Effect of Salts on the Growth, Mineral Nutrition and Quality of Brinjal (Solanum melongena)

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The accumulation of excessive amounts of soluble salts in soils is a characteristic of arid and sub-arid regions. Rainfall in these zones is inadequate to remove salts released by the weathering of rocks or initially present in the soil forming materials. Excess of soluble salts adversely affects the growth of crops by virtue of *a)* increased osmotic pressure of soil solution, *b)* poor physical condition of sodic soil and *c)* toxic concentration of any specific ion. Data on the effect of salts on plant growth have been reported by BERNSTEIN and HAYWARD [3], HAYWARD and BERNSTEIN [6] and BERNSTEIN [2].

Information on salt tolerance behaviour of vegetable crops and their mineral nutrition characteristics in saline conditions would be useful for making their choice for salt affected areas.

The present paper deals with the results obtained on the growth and quality of brinjal and the nutrient absorption behaviour by plant and fruit when irrigated with different quality waters.

Experimental

A greenhouse experiment was conducted to study the growth, mineral nutrition and quality of brinjal *(Solanum melongena)* var. "Purple Cluster" grown at five different levels of salinity (3, 6, 9, 12 and 18 mmhos/cm) in quartz sand. The solutions were prepared in half-Hoagland nutrient solution of the following composition (in me/l): KNO_3 — 2.5; $MgSO_4$ — 2; KH_2PO_4 — 1.5; $Ca(NO_3)_2$ — 5.0; and one me/l each of $CuSO_4$, $ZnSO_4$, H_3BO_3 and ferric citrate. 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 solution was run in triplicate. Six seeds of "Purple Cluster" variety of brinjal were sown in tin containers (23 cm ht. and 20 cm in diam.). After 10 days of germination, seedlings were thinned out and only four plants were kept till the harvest. The nutrient solution was replenished four times daily and was replaced by fresh one on every second day so that the desired E. C. could be maintained at the root zone throughout the growing period.

The chemical analysis of the plant and fruit was carried out for Na, K, N, P according to the standard procedures and for Ca and Mg by the modified

Table 1

Effect of salts on the growth of plant and fruit of brinjal crop

Salt concentration (mmhos/cm)	Plant			Fruit		
	Height, cm	Length of leaf, cm	Width of leaf, cm	Length, cm	Diameter, cm	Volume, ml
Control	34.2	14.2	11.9	9.1	11.1	25.4
3	24.2	10.2	8.2	8.6	9.7	19.1
6	22.6	8.2	6.5	7.2	9.0	14.3
9	20.5	8.0	6.3	7.0	8.8	11.5
12	20.0	6.6	6.2	5.7	7.7	9.5
18	17.3	5.6	5.0	5.5	6.7	7.5

method of DERDERIAN [4] using zirconium oxy-chloride octa-hydrate. Water soluble protein was analyzed by the method of LOWRY et al. [8], water soluble carbohydrate according to DUBOIS et al. [3] and reducing and non-reducing sugars by the A.O.A.C. method [1].

Results and discussion

Growth observations: The heigth of the plant, length and width of leaf and length, diameter and volume of fruit were recorded at the time of harvesting of the crop. All these data (Table 1) of plant and fruit decreased progressively with increasing salt concentration especially above the salt tolerance limit (E.C. 6 mmhos/cm) of this crop. At the highest level of salt concentration the decrease in height of plant, length and width of leaf, length, diameter and volume of fruit was 50 per cent or more as compared to the control. It was also observed that plants were stunted, thin, yellowish in colour with the increase in salt concentration and the crop had to be harvested earlier than the control at the highest salt concentration.

Table 2

Effect of salt concentration on the fruit, dry matter and root yield of brinjal (g/pot)

Yield	Salt concentration (mmhos/cm)					
	Control	3	6	9	12	18
Fruit	220.50	217.50	210.80	59.50	49.00	39.70
Dry matter	40.08	34.28	29.45	7.44	6.15	3.12
Root weight	14.93	12.75	12.60	3.34	1.39	1.29
C.D. at 1%	Fruit 10.89		Dry matter 11.77		Root weight 2.70	

Yield: The data on fruit, plant and root yields (Table 2) show that these decreased with increasing salt concentration. At the highest level of salt concentration (18 mmhos/cm) the fruit, dry matter and root yields were only 18.1, 7.8 and 8.6 per cent, respectively, as compared to the control.

Table 3

Effect of salt concentration on the uptake of nutrients by brinjal fruit

Salt concentration	N	P	Na	K	Ca	Mg
	%		me/100 g matter			
Control (1/2 Hoagland)	1.025	0.0615	55	345	45.45	25.50
3 mmhos/cm	0.962	0.0615	105	340	40.50	22.00
6 mmhos/cm	0.962	0.0525	145	325	35.75	19.50
9 mmhos/cm	0.862	0.0475	170	200	28.00	15.45
12 mmhos/cm	0.625	0.0315	195	125	20.45	12.75
18 mmhos/cm	0.540	0.0265	215	62	12.80	8.50

The statistical analysis carried out for fruit, dry matter and root yields shows that the "Purple Cluster" variety of brinjal can be successfully grown up to an E.C. value of 6 mmhos/cm of the nutrient solution. At E.C. values higher than that abrupt decrease in yields was observed.

Effect of salts on mineral nutrition

In addition to the conventional methods of judging the salt tolerance behaviour of crop plants on the basis of growth observations and yield data, it may be useful to examine the reduced crop growth in view of plant nutrition.

Analysis of fruit, plant and root revealed that the absorption of nutrients viz. N, P, Na, K, Ca, Mg was considerably affected by irrigating with brackish water.

Fruit: The absorption of N, P, Ca, Mg and K decreased with the increase in salt concentration while Na absorption increased (Table 3). The decrease in N, P, Ca, Mg and K was more above 6 mmhos/cm salt concentration, which is the salt tolerance limit of this crop. As compared to plant and root, fruit absorbs less Na and more of N, P, K, Ca and Mg.

Plant: The N, P, Na, K, Ca and Mg uptakes in plant are presented in Table 4. The absorption of N, P, K, Ca and Mg decreased with the increase

Table 4

Effect of salt concentration on the uptake of nutrients by brinjal plants

Salt concentration	N	P	Na	K	Ca	Mg
	%		me/100 g matter			
Control (1/2 Hoagland)	0.700	0.0350	90	245	50.45	30.25
3 mmhos/cm	0.675	0.0337	375	225	48.00	26.50
6 mmhos/cm	0.625	0.0325	410	210	40.50	22.00
9 mmhos/cm	0.537	0.0240	425	200	30.25	16.45
12 mmhos/cm	0.425	0.0240	465	150	25.00	12.50
18 mmhos/cm	0.315	0.0185	505	95	18.45	10.00

in salt concentration while that of Na increased. N and P range from 0.315 to 0.700 per cent and 0.0185 to 0.0350 per cent, respectively, while Na, K, Ca and Mg range from 90 to 505, 95 to 245, 18.45 to 50.45 and 10.00 to 30.25 me/l, respectively. At the highest salt concentration, the decrease in N and P is 50

per cent while in K, Ca, Mg it is 60 – 70 percent. The absorption of Na, K, Ca, Mg, N and P was more than in the root.

Root: The absorption of Na, K, Ca, Mg, N and P by the brinjal root is presented in Table 5. The uptake of N, P, Ca, Mg and K decreased with the increase in salt concentration while that of Na decreased as was observed in other portions of the plant. The uptake of all these nutrients is less than in the other parts of the crop while that of Na is more than in the fruit.

Effect of salts on the quality of crops

In order to examine how far the quality of brinjal is influenced by brackish water, the different fractions of protein and carbohydrate in plant and fruit were determined.

Protein: The total and water soluble protein in plant and fruit decreased with the increase in salt concentration (Fig. 1 and 2). The decrease in water soluble protein in fruit was abrupt at E.C. values higher than 6 mmhos/cm, which is the salt tolerance limit of this crop (Fig. 2).

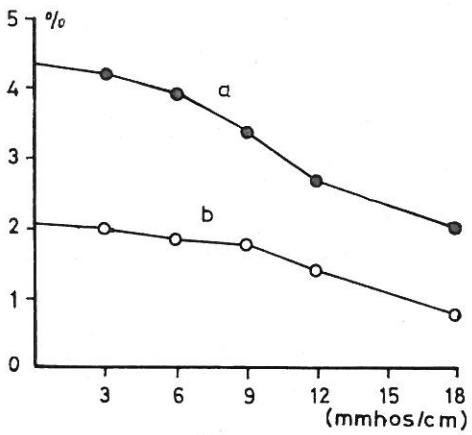

Fig. 1
Effect of salts on the synthesis of protein in brinjal plants. Ordinate: Protein content in per cent. *a)* Total protein. *b)* Water soluble protein

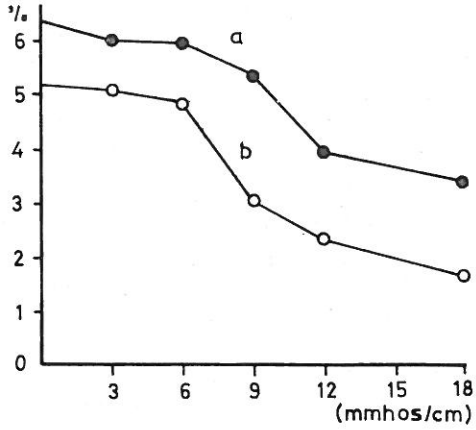

Fig. 2
Effect of salts on the synthesis of protein in brinjal fruit. *a)—b)* see Fig. 1

Carbohydrates: Data on the different fractions of carbohydrate (water soluble, reducible and non-reducible) reveal that the amount of these fractions decreased with the increase in salt concentration (Figs 3 and 4) in both plant and fruit.

The results presented above clearly reveal that dry matter and fruit yield decreased with the increase of salinity, especially beyond an E.C. value of 6 mmhos/cm. On the basis of fruit, dry matter and root yield, it may be concluded that brinjal could tolerate salts up to an E.C. of 6 mmhos/cm and may be taken as semitolerant of salts. Excessive amounts of salts appear to influence the physiological functions of the plant.

Table 5

Effect of salt concentration on the uptake of nutrients by brinjal roots

Salt concentration	N	P	Na	K	Ca	Mg
	%		me/100 g matter			
Control (1/2 Hoagland)	0.675	0.0350	34	110	30.50	20.50
3 mmhos/cm	0.506	0.0325	125	105	28.75	18.00
6 mmhos/cm	0.500	0.0290	210	105	22.50	15.45
9 mmhos/cm	0.487	0.0287	225	80	16.00	12.00
12 mmhos/cm	0.437	0.0215	235	56	12.45	8.00
18 mmhos/cm	0.375	0.0165	270	48	8.50	5.50

The absorption of nutrients and the quality of fruit were even more significantly influenced beyond the salt tolerance limit. This suggests that a certain critical quantity or a certain ratio of nutrient ions must be maintained for the normal function of the plant. The normal function can be maintained up

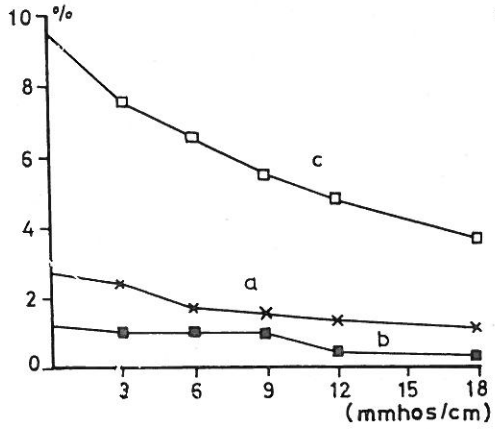

Fig. 3
Effect of salts on the synthesis of carbohydrates in brinjal plant. *a)* Reducing sugar as maltose. *b)* Non-reducing sugar as sucrose. *c)* Water soluble carbohydrate

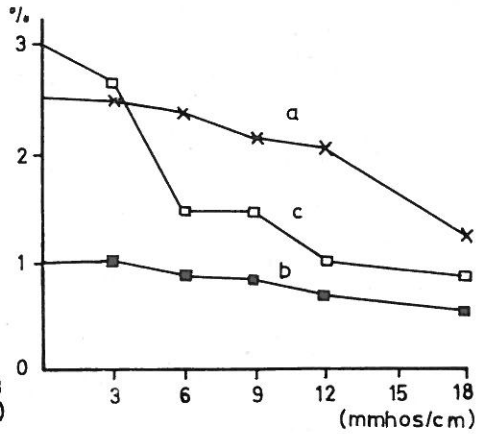

Fig. 4
Effect of salts on the synthesis of carbohydrates in brinjal fruit. *a)—c)* see Fig. 3

to the salt tolerance limit of the crop. The accumulation of sodium is greater in the leaf-stem portion of the plant than in root or fruit and may affect the metabolic activity of the plant. However, the uptake of N, P, Ca, Mg and K decreases while that of Na increases with the increase of salinity, as was reported earlier by MALIWAL and PALIWAL [9]. The carbohydrate and protein content also decreased with the increase in salinity as reported by SIEGEL et al [12], RAVIKOVITCH and YOLES [11].

The decrease in carbohydrate content may be due to the decrease in the absorption of Ca, Mg and K. Calcium ions have been reported to be cofactor for many enzymes in higher plants and for some enzyme involved in the hydrolysis of ATP and phospholipoids [13, 14]. Mg is required by a large num-

ber of enzymes involved in phosphate transfer particularly in carbohydrate metabolism [10]. K^+ deficiency could result in a block of pyruvate synthesis because K^+ is required for pyruvickinase or it could result in an inadequate energy supply attributable to insufficient carbohydrate metabolism. Thus these elements cannot be considered as the only causes of the decrease in carbohydrate content because it is also due to more utilization of its precursors for energy and/or less synthesis. Thus further work is needed with special reference to certain enzymes to establish the generality on carbohydrate synthesis. The decrease in protein content may be due to a reduced absorption of Ca^{2+}. Ca^{2+} is required for the binding of RNA to protein in chromosomes [7] and deficiency of it leads to the decrease in protein synthesis.

Summary

A greenhouse experiment was conducted in sand culture to study the effect of salts on the growth of plant and fruit, mineral nutrition and quality of brinjal *(Solanum melongena)*. Brinjal variety "Purple Cluster" could tolerate salts up to an electrical conductivity of 6 mmhos/cm. Beyond this limit the growth of plant, fruit and root was much more adversely affected. Absorption of nutrients (N, P, K, Ca and Mg) in fruit, plant and root decreased while that of Na increased with the increase of salinity.

The quality of crop — judged on the basis of the protein, carbohydrate, water soluble protein and carbohydrate, reducible and non-reducible carbohydrate contents — deteriorated with the increase of salinity.

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