Proc. Indian natn. Sci. Acad. **B 46** No. 5 pp 694-698 (1980)

Salinity and Plant Nutrition—Effect of Sodium carbonate and Sodium bicarbonate on the Growth and Absorption of Essential Macro-nutrients and Sodium in Pea (*Pisum sativum* L.)

B K GARG* and O P GARG**
Department of Botany, Harayana Agricultural University, Hissar

(Received 17 December 1979)

Effects of Na_2CO_3 and $NaHCO_3$ at equal conductivities (2, 4 & 6mmhos/cm) were studied on plant growth and nutrient absorption in *Pisum sativum* L. cv. Multifreezer in pot culture at 30, 60 and 90 days after sowing. Both the salts decreased plant height as well as fresh and dry weights of the shoot and root significantly. Na_2CO_3 was more depressive than $NaHCO_3$.

The concentrations of calcium and magnesium decreased drastically while sodium content of the tissues increased sharply with increasing salt stress. The uptake of all the nutrients excepting sodium decreased significantly due to salt application. While the uptake of nitrogen, phosphorus and potassium declined at higher salt concentrations and only towards later stage of plant growth, the uptake of calcium and magnesium decreased right from the early growth. Sodium uptake increased in salt treated plants inspite of much lower dry weights of the tissues in comparisons with control plants. Salt injury to plants had been attributed to deficiency of calcium and magnesium and accumulation of sodium to toxic levels.

Key Words: Alkalinity or Sodicity, Electrical conductivity, Nutrient uptake, Sodium toxicity, Calcium deficiency

Introduction

Suppression of plant growth in saline/sodic soils has been ascribed to a variety of factors, one of which is the non-availability of macro- and micro-nutrients to plants. Increasing salinity decreases P, K, Ca and Fe contents and increases Mg, Mn and Na contents in barley and maize plants (Burdygina & Kuzin 1966). A negative correlation between soil salinity and uptake of P, K, Ca, Cu, Fe and Mn by maize and a positive correlation with Na has been observed (Hassan et al. 1970). Although considerable research work has been carried out on the effects of chloride and sulphate types of salinity on growth, mineral nutrition and

*Present address: Junior Scientist (Plant Physiology) Central Arid Zone Research Institute Jodhpur 342 003

**Professor of Plant Physiology, Punjub University, Chandigarh

metabolism of plants, yet such studies have received little attention under the effect of alkalinity due to Na_2CO_3 and $NaHCO_3$. Agarwala et al. (1964) showed that soil alkalinity causes imbalances in the tissue concentration of macro- and micro-nutrients in paddy and barley plants. As Na_2CO_3 and $NaHCO_3$ are the major salts present in sodic soils, it was considered worthwhile to study their effect on growth and nutrient absorption in pea at different stages of growth.

Materials and Methods

This study was carried out in sand culture using earthenware pots (dia. 30 cm), lined with polythene sheet and having a drainage hole at the bottom. The salt treatments were given before sowing by raising the electrical conductivity of the canal water to 2, 4 and 6 mmhos/cm by the addition of Na_2CO_3 or $NaHCO_3$ (single salt solution) in appropriate amounts. The canal water (EC 0.2 mmhos/cm) served as the control. Seven seeds of pea (*Pisum sativum* L Cv. Multifreezer) were sown and after thinning two plants of comparable growth were kept in each pot. The pots were supplied (once every week) with equal amounts (500 ml) of complete nutrient solution of the composition as given by Went (1957). Sampling was done 30, 60 and 90 days after sowing for observations on growth (plant height, root length, fresh and dry weights of shoot and root) and nutrient estimations of shoot and root separately. Nitrogen and phosphorus were determined colorimetrically using Nessler's reagent (Lindner 1944) and Vandomolybdate reagent; (Koenig & Johnson 1942) respectively, sodium and potassium by flame photometry and calcium and magnesium by titration with Ethylene DiamineTetra Acetate (EDTA or Varsenate) as described by Cheng and Bray (1951). All the estimations were done on three replicates in each treatment. Uptake of different nutrients was also determined from the data on dry weight and concentration of nutrients in shoot and root.

Results

Growth observations

Shoot and root lengths decreased with increasing concentration of both the salts. Significant decrease was observed at 4 mmhos/cm. (figure 1). Dry weights of shoot and root recorded at various sampling dates (30, 60 and 90 days after sowing) showed a significant reduction under the effect of salt treatments. Na_2CO_3 was more depressive than $NaHCO_3$ at all the growth stages. The deleterious effects of salts increased with the age of the crop and significant decline commenced at 4 mmhos (figure 1).

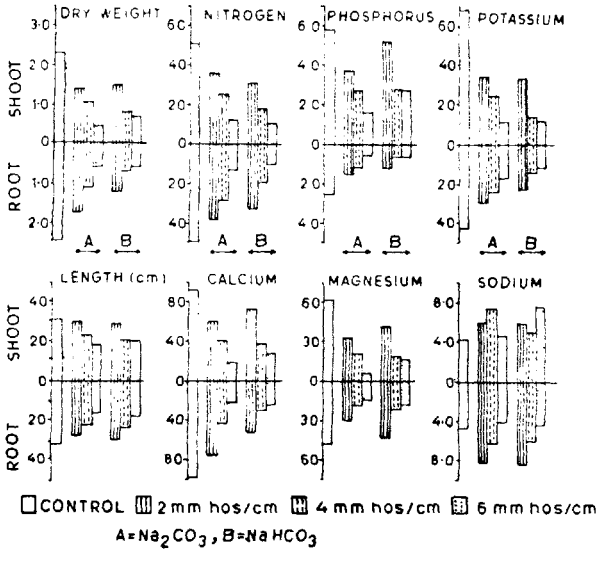

Figure 1 Effect of Na_2CO_3 and $NaHCO_3$ on growth and uptake (mg/plant) of macro-nutrients and sodium in shoot and root of pea

Nutrient concentration (table 1)

Nitrogen content of the shoot was not affected much, only a slight decrease took place as a result of salt application. Phosphorus concentration increased under $NaHCO_3$. Both the salts decreased potassium content of the shoot. Sodium concentration of the shoot increased sharply with increasing levels of Na_2CO_3 and $NaHCO_3$. Increased conductivity of the medium caused a marked reduction in the calcium and magnesium contents of the shoot. The decrease in Ca and Mg concentration was more during early growth and both the salts were equally depressive. Nitrogen content of root was always higher in salt stressed plants as compared with control. Phosphorus concentration also increased under the effect of Na_2CO_3 and $NaHCO_3$. The concentrations of calcium, magnesium and potassium in the root decreased significantly at higher stress levels. However, the concentration of sodium, increased with increasing conductivity due to Na_2CO_3 or $NaHCO_3$.

Nutrient uptake

The data on uptake of different nutrients of shoot and root at 90 days of growth have been presented in figure 1. Uptake of nitrogen by the shoot was significantly reduced under both the salts but there was more reduction under Na_2CO_3 than $NaHCO_3$. Uptake of phosphorus was depressed only at higher (4 & 6 mmhos/cm) conductivities, Na_2CO_3 being more depressive than $NaHCO_3$. Potassium

Table 1 *Effect of Na_2CO_3 and $NaHCO_3$ on concentration (%) of different macro-nutrients and sodium in shoot and root of pea*

Treatments		Nitrogen	Phosphorus	Potassium	Sodium	Calcium	Magnesium
SHOOT							
Control		3.43	0.34	2.29	0.44	4.13	2.00
Na_2CO_3	2	3.31	0.32	1.86	0.70	3.80	1.76
(mmhos/cm)	4	3.09	0.37	2.22	0.97	3.20	1.59
	6	3.03	0.34	2.13	1.40	2.66	1.36
$NaHCO_3$	2	2.74	0.36	2.11	0.80	3.93	1.84
(mmhos/cm)	4	2.58	0.39	1.82	1.21	3.53	1.51
	6	3.07	0.38	2.02	1.83	2.93	1.52
C. D. 5%		0.22	0.04	0.21	0.12	0.46	0.26
ROOT							
Control		2.26	0.15	1.70	0.41	4.13	1.99
Na_2CO_3	2	2.54	0.20	1.56	1.24	4.00	2.48
(mmhos/cm)	4	2.58	0.23	1.66	1.08	3.73	1.48
	6	2.64	0.17	1.81	1.40	3.40	1.90
$NaHCO_3$	2	2.56	0.18	1.48	1.21	3.66	2.37
(mmhos/cm)	4	2.96	0.17	1.51	1.41	3.60	2.56
	6	3.12	0.17	1.43	1.65	3.46	2.00
C. D 5%		0.24	0.05	0.23	0.13	0.27	0.27

uptake was depressed by both the salts but more so with Na_2CO_3. The salt treatments of Na_2CO_3 and $NaHCO_3$ brought about an increase in the uptake of sodium markedly, inspite of the fact that dry weights were much less due to salt stress. The uptake of calcium and magnesium was decreased drastically by both the salts. The data on root uptake of different nutrients (figure 1) followed the same pattern as discussed for shoot. During early growth Na_2CO_3 and $NaHCO_3$ reduced the nitrogen uptake at 4 mmhos. However, at 90 days of sowing all concentrations decreased nitrogen-uptake significantly. Phosphorus uptake was reduced markedly only at 6 mmhos. The uptake of potassium decreased at all concentrations of Na_2CO_3 and $NaHCO_3$. Sodium uptake was enhanced under the effect of Na salts, upto 60 days of growth, later on the differences were less marked. Calcium and magnesium-uptake of root was also reduced drastically as in the case of shoot. Na_2CO_3 was more depressive than $NaHCO_3$.

Discussion

The saline-alkaline conditions of the soil may be due to an excess of cations; Ca^{++}, Mg^{++}, K^+ and Na^+ and anions: Cl^-, SO_4^{--}, NO_3^-, HCO_3^- and CO_3^{--}, but the proportion of different ionic species varies from one soil to the other. The excess of some ions in the soil would prevent the uptake or availability of others present in relatively smaller amounts besides other osmotic and specific ion effects.

Soil alkalinity (predominance of Na_2CO_3 and $NaHCO_3$) has been reported to result in a decrease of calcium content and sometimes of magnesium and potassium as well (Chang & Dregne 1955, Agarwala et al. 1964, Kanwar & Kanwar 1971). Several workers have also reported the non-availability of nitrogen, phosphorus, copper, iron and mangnese apart from calcium, magnesium and potassium under saline-alkaline conditions (Saxena & Sinha 1966). However low calcium has been considered as one of the major effects of alkalinity in the sodic soils (Poonia & Bhumbla 1973). On the other hand, several investigators have attributed sodium injury to the accumulation of sodium to toxic levels in the shoot and root of plants (Bernstein & Pearson 1956, Bernstein 1975). Moreover, high bicarbonate/carbonate has been shown to permit the accumulation of sodium by plants which normally exclude it (Wadleigh & Brown 1952).

Results of the present study on the concentration and uptake of various nutrients bring out the depressive effects of the salt treatments very clearly (figure 1). On the one hand, calcium and magnesium contents decreased drastically in response to salt treatments, and on the other hand, sodium content of the shoot and root increased sharply with increasing concentration of the salts in the medium. Na_2CO_3 was generally more depressive than $NaHCO_3$ and these depressive effects increased with the age of the crop largely due to large differences in dry weight of the tissues in control and stressed plants as the concentration of the nutrients did not show large differences with ageing. Sodium salts decreased the potassium of the tissues to a lesser extent but depressed its uptake markedly for the same reason.

Deficiency of essential nutrients and especially of calcium and magnesium and accumulation of sodium to toxic levels appear to be responsible for reduced growth of the plants in the

present studies. However, our unpublished data suggested that disturbances in normal plant metabolism are equally significant in depressed plant growth. But how far calcium and magnesium deficiency on the one hand and sodium accumulation on the other hand affect plant metabolism remains to be demarked.

Acknowledgement

The Senior author is extremely thankful to the Indian Council of Agricultural Research, for awarding Senior Research Fellowship, enabling him to carry out research work for Ph.D degree. The results presented here form a part of the dissertation submitted to the Harayana Agricultural University, Hissar.

References

Agarwala S C, Mehrotra N K and Sinha B K 1964 Influence of exchangeable sodium on the growth and mineral composition of plants. I. Paddy and Barley; *J. Indian Soc. Soil Sci.* **12** 7-24

Bernstein L 1975 Effects of salinity and sodicity on plant growth, *Ann. Rev. Phytopath.* **13** 295-312

——and Pearson, G A 1956 Influence of exchangeable sodium on the yield and chemical composition of plants. I. Greenbeans garden beets clover and alfalfa; *Soil Sci.* **82** 247-58

Burdyg na V S and Kuzin A T 1966 Effect of the saline concentration of soil on the yield of maize; *Akad. Nauk. Turkman SSR Ser. Biol.* **6** 759

Chang C W and Dregne H E 1955 Effect of exchangeable Na on soil properties and on growth and cation content of alfalfa and cotton; *Proc. Soil Sci. Soc. Amer.* **19** 29-35

Cheng K L and Bray R H 1951 Determination of calcium and magnesium in soil and plant material; *Soil Sci.* **72** 449-58

Hassan N K, Drewy J V, Mudren K, Knadsin D and Olseon R A 1970 Influence of soil salinity on production of dry matter and uptake and distribution of nutrients in barley and corn; *Agron. J.* **62** 43-45

Kanwar S S and Kanwar J S 1971 Effect of residual sodium carbonate in irrigation waters on plant and soil; *Indian J. Agric. Sci.* **41** 54-66

Koenig R A and Johnson C R 1942 Colorimetric determination of phosphorus in biological material; *Industr. Engng. Chem. (Anal.)* **14** 155-56

Lindner R C 1944 Rapid analytical methods for some of the more common inorganic constituents of plant tissues; *Pl. Physiol.* **19** 76-89

Poonia S R and Bhumbla D R 1973 Availability of Ca from $CaSO_4$ in a highly saline sodic soils; *Pl. Soil* **38** 675-78

Saxena S S and Sinha S K 1966 Interaction of nitrogen, phosphorus and *p*H on growth and yield of linseed; *Indian J. Pl. Physiol.* **19** 22-33

Wadleigh C H and Brown J W 1952 The chemical status of bean plants affected with bicarbonate-induced chlorosis; *Bot. Gaz.* **113** 373-92

Went F W 1957 in *Experimental Control of Plant Growth* pp 77-93 (Mass. : Chronica Botanica Co. Waltham)