and Munns, 1992; Wahid *et al.*, 1997a, 1999b).

Further studies were imperative to find out promising genotypes which were salt tolerant and to discover novel salt tolerance mechanisms if not reported otherwise. In addition, such information is useful for the utilization of saline water for irrigation purposes.

The major objective of screening for salt tolerance is to select genotypes that would give maximum yield on saline field under the given climatic conditions (temperature, humidity, etc.). soil types, levels and types of salinity and associated problems of waterlogging and sodicity, permeability, bulk density, pH etc.

In wheat, significant differences among cultivars for salt tolerance and for various physiological parameters have been reported (Ashraf and O'Leary, 1996; Qureshi *et al.*, 1990). Full or partial hybrids show enhanced salt tolerance (Gorham *et al.*, 1986a).

Wheat (*Triticum aestivum* L.), as a principal cereal crop, is grown throughout Pakistan and is cultivated on approximately 8.4 Mha (Anonymous, 2000). The productivity of wheat could be increased by inducing better adaptability to salinity. Hence the knowledge of morphological and physiological markers that bestow tolerance under saline condition is likely to pay rich dividends in the form of enhanced productivity in saline areas.

In view of the above facts, studies were under taken to explore:

1. indigenous wheat germplasm for salinity tolerance
2. possible mechanisms of salt tolerance and

Chapter 2

REVIEW OF LITERATURE

2.1 PRELIMINARY

Salinity is a great socioeconomic problem in Pakistan resulting in the dislocation of population and forcing farmers to look for other means of subsistence. Reclamation of salt affected soil is a very expensive venture and needs plenty of water, power or chemical treatment for leaching the excessive soluble salts, which are detrimental to crops.

The studies on the induced damage and the mechanism of salt tolerance have been extensively reviewed (Flowers *et al.*, 1977; Gorham *et al.*, 1985; Wyn Jones, 1985). Salinity exerts manifold effects on plant growth and metabolism. Large quantities of toxic salts and ions such as Na^+ and Cl^- in the root environment may interfere with the nutritional status of the plant. Moreover, uptake and translocation of nutrient ions like K^+ and Ca^{2+} are greatly reduced by salinity stress (Gorham *et al.*, 1986b; Francois *et al.*, 1988).

Sodium chloride salinity is more deleterious to plant growth and nutrient uptake than the other salts (Chaudhary *et al.*, 1991). Resistance to salinity is a desirable attribute for many crops that are raised in salt affected climates and has