PHYSIOLOGICAL STUDIES ON SALT TOLERANCE IN SOME PLANTS

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I. INTRODUCTION

The ability of plants to tolerate excess soluble salts in the rhizosphere is of considerable importance to agriculture in semi-arid and arid regions. There are in the literature some records indicating the possibility of improving salt tolerance in plants through certain treatments. On the other hand, certain trials have been made in attempting to elucidate the metabolic adaptive responses under salinization conditions, though such attempts are relatively few. In main they aimed to study, how could the metabolism in salt-tolerant plants be adapted to the unfavourable conditions. However, little attention has been paid to the metabolic responses resulting from treatments that appeared to improve the tolerance of salt-sensitive plants. In view of this, the present work was carried out. It aimed to show, on one hand, how could the metabolic adaptive responses in case of the salt tolerant plants be modified throughout development. On the other hand, the same investigation aimed to clarify, whether or not the mode of metabolic adaptive responses is identical for the various treatments used to improve the tolerance of salt-sensitive plants.

The salt-tolerant plant used in our study was Zygophyllum album, whereas the salt-sensitive one was Lycopersicon esculentum, that is known to be amongst the important economic vegetables grown in A.R.E. On the other hand, the treatments employed in this investigation for improving salt tolerance in plant have been more or less similarly tested before in the literature. These were the gradual salinization and the spraying with any of the three compounds : $MgSO_4$, or (2-chloroethyl)-trimethyl-ammonium chloride (CCC) or N^6-benzyladenine (BA). As an indication for the extent of tolerance, the dry matter accumulation was taken in our investigation. For the metabolic adaptive responses, the changes in the content and composition of protein and nucleic acids were studied, since this type of metabolic changes as reported in the literature plays a role in resistance of plants to unfavourable conditions.

II. REVIEW OF LITERATURE

As mentioned in the "Introduction" the present work aimed partly to study how could the salinity affect the growth as well as some aspects of the metabolism of a salt-tolerant plant. On the other hand, the same investigation aimed to improve the salt tolerance of a salt-sensitive plant using certain treatments. In this regard, the changes in growth were taken as an indication for the effectiveness of such treatments, while the changes in the content and composition of nucleic acids and protein were shown to be rather helpful in interpreting the obtained results. Therefore, for the presentation of the appropriate literature, it was thought advisable to comprise herein only the studies carried out in two main fields. The first deals with the effect of salinity alone on the growth and metabolism of both the salt-sensitive and salt-tolerant types of plants. The second, however, deals with the response shown in the same regard by the salt-sensitive plants when using the treatments suggested in our study for salt tolerance improvement, namely the gradual exposure to salinity and the spraying with Mg^{++}, CCC or BA. In this concern, and due to the limited work upon salinity, literature on the effect of these treatments under drought conditions will be included; recognizing that salinity and water-stress have been considered identical by several investigators (Richard and Wadleigh, 1952 and Bernstein and Pearson, 1954). It ought to point out that, in our review only the literature dealing with nucleic acids and protein was presented in the area of metabolic changes; the study of metabolism in our work was confined to these two aspects.

Furthermore, it has to be recognized that in the literature dealing with the effect of salinity alone on growth of salt-sensitive plants different genera and species were extensively studied. Hence the pretaining review of literature in this particular area of research will be mainly concerned with the salt-sensitive plant used in our investigation, namely tomato plant.

A. Response of Growth and Metabolism of Nucleic Acids and Proteins in Plants to Salinity

I. Growth

Bernstein and Pearson (1954) showed that tomato and pepper plants grown under saline conditions can survive under high osmotic pressure up to 12 atm for a day or two and that no growth was observed if the osmotic pressure was maintained continuously at 6 atm.

Black (1956) revealed that *Atriplex vesicaria* (perennial) was more adapted than *Atriplex hastata* (annual) to high levels of NaCl. The latter plant is probably well adapted to the fluctuating salinity conditions, typical of moist coastal salt-marshes. Thus, its relatively vigorous growth could be completed in short period after rain, when the salinity conditions were most favourable. The growth of Atriplex vesicaria was little affected at 0.3-0.4 M NaCl, while that of the Atriplex hastata was markedly inhibited. On the other hand, the same author mentioned that tomato plant possessed the least degree of tolerance to NaCl.

Ashby and Beadle (1957) dealing with tomato, Atriplex nummularia and Atriplex inflata, pointed out that tomato grew less to much less with added salts. On the contrary, both salt-bushes plants produced much greater dry weight with added salt, somewhat irrespective of the salt added.

Brownell (1965) suggested that small amounts of sodium are essential for the growth and development of Atriplex vesicaria. He found that plants receiving 0.46 ppm Na_2SO_4 made favourable growth and had, when harvested on the 14th day, approximately 10 times the dry weight of plants which had not received sodium.

Bakr Ahmed et al. (1970 a) showed that growth, as expressed on the average height, increased in the salt-tolerant plant Atriplex nummularia with the increased concentration of NaCl from 0 to 0.10 M. Reduction of growth occurred with further increase in salinity to 0.15 M NaCl. In the succulent plant Zygophyllum album, however, no correlation could be detected between the plant height and salt treatment.

Shalaby (1970) found that the height of L. esculentum plants was decreased with increasing NaCl. However, in Atriplex nummularia plant, NaCl up to 0.05 or 0.10 M increased the plant height. Higher levels of NaCl (0.15 and 0.20 M) were lethal for L. esculentum and the survival did not extend more than 6 weeks from salt application.

Tal (1971) studied the salt tolerance in the wild tomato species Lycopersicon peruvianum relative to the cultivated tomato Lycopersicon esculentum and the plants originating from the wild species L. esculentum Minor. He showed that plant growth, shoot/root dry weight ratio, relative water content, and potassium concentration decreased under salinity in cultivated and wild plants. In all instances except for potassium, the decrease was smaller in the wild plants. Fruit size decreased under salinity in the cultivated species but remained unchanged in the wild plants.

Ahmed (1975) showed that the fresh weight and dry weight of tomato shoot decreased with increased NaCl concentration (from 0 to 0.20 M NaCl) of the culture solutions.

2. Metabolism of nucleic acids and protein

a. Nucleic acids

Zhukovskaya (1962) found that both chloride and sulphate types of salinity caused a decrease in the rate of nucleic acid synthesis in tomato plants. At all concentrations chloride salinity decreased the synthesis of nucleic acids in roots and leaves during development. Sulphate salinity at a concentration of 0.3 and 0.45 % of soil salts, inhibited the synthesis of nucleic acids in the roots but intensified them in the leaves.

Saakvan and Petroyan (1964) dealing with grape leaves, showed that the degree of soil salinity had a marked effect on the content and the nature of RNA variations. They found that the RNA content decreased with increasing alkalinity. They also indicated that cation balance, particularly the abundance of Na^{+} cations in the cell, was disturbed by soil salinization and this apparently caused a disturbance in nucleic acid metabolism, leading to an inhibition of the growth processes. However, a relatively high RNA content was found in grape seeds during the early periods of their development which indicated that both morphogenetic and growth processes were intensified.

Nieman (1965) showed that salinity suppressed the rate of RNA and protein synthesis along with cell enlargement of bean leaves. Salinity prolonged all the three processes, so that cell size and the amount of RNA and protein per cell eventually approached the respective maximum values attained earlier by the control. He also added that over the long term, salinity suppressed cell enlargement and cell division proportionately so that there was no obvious indications of being affected more than the other. He suggested that the synthesis of RNA and protein appears to be essential for sustained cell enlargement.

Rauser and Hanson (1966) examined the effects of sodium and potassium sulphate on DNA and RNA in two soybean varieties differing in salt tolerance. They found that sulphate salts inhibited DNA synthesis and dry weight production in both varieties, and that sodium salts were more inhibitory than potassium. Salinity whether caused by sodium or potassium retarded RNA synthesis. Both salts accelerated the endogenous degradation of RNA in root homogenates and that sodium, in this respect, being more effective than potassium and that ribosomal-RNA was degraded primarily. They postulated that monovalent cations in high concentration could displace Ca^{++} and Mg^{++} from the polyanionic structures leading to degradation.