EFFECT OF SALTS ON THE GROWTH AND MINERAL NUTRITION OF CABBAGE (*BRASSICA OLERACEA*) IN SOIL AND SAND CULTURE

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Effect of salts (3 to 18 mmhos/cm) on the growth and chemical composition of cabbage was studied in a greenhouse and field experiment on a sandy loam soil. Growth of cabbage and uptake of N, P, K, Ca and Mg by it decreased and of Na increased with the increase of salinity. In the same salinity range, growth of cabbage was 25 per cent more in soil than in sand culture. Lesser variation in cationic ratio (Na + K/Ca + Mg) appears to be the main cause for better crop growth in soil. It is inappropriate to use salt tolerance limits of a crop on the basis of sand culture for field application.

INTRODUCTION

In saline-sodic soils, crop growth is adversely affected by excessive osmotic stress, dispersion of sodic soil and imbalanced mineral nutrition of plant. Hayward and Bernstein (1958) concluded that table beets, asparagus and spinach are among the most salt tolerant of the vegetables, and other vegetable crops are medium salt tolerant. The plant growth and fresh weight of tops of cabbage was improved at lower salt concentration (1000 ppm NaCl), while at higher (4000–16000 ppm NaCl) concentration, growth was decreased (Hayward and Bernstein 1958; Nieman 1962). Osawa (1965) also observed that cruciferous vegetables were generally more salt tolerant than leguminous and other fruit vegetables.

Studies on salt tolerance behaviour of the crop in sand culture appears to be of limited use for field application by virtue of fluctuating water and salt content and ion exchange reactions between soil and plant system. Moreover, the mineral nutritional behaviour of crop plant is more complex and less understood in saline conditions (Paliwal 1972).

Attempts have been made in this paper to examine the growth and nutrients absorption behaviour of the tops of cabbage in graded salinity both on the basis of sand culture and soil. A comparison of the growth behaviour of the plant in sand culture and soil media has also been made to utilise the results for predicting the salt tolerance limits as obtained from the sand culture data for field application.

MATERIALS AND METHODS

Sand culture—A greenhouse study was conducted on cabbage (*Brassica oleracea;* variety Golden Acre) grown at five levels of salinity (3, 6, 9, 12 and 18 mmhos/cm)

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in quartz sand. The solutions were prepared in half-Hoagland's nutrient solution of the following composition in meq/l : $Ca[(NO_3)]_2$, 5; $MgSO_4$,2; KH_2PO_4, 1.5; KNO_3, 2.5 and one meq/l each of ferric citrate, $CuSO_4$, $ZnSO_4$ and H_3PO_4. Sodium and calcium were used in the ratio of 4 : 1 as their chlorides, and the desired conductivity was adjusted by the solubridge. Each treatment along with the control in half-Hoagland's nutrient solution was run in triplicate. Six seeds of cabbage were sown on 12-10-1970 in plastic containers (23 cm ht. and 2 cm diam.) and after 10 days of germination, only two seedlings were maintained till the harvest.

Field experiment—A field experiment was also conducted on the sandy clay loam soil of Kushal Bagh Farm of Udaipur University, Udaipur, Rajasthan, on cabbage (var. Golden Acre) irrigated with four different quality waters: (1) well water (w = 28 meq/l); (2) w + 40 meq/l; (3) w + 80 meq/l; (4) w + 120 meq/l, in 2 × 1 meter plots. The different quality waters were prepared by mixing chloride salts of sodium and calcium in the ratio of 4 : 1. The plots were irrigated at 15 days interval and soils were analysed at the time of harvest. The plots were fertilized with 75 kg N and 75 kg P_2O_5/ha in the form of ammonium sulphate and single superphosphate. A week before transplanting, 50 kg of N and 75 kg P_2O_5/ha were applied and a top dressing of 25 kg/ha of N was given after one month. The seedlings were transplanted on flat beds on 22-10-1970 maintaining a row to row distance of 60 cm and seedling to seedling distance of 45 cm and the crop was harvested at maturity. The experiment was run in three replicates. Eight irrigation of 50 litre solution each, were applied during the growth period. The control plot was irrigated with the well water. In order to compare the effect of sand culture and soil medium, the EC, values for the two depths of the root zone (0–15 and 15–30 cm) were averaged assuming a zone of 30 cm depth as the major part of the root growth. The nutrient contents of the leaves were estimated as described by Jackson (1962). Calcium and magnesium were determined using zirconium oxychloride (Derderian 1961).

RESULTS

Yield—Data on the fresh yield of cabbage in sand culture show (Table I) that it regularly decreased with the increase of salt concentration in the growth medium. However, the reduction at the highest salt concentration (18 mmhos/cm) was upto 85 per cent of the control. Data also show that the percentage reduction in yield

TABLE I

Effect of salts on the fresh yield of cabbage

	Control	Salinity(mmhos/cm)				
		3	6	9	12	18
Yield (g/pot)	212.6	186.0	170.6	136.0	99.3	38.0

C.D. at 1% = 45.5

was slightly more after an EC value of 6 mmhos/cm. Statistical analysis shows that cabbage can grow satisfactorily upto an EC value of 6 mmhos/cm.

The yield of cabbage in the field experiment irrigated with increasing levels of salt concentration also regularly decreased with the increase of salt concentration, and the reduction was about 48.4 per cent at the highest salt concentration (Table II). The statistical analysis shows that cabbage (variety Golden Acre) can grow well upto a salt concentration of 108 meq/l in irrigation water which corresponds to an EC value of 10.75 mmhos/cm of the saturation extract of the soil taking 30 cm as the major depth of the root zone.

TABLE II

Effect of salinity on the fresh yield of cabbage
(Field experiment)

Quality of irrigation waters	E.C. (mmhos/cm) of saturation extract			Yield (kg/ha)
	0–15 cm	15–30 cm	Mean (0–30 cm)	
Well water (w = 28 meq/l)				
$w + 20$,,	2.5	1.5	2.00	1875
$w + 40$,,	8.0	5.5	6.75	1850
$w + 80$,,	12.5	9.0	10.75	1650
$w + 120$,,	20.0	15.0	17.75	965

C.D. at 1% level = 265.

TABLE III

Effect of salinity on the uptake of nutrients by cabbage in sand culture and soil medium

Salinity levels (mmhos/cm)	Nitrogen (%)	Phosphorus (%)	Sodium	Potassium	Calcium	Magnesium
			(meq/100 g)			
Sand culture						
Control	2.54	0.35	20.5	93.5	20.0	12.5
3	2.44	0.29	58.5	60.5	20.0	10.0
6	1.54	0.22	115.0	52.5	15.0	5.0
9	1.41	0.20	165.5	30.5	12.5	2.5
12	1.24	0.20	202.0	25.0	7.5	2.5
18	1.21	0.18	225.5	20.5	5.0	2.0
Soil medium						
2.00	1.49	0.57	150.0	30.5	25.0	22.5
6.75	1.10	0.45	305.0	26.0	22.5	22.5
10.75	0.86	0.41	325.0	18.0	15.0	12.5
17.75	0.59	0.32	350.0	11.5	10.5	5.0

Mineral nutrition — Amongst the nutrients studied, the uptake of nitrogen, phosphorus, potassium, calcium and magnesium regularly decreased while that of sodium increased with the increase of salt concentration (Table III). In sand culture, at the highest salinity N, P, K, Ca and Mg were decreased by 52.4, 49.0, 78.1, 75.0 and 84.0 per cent respectively and Na was increased upto 11 times that of the control.

The uptake of N, P, K, Ca and Mg from the soil media also decreased with the increase of salt concentration. At the highest salt concentration, N, P, K, Ca and Mg were decreased by 60.4, 44.7, 62.3, 58.0 and 77.8 per cent respectively, as compared to that grown on irrigation with the well water.

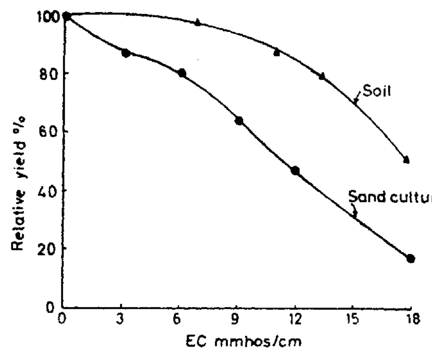

FIG. 1. Effect of growth media on the relative yield of cabbage in saline substrate.

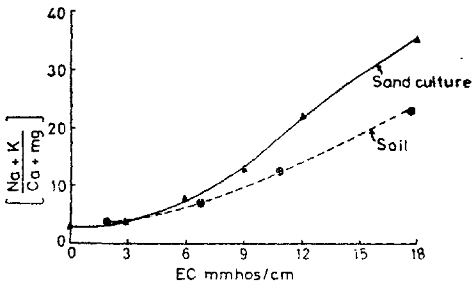

FIG. 2. Effect of cultural media on the uptake ratio of mono- and divalent cations by cabbage in relation to salinity.

DISCUSSION

The growth of cabbage decreases regularly with the increase of salt concentration and on the basis of statistical analysis it can be safely grown up to an EC value of 6 mmhos/cm in sand culture. However, on the sandy clay loam soil of Udaipur, its growth is satisfactory even on irrigating with saline water having a salinity of 108 meq/l, corresponding to an EC value of 10.75 mmhos/cm of the saturation extract. This variety appears to be more salt tolerant than reported by Richards (1954). Assuming the electrical conductivity of the saturation extract of the soil at par with EC of sand culture, a comparison of the relative yield on per cent basis of the control has been made which clearly shows (Fig. 1) that percentage reduction and rate of decrease in the yield of cabbage is less in soil medium than in the sand culture. Above an EC value of 6 mmhos/cm, there was 20 to 35 per cent more reduction in yield, in sand culture, than in the soil medium. It may, therefore, be concluded that, in general, yield of cabbage can be obtained 25 per cent more in soil media than that in sand culture at the same salinity level. Hence, it is not fair to use the same salt tolerance limit for field soils as obtained on the basis of sand culture experiments. A higher degree of salt tolerance in soil than that in sand culture may probably be due to the fact that in sand culture, the roots are fully surrounded by the salt solution and there is constantly the same osmotic stress, while in soil medium the soil particles act as mediators and there is less possibility of a direct osmotic stress. Consequently, there is more time lag between the supply and uptake of the nutrients at the root zone in the soil than in sand culture. Moreover, fluctuations in moisture content in soils cause less adverse effect of salt stress on the growth regulatory mechanism of the plant.

A comparison of the uptake of nutrients from the sand culture and soil medium reveals that uptake of phosphorus, calcium, magnesium and sodium is more from the soil medium than that from the sand culture. However, on the other hand, nitrogen and potassium are taken more from the sand culture than the soil. Low nitrogen status of salt affected soil and its reduced rate of mineralization are the main causes of low nitrogen uptake from the soil (Paliwal and Maliwal 1972). In case of potassium, its fixation in soil in addition to ion antagonism to sodium and calcium may be the cause for the low K uptake from the soil than sand culture. It may further be noted (Table III) that in spite of the same range of salt concentration, both in saturation extract of the soil and the sand culture, there is a higher degree of variation in the uptake of the individual ions at the highest salt concentration as compared to the control in sand culture than in soil medium, and it is worth to work out the mechanism of such a differential behaviour.

An appropriate ratio of mono- and divalent cations (Na+K/Ca+Mg), in equivalent, particularly in saline conditions, is essential for a satisfactory crop growth, and when such a ratio is upset in the plant, its effect is reflected in the form of reduced crop growth. A comparison of the mono- and divalent cation ratios in the plant at different salinity levels, both in sand culture and soil, reveals (Fig. 2) that in spite of higher uptake of Na by the plant grown in soil, there was lesser degree of variation in the ratio of Na+K/Ca+Mg in the plants, grown in soil than in sand culture throughout the salinity range. At low salinity levels upto an EC value of 5 mmhos/cm the ratio is nearly the same, but beyond this, it slowly increases and more so above 6 mmhos/cm in sand culture than in soil at the same salinity. Moreover, the rate of increase of cation ratio was less in soil than in sand culture. In addition to several other factors, better crop growth in soil than sand culture at the same salinity level appears to be related with a more favourable cation ratio in plants grown in soil than sand culture.

The nature of the growth medium of the plant appears to affect the nutrient absorption characteristics of the plant. Besides, the other favourable factors in soil, as lesser contact of salts to the roots, better aeration and fluctuation in salt concentration and ion exchange reactions between the exchange complex of soil and active surfaces of the plant roots tend to reduce cationic imbalance in the mineral nutrition of the plant system. Thus, relatively there is less imbalance in the relative cationic composition of the plant grown in soil than in sand culture. Hence, a better relative cationic composition of plant grown in soil medium than sand culture appears to be the main cause for better crop growth and higher salt tolerance in soil than in sand culture.

It may, therefore, be concluded that it is not appropriate to use the same salt tolerance limit for field conditions obtained on the basis of sand culture because at the same salinity level there was about 25 per cent more reduction in crop yield in sand culture than in soil.

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