NUTRIENTS UPTAKE AS INFLUENCED BY EXCHANGEABLE SODIUM

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1. INTRODUCTION

Exchangeable sodium often represents a major part of the exchangeable cations in salt affected soils in the U.A.R. as well as in other countries of arid and semiarid regions. The presence of high exchangeable sodium exerts direct effects on plant growth, due to its interference with nutrients uptake and indirect effects, through its influence on the soil physical characteristics. Both cases represent a vital problem in the course of the plant life.

This investigation was carried out to obtain additional informations on the influence of different levels of exchangeable sodium on the uptake of nutrients, with especial regards to that of the anions.

In this investigation, a mixture of sand and synthetic cation and anion exchange resins was employed to eliminate the physical effect which exists in natural soils and to avoid the associated cation effect when anion added in salt form.

2. REVIEW OF LITERATURE

The interactions of nutrients due to various exchangeable sodium percentages (ESP) or varied ratios between exchangeable sodium (ES) and other exchangeable cations in different media and their effect upon nutrients content of plant have been studied by many authors. Due to the complexities of this study and for the sake of clarity, the literature concerning this subject will be reviewed under the following headings.

2.1. Plant growth as influenced by exchangeable sodium:

Kelley (1928), Kelley and Thomas (1928) and Gedroiz (1931) presented evidence that plant growth on a soil high in ES is inhibited. Breazeale and McGeorge (1932) and McGeorge (1936) have shown that the high soil pH values frequently associated with the presence of exchangeable sodium may be responsible for various nutritional disorder in plants. Also a high degree of saturation of soil exchange complex with exchangeable Na may in itself be quite harmful to plant growth. Ratner (1935) found that the influence of exchangeable Na on the growth of Oats and wheat in a chernozem soil begins to be deleterious when it amounts to about 50 per cent of the total exchangeable basis. Death of the plants occurs when exchangeable Na increases to 60 to 70 per cent. Van Itallie (1938) found that the growth of Italian ryegrass was adversely affected and prevented at an exchangeable Na percentage of 26 and 51 respectively. Joffe and Zimmerman (1944) showed the injurious effects of exchangeable sodium percentage above 10 on the growth of sudan grass, even with a high Ca: Mg ratio. Thorne (1944) stated that the yield of stone tomato plants was decreased as the ESP exceeded 40. The highest level of ESP tolerated by the plants was between 60 and 70. Bower and Wadliegh (1948) showed that the tolerance of the different species to ESP varied greatly. Growth of beans was markedly decreased at exchangeable sodium percentages as low as 15 and almost completely inhibited at exchangeable sodium percentages of 45, 60 and 75. Significant reduction in the growth of Rhodes grass, Garden beets occurred only at 75 ESP. Martin, Harding and and Murphy (1953) reported that the growth of citrus seedling was appreciably reduced by 14 ESP. Martin and Bingham (1954) stated that in a soil with an exchange capacity of approximately 19 me./100 g, leaves of some avocado seedlings were injured by as little as 4 % ES, 7 % caused moderate injury, 14 % severe injury, and 28 % killed Avocado seedlings. Growth reduction was less in soil with a relatively low exchange capacity than in a similar soil with a relatively high capacity. El Gabaly (1955) showed that the growth of barley was better in systems having a concentration of any two cations, within a given range, than in homoionic or pure sand systems. The range within which stimulation took place varied with nature of the two cations, being narrower for Na-Mg systems, wider for Ca-Mg systems and intermediate for Na-Ca systems. Depression in growth caused at high Na-saturation percentage. Bernstein and Pearson (1956), and Pearson and Bernstein (1958) stated that the yield for many crops were related to ESP rather than to the absolute level of ES. Schreiber et al (1957) studied the influence of adsorbed cations on radish seedlings development. In Ca-Na systems, maximum growth was obtained in the range of 10-20 % adsorbed Na. Martin, Ervin, and Shepherd (1961), Lunin, Gallatin and Batchelder (1964) and Anter (1966) stated that the growth was hardly affected by any increase in ESP.

2.2. Cation uptake by plants as influenced by exchangeable sodium:

2.2.1. Sodium-Potassium relationship :

Van Itallie (1938) studied the Cationic uptake by Italian rye grass in relation to changes in the ratio of Ca, Mg, K, and Na in the soil. Great changes in plant composition were found under the influence of the varying ratio in the soil. The well known mutual replacement of the cations in the plant took place in this experiment, for the most part in nearly equivalent amounts, the uptake and the replacement value being larger for potassium than for sodium. Lehr (1942) stated that in the equilibrium of ions in the foliage Na plays a very important part, whereas in the equilibrium of ions in the root, K is very important. Thorne (1944) showed that the percentages of potassium in the plant was decreased with high levels of sodium on clay.

Bower and Wadliegh (1948) studied the influence of various levels of exchangeable Na upon cationic accumulation by Dwarfredkidney beans, Garden beets, and Rhodes and Dallis grasses. The cultural media consisted of a mixture of sand and synthetic cation and anion exchange resins containing the desired amounts of various cations and a[illegible] in adsorbed form. They noted that accumulation of K by the plants as a whole tended to decrease and that of Na to increase progressively as higher proportions of exchangeable Na were supplied. The magnitude of the decrease in K accumulation and the extent of Na accumulation varied greatly among the species studied and between the the roots and top parts of the plant. Accumulation of K by the root of beans was greatly depressed as the proportion of ES was increased. It was noted that the yields and the K contents of the roots were closely related. Except at the exchangeable Na percentages of 60 and 75, accumulation of K by the tops was unaffected. The decreased content of K in the roots was more than offset by the concentration of Na. The results for garden beets showed that the potassium contents of the leaves as well as the roots were lowered with increases in the level of ES supplied. The increases in Na accumulation by the tops of Rhodes-grass were accompanied by a reduction in K but cation replacement was not quantitative in so much as the increases in Na content were more than offset the decreases in K. In contrast with the data obtained for beans and beets, accumulation of K by the roots was not significantly affected by Na treatments. However, as the level of Na supplied was increased, accumulation of K by the tops of Dallis grass was depressed slightly. The reduction in K content was approximately counterbalanced by Na. Martin, Harding, and Murphy (1953) studied the effects of various exchangeable Ca, K, Na, H and NH_4 ratios and of excess Ca CO_3 in soils on growth and chemical composition of first and second plantings of citrus seedlings. They stated that the lower percentages of Na slightly increased K absorption by these plants, but the higher percentages decreased the K content. In a similar study Martin and Bingham (1954) showed that increasing soil Na increased leaf K but decreased root K of Avocado seedlings. Also they stated that Na effected the movement of K in the plant rather than total K absorption. ElGabaly (1955) showed that increasing Na-saturation in the medium is accompanied by an increased absorption of Na by plants, and increased depletion in K^+. Bernstein and Pearson (1956) indicated that increasing ESP results in increased sodium accumulation in the tops of beets, alfalfa, clover, and beans, but K may increase or decrease depending upon crop specificity. Lunin, Gallatin, and Batchelder (1964) stated that increasing ES in the substrate increased the K content in Greenbeans. Anter

(1967) showed that K uptake by barley decreased by increasing Na : Mg ratio or Na : Ca ratio.

2.2.2. Sodium-Calcium relation ship :

Most of the early and recent studies concerning the relationship between Na and Ca was dealing with alkali soils. This is because of Na is the predominant exchange able cation present in such soils.

Kelley (1928) suggested that the presence of relatively a high proportion of exchangeable Na may prevent the plant roots from obtaining an adequate supply of calcium because of " the pronounced avidity of the sodium exchange complex for calcium ". Gedroiz (1931) presented evidence that plant growth is inhibited on high Na soils owing to low availability of calcium. Hence, tolerance to soil alkali may involve the capacity by plant to secure an adequate supply of calcium under conditions of relatively low availability. Ratner (1935) reported that the destruction of plant life in pot experiments when there is a large amount of exchangeable Na is difficult to explain (in case of non carbonate soils) by the alkaline reaction of the medium, by the accumulation of soda, or by the unfavourable physical proper-