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COMPARATIVE EFFECT OF SODIUM CHLORIDE AND SULPHATE ON GROWTH AND ION ACCUMULATION IN *ZEA MAYS* L.*

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Abstract

The growth of *Zea mays* L. plants was reduced to the same extent by equivalent concentrations of sodium chloride and sodium sulphate in the substrate, whereas at iso-osmotic concentration the sodium sulphate produced higher reduction in growth. Following salinization, sodium ion accumulated in different parts of the plants to the same extent from equivalent concentrations of sodium salts. On the other hand its accumulation was higher from sodium sulphate compared to chloride at iso-osmotic concentration. After salinization with sodium chloride or sulphate the increase of sodium in plants was accompanied by a substantial decrease of potassium contents. The potassium contents of plants appears to be affected by anions.

Introduction

Several studies have been made to compare the effects of chloride and sulphate salts of sodium on the growth and ion accumulation in different plants (Hayward & Long, 1941; Ayers, 1950; Strogonov, 1964; Bernstein & Hayward, 1958; Naqvi 1972). Substantial difficulties in evaluating the effects of these salts have been due to their differences in specific and non-specific properties. One of these difficulties is to equalize the salts compared in their equivalence and iso-osmotocity. For example, to create an osmotic concentration of 3.27 atm. it is necessary to introduce 121.47 mequiv/L of sodium sulphate to the nutrient solution, but only 78.75 mequiv/L of sodium chloride. On the other hand in equivalent concentration sodium sulphate is capable of creating an osmotic concentration of only 2.12 atm. Therefore, comparative studies of the effects of sodium chloride and sulphate salts on plants have been made in equivalent or iso-osmotic concentrations. In the later case the equivalence of both cations and anions, to be compared is increased which result in greater growth depression and intensive ion accumulation (Hayward & Long, 1941; Eaton, 1942).

In the present study, the effect of sodium chloride and sodium sulphate at both

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equivalent and iso-osmotic concentrations was studied on the growth of *Zea mays* and the distribution of sodium and potassium in plant tissues were considered.

Materials and Methods

Seedlings of *Zea mays* L. (cv. Akbar) were produced by germination of seeds in petri dishes on cotton wool, moistened with distilled water. Two days old seedlings were suspended through holes in hard board sheets which were placed on two litre plastic buckets and were grown for three days in full strength Hoagland solution. (Hoagland. 1919). After four days of growth the solution was replaced with nutrient solution containning NaCl or Na_2So_4 (Table 1). The osmotic concentrations of salts were calculated from the tables and graphs provided by Strogonov (1964). Each treatment was replicated four times in a randomised block design and the solutions in the buckets were renewed twice a week. The experiment was conducted in a growth room maintained at $27^{o} \pm 1^{o}C$ and a photoperiod of 16 hours. Plants were harvested after two weeks of growth and were separated into leaves, sheath stem and roots. After washing in three changes of distilled water the material was dried over night at $60^{o}C$ in an oven.

TABLE 1. The treatment solutions with concentrations and osmotic pressure of the salts used in the experiment.

Treatment	Salt concentrations mequiv/L.	Osmotic pressure atm.
Control (nutrient solution)	—	0.78
Nutrient solution + NaCl	68.5	0.78+3.0=3.78
Nutrient solution+Na_2SO_4 (equivalent)	68.5	0.78+2.0=2.78
Nutrient solution+Na_2SO_4 (iso-osmotic)	109.8	0.78+3.0=3.78

For chemical analysis the material from two replicates was pooled together, so that there were two samples of each part of the plant from 4 replicates. The dry material was ground in a wiley mill and 0.5 gram of sample was wet digested in a nitric, perchloric and sulphuric acid mixture (10:1:4). Potassium and sodium were determined flame photometerically on dilute aliquots of the digest, using an E.E.L. flame photometer. The results were expressed as mequiv/gram of dry material.

Results

The visible toxic symptoms in plants grown under chloride salinization appeared after four days growth as bleaching of the chlorophyll near the leaf tip which developed progressively with time and at the time of harvest it was completely brown. Under sulphate salinization at equivalent and iso-osmotic concentration bleaching appeared in between the margins on the leaf lamina.

TABLE 2. The dry weight yield of *Zea mays* plants grown under salinization of the substrate by equivalent and iso-osmotic concentrations of sodium chloride and sodium sulphate (gm/plant.).

Treatment	Leaves	Stem and sheaths	Roots
Control (Nutrient sol.)	2.918	2.529	2.404
Nutrient+NaCl	1.533	1.422	1.373
Nutrient+Na_2SO_4 (equivalent)	1.520	1.427	1.376
Nutrient+Na_2SO_4 (iso-osmotic)	0.853	0.830	0.752
L.S.D. at 5%	0.081	0.022	0.112

The dry weight yield of roots, leaves, stem sheaths were reduced more or less equally by sodium chloride and sulphate at equivalent concentrations, but sulphate at is0-osmotic concentration produced greater reduction in growth (Table 2).

Following salinization of the substrate, the plants absorbed significant amount of sodium (Table 3). At equivalent concentration of sodium chloride and sulphate the individual parts of the plant contained practically similar amounts of sodium while at iso-osmotic concentration the sodium contents were higher. The accumulation of sodium was accompanied with a substantial decrease of potassium (Table 3). The effect of two salts at equivalent concentrations were identical on the potassium contents of the individual parts of plants, but at iso-osmotic concentrations the effect of sulphate type of salinity was more pronounced.

Discussion

In the present study sodium chloride and sodium sulphate at equivalent concentrations reduced the growth of *Zea mays* plants to the same extent whereas at iso-osmotic concentration sulphate produced greater effect. This is in accordance with the suggestions made by Hayward & Long (1941) and Eaton *et al.* (1971). Under chloride salinization of the substrate the plants showed leaf tip burn while these symptoms appeared in between the margins of the leaf under sulphate type of salinity. These effects have also been reported in other plants (Ayers, 1950; Strogonov, 1964).

TABLE 3. The sodium and potassium concentrations in different parts of the plant grown under sodium chloride and sodium sulphate salinization at equivalent and iso-osmotic concentration (mequiv/g Dry. wt. of plant).

Treatment	Leaves		Stem sheaths		Roots	
	Na	K	Na	K	Na	K
Control	0.211	4.772	0.451	3.877	1.121	1.856
Nutrient+NaCl	7.710	2.790	8.365	2.110	8.79	1.166
Nutrient+Na_2SO_4 (equivalent)	6.969	1.554	8.265	1.436	8.910	0.612
Nutrient+Na_2SO_4 (iso-osmotic)	10.720	1.099	13.235	1.011	20.740	0.321

Each figure is a mean of two replicates.

Sodium ions accumulated to the same extent in individual parts of plants grown in sodium chloride and sulphate at equivalent concentrations in the ambient solution, while it accumulated more in case of sulphate at iso-osmotic concentration. This difference may be explained as due to an increase in the concentration of sodium ion under sulphate type of salinity. The absorption of sodium was accompanied by a substantial decrease of potassium in different parts of the plant. Such similar observations have been made in barley (Greenway, 1962) tomato (Tal, 1970) and Glycine (Wilson *et al*, 1970). This reduction of potassium contents of the plant does not seem to be influenced by the osmotic pressure of the salts. Since sodium sulphate at equivalent concentration created low osmotic pressure in the ambient solution but with identical effect, it is therefore, influenced either by cations or anions. Heimann (1959) and Epstein (1961) reported that the basic cause of potassium deficiency in case of salinization is a competitive interrelationship between sodium and potassium. However, in the present studies it has been observed that the anions sulphate and chloride influenced the potassium

contents in plants differently (Table 3). The sulphate at equivalent concentration where the sodium contents in two substrate were the same, produced higher deficiency of potassium. This effect was even more pronounced at iso-osmotic concentration. Genkel & Solov'ev (1958) working with pumpkin plants have reported a similar effect.

It is, therefore, concluded that in studying the influence of sodium chloride and sodium sulphate at iso-osmotic concentrations, the difference in the contents of the cation sodium may greatly distort the picture of the actual influence of the anions compared. In equivalent concentrations of these salts in the substrate, the influence of chloride and sulphate is manifested so strongly that differences in the osmotic concentrations, which they produce, can not be detected practically.

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