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A STUDY ON THE PHYTOSIDERPHORES EFFICIENCY FOR SPECIES OF SOME FIELD CROPS GROWN UNDER SALINITY STRESS CONDITIONS IN CALCAREOUS SOILS

BY

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CONTENTS

CHAPTER 1

INTRODUCTION

Limited availability of additional land for crop production, along with declining yield growth for major food crops, have heightened concerns about agriculture’s ability to feed a world population expected to exceed 7.5 billion by the year 2020 (Gruhn *et al*., 2000). With respect to Egypt, United Nation report indicated that the population in Egypt expected to grow from 67.3 to 95.6 million in 2026 (Khalifa *et al*., 2000). Decreasing soil fertility has also raised concerns about the sustainability of agricultural production at current levels. Future strategies for increasing agricultural productivity will have to focus on using available nutrient resources more efficiently, effectively, and sustainably than is the past. Integrated management of the nutrients needed for proper plant growth, together with effective crop, water, soil, and land management, will be critical for sustaining agriculture over the long term. Currently, the reclaimed calcareous soils reached to more than 1.12 million feddan mostly located in the north western part of Nile Delta. Such soils are characterized by high content of $CaCO_3$, poor in content of 2:1 clay minerals, very low percent of organic matter and low cation exchange capacity. Significant part (about 25-35%) of the calcareous soils in Egypt is classified as saline soils. Also there are scattered areas of gypsiferous soil in Bangar Elsokkar, North Tahrir, and Mechanical Farm (El-Damarawy, 2002). On the other hand, the scarcity of canal irrigation water obligates the farmer to use low quality irrigation water such as the ground water and drainage water.

Iron and the other micronutrients uptake represent the major problem for the plants grown in calcareous soils and various attempts for managing the iron deficiency were conducted particularly in non saline calcareous soils. The main attention of the present research work is being centered to find out some solutions for enhancing the native soil iron availability under normal and saline conditions of calcareous soils using the plant species that able to deal with the Fe-deficiency problem through internal physiological adaptation patterns (mechanisms) to cover their Fe requirements. Wheat and barley are major grain crops grown in calcareous soils and are classified as graminaceous plants. Some cultivars of these crops are able to grow well under high salt concentrations either in soil or in water cultures. On the other hand, some cultivars of wheat and barley are successfully grown in Fe-deficient calcareous soils. The aim of the present study is mainly directed to evaluate the relative performance of local wheat and barley cultivars, with respect to efficiency on Fe uptake and other micronutrients, from the Fe-deficient calcareous soils, under salt stressed conditions.

These objectives in detail are:

1. To study the growth response of barley and wheat genotypes to the added sodium chloride (NaCl) salinity in the hydroponic and soil systems.
2. Selecting of barley and wheat plant genotypes having abilities of releasing the root exudates (phytosiderophores) as a results of the growth in the Fe-free nutrient solution cultures.
3. To study the effect of NaCl salinity on the phytosiderophores production by barley and wheat plants grown in the nutrient solution cultures.

4. Trying using the indirect quantitative method in determination of the released amounts of barley- and wheat-phytosiderophores.
5. Evaluating the efficiencies of barley and wheat genotypes for uptake of Fe, Mn, Zn and Cu from Fe-deficient calcareous soil under normal and saline growth conditions.

CHAPTER 2

REVIEW OF LITERATURE

I- Characteristics of Calcareous Soils

Calcareous soils are the soils that have free calcium carbonate ($CaCO_3$) in the profile, i.e. contain enough $CaCO_3$ so that it effervesces when treated with hydrochloric acid. When free carbonates present, the acid will produce bubbling due to the evolving of CO_2 gas (Loeppert and Suarez, 1996):

$$\mathbf{CaCO_3 + 2H^+ \leftrightarrow Ca^{2+} + CO_2 + H_2O} \qquad \mathbf{(1)}$$

In calcareous soils, calcium carbonate dominates the problems related to agricultural land use. Calcareous soils are characterized by the presence of calcium carbonate in the parent material and by a calcic horizon, a layer of secondary accumulation of carbonates (usually Ca or Mg) in excess of 15% calcium carbonate equivalent and at least 5% more carbonate the underlying layer. Calcareous soils cover more than 30% of the earth surface, and their $CaCO_3$ content vary widely from a few percent to 95% (Marschner, 1995). According to the world reference base (WRB) soil classification system, calcareous soils may mainly occur in the reference soil group of calcisols (FAO, 2000).

Calcareous soils occur naturally in arid and semi-arid regions because of relatively little leaching (Brady and Weil, 1999). They also occur in humid and semi-humid zones if their parent material is rich in $CaCO_3$, such as limestone, shells or calcareous glacial tills, and the parent material is relatively young and has undergone little weathering. Some soils that develop from calcareous parent material can be calcareous throughout their profile. This will generally occur in the arid regions where precipitation is scarce. In other soils, calcium carbonate has been leached from the upper horizons and accumulated in B or C horizons. These lower $CaCO_3$ layers can be brought to the surface after deep soil cultivation (Brady and Weil, 1999).

In some soils, the calcium carbonate deposits are concentrated into layers that may be very hard and impermeable to water. This is called **Calishe** layer. These calishe layers are formed by rainfall leaching the salts to a particular depth in the soil at which water content is so low that carbonates precipitate (Jackson and Erie, 1973).

Soils can also become calcareous through long period of irrigation with water containing $CaCO_3$ (Hagin and Tucker, 1982). The secondary calcium carbonates are formed under arid and semi-arid climatic conditions when the carbonate concentration in soil solution remains high. Accumulation starts in the fine and medium-sized pores at the surface of contact between the soil particles. This accumulation may be rather concentrated in a narrow zone of the solum or more dispersed, depending upon the quantity and frequency of rainfall, topography, soil texture, and vegetation (FAO, 2000).

Calcareous soils are alkaline because of the presence of $CaCO_3$, which dominates their chemistries. Depending on the solubility product of $CaCO_3$, the dissolution results in a high solution HCO_3^- concentration, that buffers the soil in the pH range of 7.5 to 8.5 (Imas, 2000):

$$\mathbf{CaCO_3 + H_2O \leftrightarrow Ca^{2+} + HCO_3^- + OH^-} \qquad \mathbf{(2)}$$

As salts dissolve, the cations entering solution are attracted to the exchange sites usually according to valence and mass action. Except for very small amounts of micronutrient cations, and some NH_4^+, it is the Ca, Mg, K, and Na ions that dominate the exchange sites. Their abundance parallel the energy of adsorption sequence, with Ca the most abundant and Na the least. The calcareous soils have 100% base saturation and calcium is the dominant cation on the exchange complex and in soil solution (Loeppert and Suarez, 1996). The cation exchange capacity of a calcareous soil (C horizon) developed from loess of Iowa was reported to be saturated 67% by Ca, 30% by Mg, 2% by K, and 1% by Na (Foth and Ellis, 1988).

As a result of calcareous soils development in regions of low rainfall (irrigated areas), one of the main agricultural constraints is the potential of water availability. The quality of irrigation water is the cause of many management problems. Almost, all waters used for irrigation contain inorganic salts in solution. These salts may accumulate in considerable amounts within the soil profile to such concentrations that may modify the soil structure, decrease the soil water permeability and seriously injure plant growth. Crusting of the surface may affect not only infiltration and soil aeration but also the emergence of seedlings. Cemented conditions of the subsoil layers may hamper root development and water movement characteristics.

Particle size distribution, surface area and reactivity are important properties of soil carbonates which influence soil pedogenic, chemical, and rhizosphere processes (Loeppert and Suarez, 1996). Calcium carbonate provides a reactive surface for adsorption and precipitation reactions, for example, phosphate, trace elements such as zinc and dissolved organic compounds (Amer *et al.*, 1985; Amer *et al.*, 1991; Saleh *et al.*, 1998). Carbonate reactivity influences the rate of volatilization of ammonia (Ryan *et al.*, 1981). Carbonate affects also rhizosphere processes, specially those in which acidification is an important factor. For example, the Fe-deficiency response of dicotyledons involves the oxidation of protons and acidification of the rhizosphere. The effectiveness of Fe-deficiency stress response is therefore negatively influenced by the reactivity of the carbonate phase (Loeppert *et al.*, 1988; Morris *et al.*, 1990).

Reported symptoms of impaired nutrition in calcareous soils are chlorosis and stunted growth. This is attributed to the high pH of soil solution and reduced nutrient availability as direct toxicity of bicarbonate ions to physiological and biochemical systems is much less likely (Pearce *et al.*, 1999).

Improved nutrition management is required to grow crops successfully on calcareous soils. Crops fertilizer management on calcareous soils differs from that on non calcareous soils because of the effect of soil pH on soil nutrient availability and chemical reactions that affect the loss or fixation of some nutrients. The presence of $CaCO_3$ directly or indirectly affects the chemistry and availability of nitrogen, phosphorus, iron, zinc, magnesium, calcium, potassium and copper (Oberza *et al.*, 1993; Marschner, 1995). Nitrogen fertilizers should be incorporated into calcareous soils to prevent ammonium-N volatilization. The availability of phosphorus is reduced by the level of calcium and magnesium that are associated with carbonates. In addition, iron, zinc and magnesium deficiencies are common in soils that have high $CaCO_3$ due to reduced solubility at alkaline pH values (Marschner, 1995; Brady and Weil, 1999).

II- Soil salinity and its effect on plant nutrition

Salinity is the major environmental factor limiting plant growth and productivity and the detrimental effects of high salinity on plants can be observed at the whole-plant level as the death of plant and/or decreases in productivity (Parida and Das., 2005). Salinity affects 7% of the world's land area, which amounts to 930 million ha (Munns, 2002). The area is increasing; a global study of land use over 45 years found that 6% had become saline (Ghassemi *et al.* 1995). This amounts to 77 million ha. Irrigation systems are particularly prone to salinization; about half the existing irrigation systems of the world are under the influence of salinization, alkalization or waterlogging (Szabolcs 1994). Irrigation schemes cover only 15% of the cultivated land of the world (227 million ha in 1987), but as irrigated land has at least twice the productivity of rain-fed land, it may produce one-third of the world's food. Reducing the spread of salinization, and increasing the salt tolerance of high yielding crops, are important global issues. Salinization can be managed by changing farm management practices. In irrigated agriculture, better irrigation practices, such as drip irrigation, to optimize use of water can be employed. In rain-fed agriculture, practices such as rotation of annual crops with deep-rooted perennial species may restore the balance between rainfall and water use, thus preventing rising water tables bringing salts to the surface. All such practices will rely on a high degree of salt tolerance, not only of the perennial species used to lower a saline water table, but also of the crops to follow, as some salt will remain in the soil. Salt tolerance is usually assessed as the percent biomass production in saline versus control conditions over a prolonged period of time.