SALT PLANT TOLERANCE IN RELATION TO SPECIFIC ION EFFECT AND NUTRIENT BALANCE

By

FERIAL BAYOUMI MOUSTAFA

B. Sc. (Agric.) Ain Shams University 1961

M. Sc. (Agric.) Ain Shams University 1968

THESIS

Submitted in Partial Fulfilment of the
Requirement for the Degree of
DOCTOR OF PHILOSOPHY
in Soil Science

Soils Department
Faculty of Agriculture
Ain Shams University Caire

1978

APPROVAL SHEET

Name : Ferial Bayoumi Moustafa

Title : Salt Plant Tolerance ~~and~~ in Relation to Specific Ion Effect and Nutrients Balance.

Thesis submitted for the degree of Ph.D.

in

Soil Science

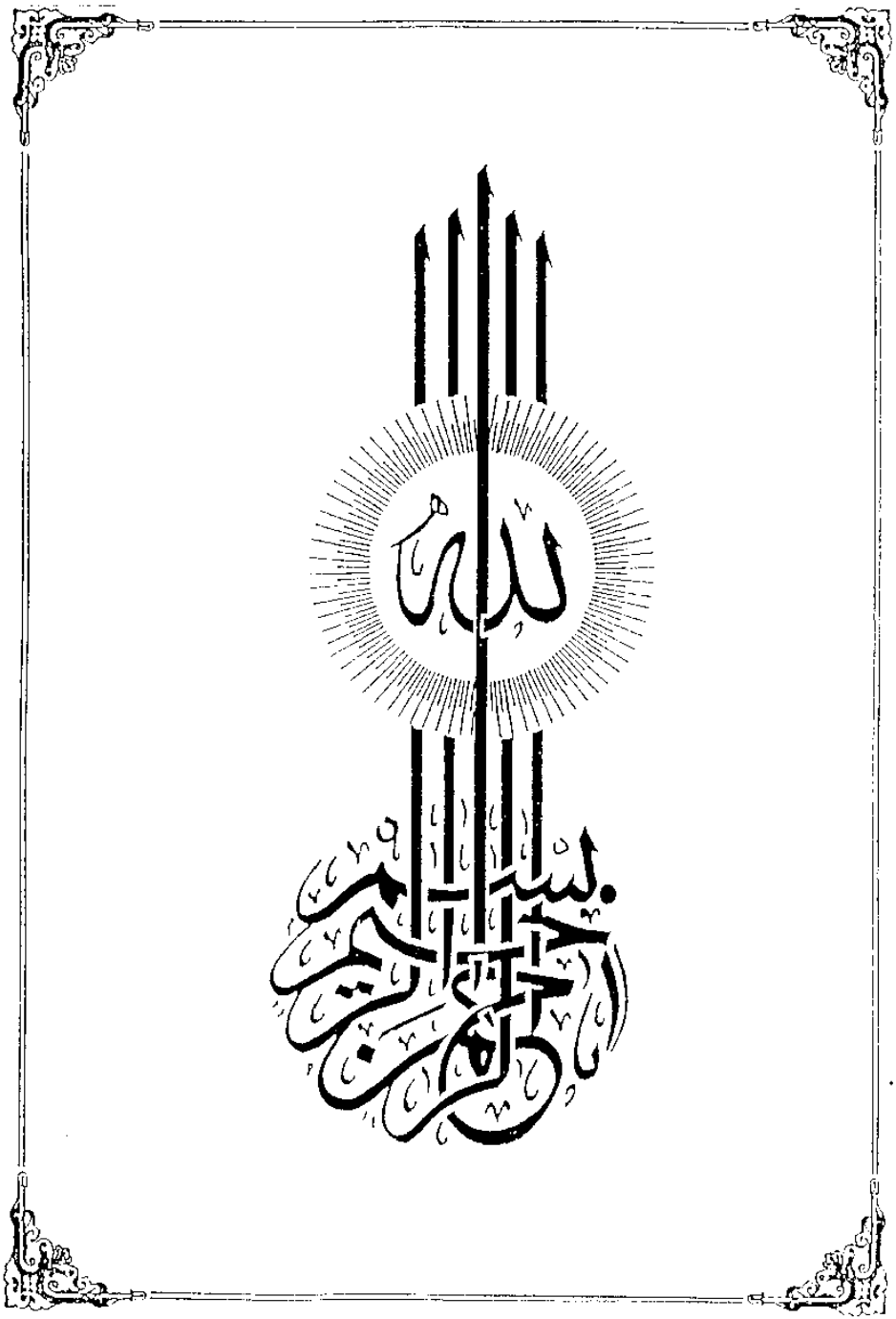
This Thesis has been approved by:

.....M.A.Awad.....

.E...A...Awadalla

...A...El Gabaly....

Date: 20/ /12/ 1978



CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

ACKNOWLEDGMENTS

The authoress wishes to express her gratefulness to Prof. Dr. H. M. HAMDI, Former Dean of Faculty of Agriculture, Ain Shams University, for his supervision, his splendid co-operation and constructive helpful criticism throughout this work.

My gratitude is also owed to Mrs. Dr. K. S. ABDEL-FATTAH, Ass. Prof., Soils and Water use Laboratory, National Research Centre , for her interest, valuable guidance, and continuous assistance.

Thanks are due to all members of Soil and Water Institute, Ministry of Agriculture for providing all facilities to carry out this study, and for their help during this research.

INTRODUCTION

The problem of soil salinity is shared by agriculturists throughout the world due to the fact that large tracts of arable land are rendered unproductive as a result of excessive accumulation of salts in the rhizosphere of crop plants. The amendment of soil is the ultimate remedy, but crop culture on such land is equally important for their utilization at different stages of reclamation. An understanding of the relative tolerance of crops and their varieties, therefore, assumes immense significance.

The mineral nutrition and salt tolerance of plants as related to salinity of their growth media is usually an interesting subject of research. Salinity has a great role in the definition of the absorption phenomenon of plant roots which should be reflected on the behaviour of any particular crop with respect to physiological and metabolic activities.

Higher plants have developed various mechanisms for regulating uptake and distribution of mineral elements. Uptake rate is generally influenced by a number of factors; the most important is the internal concentration

of mineral elements, K, Na, Ca and Mg. Under nutrient stress, some plant species develop special regulating mechanism for the uptake of an essential element. These mechanisms are still not fully understood. Salts affect plant's growth by osmotic pressure, toxicity of certain elements, and its effect on soil physical properties. Specific ion effects (Toxicities and nutritional distrubances) may be superimposed on the general osmotic effects depressing the yield further.

The present work has been designed to evaluate the variability in salt balance of both barley and rice as affected by specific ion and nutrients balance in relation to potassium uptake by plants under different KCl concentrations. As it is a well known fact ~~that~~ potassium plays an important role in nutrients balance.

Four salts (Na Cl, Na_2 SO_4, $CaCl_2$ and Mg Cl_2) - commonly found in soils under arid and semi arid conditions-are used in the current study. The specific effect of each ion at different concentrations on K-uptake by barley and rice seedlings is investigated. The uptake of major ions as influenced by their external concentrations in the media in the presence of different KCl concentration is also included.

2. REVIEW OF LITERATURE

2.1: Salt tolerance and its physiological mechanism:

Salt tolerance refers to the ability of plants to tolerate concentrations of soluble salts in the root medium.

Information on salt tolerance of crops is rather essential from different aspects; namely, in diagnosing suspected salt injury in the field, in selecting tolerant crop for saline soils, in determining the suitable irrigation water, the drainage requirements, and management practices.

Salt tolerance of any crop has been appraised, and the data were initially reported in terms of salinity level (EC_e) that would be expressed to give a 50 percent reduction in yield, Richards (1954).

It is worthy to note that climatic conditions as well as the stage of development may influence plant sensitivity to salinity in hot dry areas than in cool , and humid ones, Magistad et al. (1943). During certain stages of development, some plants are sensitive to salinity but tolerant at other stages, Bernstein and

Hayward (1958) and Bernstein (1961). Pearson and Ayers (1958) found that rice can germinate at salinities up to 10-15 mmhos/cm., but the plants usually die if the salinity exceeds 5 or 6 mmhos/cm. during the seedlings stage. Barley resembles rice in being more sensitive to salinity during the seedling stage than at earlier or later growth stages. Rice is quite tolerant during seedling stage, and again rather tolerant during the fertilization of the florets, Pearson and Bernstein (1959).

Successful agriculture on saline and alkali soils requires the use ofacrop capable of producing a satisfactory yield under moderate intensities of salt or alkali accumulation. The question arises immediately as to what constitutes the physiological capacity of a plant to tolerate salt or alkali.

In discussing the physiological basis for the various degrees of salt tolerance which prevail among crop plants, it may be helpful to consider the characteristics of the natural halophytes. Halophytes could be described as those plants which have led to their

survival under saline conditions, and the capacity to develop rather high osmotic pressures of the tissue fluid to counteract the increased osmotic pressure of the substrate. They have the capacity to accumulate considerable quantities of salts in the tissue fluids and to regulate that accumulation. Moreover, Hayward and Wadleigh (1949) stated that plants whose protoplosm is resistant to relatively high accumulation of sodium ions in the cell sap should be considered halophytes.

They concluded that earlier investigations showed that halophytism is essentially xerophytism as both halophytes and xerophytes are physiologically and anatomically adapted to the scarcity of water. Anatomical studies revealed, however, that the two groups of plants should be physiologically regarded. When they used an indirect method to measure the osmotic pressure of the cell contents of different species of plants in North African Desert, the highest osmotic pressures, 100 atmospheres or above, were found in plants growing on dry or highly saline soils. Those growing on moist non-saline soils showed osmotic pressures of 10-20 atm.

The osmotic pressure of the different species, however, tended to vary with the physiological scarcity of water in the environment. They stated that there were variations in the osmotic pressure of the tissue fluids of the leaves of Atriplex confertifolia from 31.2 to 153 atm., in Allenrolfea occidentalis from 22.5 to 61.8 atm., in Sacrobatus vermiculatus from 22.7 to 39.8 atm., and Salicornia ulahensis from 36.8 to 51.9 atm. Much of the variations in the osmotic pressure of the tissue fluids were found to be associated with the chloride contents. They observed that some halophytes may regulate the salt content of their tissue fluids independently of the salinity of the environment. Salicornia may contain a lower concentration of sodium chloride than that in the soil, or it may accumulate higher NaCl concentration than that in the soil. Hayward and Wadleigh(1949) pointed out that salt tolerance of a given species of crop depends on the same three attributes that were stipulated as essential for halophytism. It is apparent, however, that the main defficiency of economic crops which lack salt tolerance is the inhibitory behaviour to regulate adequately the intake of salt, and the