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EFFECT OF SALINITY ON GROWTH AND MINERAL COMPOSITION OF CUCUMBER, SNAKE MELON AND PEANUT

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Abstract

Sand and gravel culture techniques were used to study the effect of irrigation with saline nutrient solution on dry matter yield and nutrient content of leaves and stems of cucumber, snake melon and peanut. Dry matter yield of cucumber and snake melon decreased at high salinity level. There was no effect of salinity upto 4000 ppm on the dry weight of peanut. Maximum fruit yield of snake melon was recorded at 2000 ppm salinity level while reproductive growth of cucumber and peanut was severely affected. Salinity caused accumulation of Na in leaf and stem of test plants where K, Ca, Mg, Fe and Mn significantly decreased with increasing salinity levels in all plant parts.

Introduction

Sandy deserts and barren lands constitute a great part of semi-arid and arid zone of the world. Good quality irrigation water is scarce in these areas and sub-soil water is generally brackish and contains an appreciable amount of soluble salts (Ahmed & Abdullah, 1979). In such areas hydroponic culture has proved an alternative for raising vegetables and other crops. In this system instead of soil, gravel or sand serves as the supporting medium and due to recycling of irrigation water there is a substantial saving on irrigation water. Sandy desert provides an excellent media for quick percolation of water from the root zone. The Thar desert of Sind could therefore be used for cultivation of crops, if the saline underground water is appropriately amended.

The present studies describes the effect of saline irrigation on the growth and nutrient contents of cucumber, snake melon and peanut raised in desert sand or gravel beds.

Materials and Methods

Tube-well water of the Atomic Energy Agriculture Centre Tandojam (Table 1) was amended to give nutritionally balanced irrigation water covering a range of salinity treatment from 1250 ppm to 4000 ppm total salts (Table 2). The salinity levels were achieved by the addition of NaCl and $NaHCO_3$ in suitable quantities and commercial grade salts were added to make a balanced nutrient solution.

Cucumber (*Cucumis sativa*), snake melon (*Cucumis melo*) and peanut (*Arachis hypogaea*) were sown directly in 11.36 sqm. beds filled with desert sand and gravel.

Table 1. Ionic composition of Centre's tube-well water (ppm)

Na^+	K^+	Ca^{++}	Mg^{++}	N	P	Cl^-	SO_4	HCO_3	$CO_3^=$	TSS	pH	SAR
98	10	116	40	2	1	85	295	145	Nil	745	7.6	2.39

Table 2. Ionic composition of nutrient solutions used (ppm)

Salinity levels in approx (ppm)	Na^+	N	P	K^+	Ca^{++}	Mg^{++}	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	SAR
Control	98	200	120	160	300	50	Nil	145	85	295	1.38
2000	290	200	120	160	300	50	-	245	386	540	4.07
3000	660	200	120	160	300	50		300	926	540	9.27
4000	1000	200	120	160	300	50	-	350	1390	540	14.04

Eight hills were maintained for each crop in each portion of the bed and each hill was considered as a replicate. The plants were supplied with normal Hoagland solution for the first 10 days and thereafter the beds were irrigated with the salinized nutrient solution stocked separately in four tanks. The gravel beds were irrigated daily while weekly irrigation was given to the beds of desert sand. Plants were regularly sprayed with 0.1% anthio to protect them against insects. pH of the nutrient solution was maintained between 6.5 and 7.0 using sulphuric acid. Vines of cucumber and snake melon were trailed on hanging cords during the growth period. From 5 plants, the third leaf was taken at 40 and 60 days of growth. The whole plant of snake melon and cucumber were harvested at 80 days and peanut at 108 days of growth and their dry weight determined. One plant from each bed was taken for analysis. Stems and leaves were separated, washed several times with distilled water and dried in an oven at 70°C.

A known portion of dried plant material was digested in a mixture of nitric, perchloric and sulphuric acid. Total P was determined colorimetrically (Jackson, 1958), nitrogen by micro-Kjeldahl method; Na, K and Ca by flame photometrically and Mg by EDTA-method (Jackson, 1958). Iron and Mn were determined colorimetrically using phenanthroline and periodate methods respectively (Jackson, 1958).

Results and Discussion

Salinity levels upto 4000 ppm did not affect the dry weight of cucumber and snake melon (Table 3) when grown in desert sand. However, salinity affected the dry matter yield of cucumber above 2000 ppm and of snake melon at all levels when grown in gravel. There was no effect of salinity upto 4000 ppm on the dry weight of peanut regardless of the media. The physical appearance of snake melon plant, upto 2000 ppm salinity, was healthy with thick stems and broad leaves, while at 4000 ppm salinity,

Table 3. Effect of salinity on the dry matter of cumumber, snake melon and peanut grown in desert sand and gravel (gm)

Salinity Levels (ppm)	Cucumber		Snake melon		Peanut	
	Desert sand	Gravel	Desert sand	Gravel	Desert sand	Gravel
Control	209.12	219.73	216.92	335.32	58.55	47.90
2000	330.60	239.76	307.74	290!15	78.91	78.92
3000	329.95	196.52	270.15	268.41	39.82	43.96
400	295.12	140.35	381.70	236.52	82.34	66.15
LSD 5%	13.09	7.83	6.97	12.33	2.05	1.76
1%	18.31	10.95	9.75	16.22	2.87	2.46

leaves were yellowish green in colour and with thin stem. There was no formation of fruit in cucumber and peanut plants in the salinized treatments while in the control plants only a few fruits were recorded.

Salinity at 2000 ppm enhanced fruit yield in snake melon but at higher salinity levels the fruit yield was reduced (Table 4) and the treatments differed significantly. There was no fruit formation in cucumber and peanut plants as their reproductive growth was adversely affected by salinity treatment.

Desert sand with its fine texture retained moisture and nutrients for a longer period whereas gravel caused rapid percolation of water. Plants grown in gravel apparently suffered from moisture stress which was further aggravated by increased salinity level. The decrease in growth due to salinization probably resulted from the increased toxicity of NaCl in the root media. The decrease in the growth of different plant species with increasing salinity has been reported (Hasan *et al.*, 1970; Maas *et al.*, 1972; Sonneveld & Voogt, 1978; Pakroo & Kashirad, 1981).

Table 4. Effect of salinity on the fruit yield of snake melon grown in desert sand and gravel

Salinity levels ppm	Yield kg/ha	
	Desert sand	Gravel
Control	20423ab	15714a
2000	23042a	16984a
3000	17301b	15873a
4000	12037c	8862b
LSD 1%	3105	1880

Considerable differences in the mineral content of leaves of the test plants at different salinity levels was observed (Tables 5–7). With increased NaCl and $NaHCO_3$ levels in the experimental solutions, the concentration of Na in the leaves and stems greatly increased irrespective of the growth medium. Lunin *et al.*, (1964) and El-Shourbagy & Missak (1975) with three varieties of castor bean, reported that sodium increased with saline irrigation. In our experiment the extent of Na accumulation with saline irrigation waters varied highest concentration of Na was found in cucumber plant followed by snake melon and peanut.

Total nitrogen content increased with increasing salinity levels in desert sand while it decreased in plants grown in gravel. The nitrogen content in the stems was unaffected at all salinity levels. Bernstein (1962) reported an increased N content of plants at higher

Table 5. Effect of salinity on the chemical composition of cucumber grown in desert sand.

Salinity levels (ppm)	Na	N	P	K	Ca	Mg	Fe	Mn
	% dry wt.						μg/g dry wt.	
40 days								
Control	0.10	2.37	0.32	3.63	4.56	0.138	3134	150
2000	0.21	3.76	0.60	2.78	2.64	0.071	3042	101
3000	0.31	5.04	0.61	2.96	3.63	0.066	2481	158
4000	0.59	2.97	0.57	2.78	3.64	0.005	2339	89
LSD 5%	0.05	0.13	0.04	0.09	0.17	0.007	68	16
LSD 1%	0.07	0.17	0.05	0.12	0.23	0.010	96	23
60 days								
Control	0.09	0.21	0.31	0.23	3.01	0.204	429	36
2000	0.20	4.37	0.45	2.26	2.57	0.173	658	58
3000	0.25	2.49	0.26	1.97	2.73	0.126	562	58
4000	0.32	2.33	0.29	1.64	3.25	0.116	493	58
LSD 5%	0.03	0.29	0.03	0.12	0.13	0.009	24	6
LSD 1%	0.04	0.40	0.05	0.17	0.18	0.013	34	9
80 days								
Whole leaf								
Control	0.09	1.70	0.08	2.11	3.11	0.122	1006	323
2000	0.18	1.86	0.10	2.41	3.88	0.094	2366	427
3000	0.31	2.32	0.10	2.00	2.97	0.052	2325	507
4000	0.38	1.78	0.12	2.75	2.91	0.048	1043	110
LSD 5%	0.03	0.15	0.016	0.20	2.91	0.048	151	29
LSD 1%	0.04	0.21	0.023	0.27	0.13	0.013	211	41
Stem								
Control	0.20	1.42	0.10	3.16	2.06	0.090	996	104
2000	0.81	1.20	0.18	4.61	3.39	0.034	980	101
3000	1.95	1.25	0.16	3.63	2.59	0.028	1152	136
4000	1.91	1.33	0.22	2.88	2.23	0.013	972	119
LSD 5%	0.10	NS	0.02	0.36	0.25	0.008	49	59
LSD 1%	0.14	NS	0.03	0.50	0.35	0.012	69	83

Table 6. Effect of Salinity on the chemical composition of snake melon grown in desert sand.

Salinity levels (ppm)	Na	N	P	K	Ca	Mg	Fe	Mn
	% dry wt.						μg/g dry wt.	
40 days								
Control	0.22	2.40	0.43	4.10	4.99	0.199	3829	153
2000	0.40	2.65	0.62	2.38	4.53	0.148	2507	100
3000	0.43	2.92	0.69	3.79	3.55	0.120	2170	62
4000	0.53	3.08	0.69	3.80	3.40	0.098	1665	65
LSD 5%	0.03	0.09	0.18	0.11	0.08	0.006	60	13
LSD 1%	0.04	0.13	NS	0.15	0.12	0.12	84	18
60 days								
Control	0.09	2.46	0.25	1.77	3.04	0.233	475	93
2000	0.34	4.49	0.39	3.19	3.40	0.148	659	60
3000	0.44	5.10	0.24	1.85	3.45	0.143	748	62
4000	0.50	2.58	0.25	2.63	3.16	0.128	475	77
LSD 5%	0.07	0.23	0.04	0.24	0.12	0.009	46	12
LSD 1%	0.10	0.32	0.06	0.34	0.17	0.012	65	17
80 days								
Whole leaf								
Control	0.28	1.87	0.17	1.81	2.63	0.112	1590	217
2000	0.42	3.18	0.19	2.58	3.61	0.066	1824	256
3000	0.61	2.33	0.31	2.12	2.70	0.062	1690	432
4000	1.02	2.25	0.26	4.11	2.91	0.052	1724	236
LSD 5%	0.05	0.18	0.02	0.12	0.19	0.019	257	20
LSD 1%	0.07	0.26	0.03	0.17	0.27	0.027	NS	28
Stem								
Control	0.15	1.17	0.12	2.84	2.45	0.101	937	218
2000	0.40	2.20	0.21	5.94	3.46	0.063	890	159
3000	0.89	1.33	0.19	6.01	3.05	0.050	654	220
4000	1.77	0.92	0.18	4.35	2.99	0.031	1018	152
LSD 5%	0.08	0.08	0.03	0.22	0.25	0.007	41	19
LSD 1%	0.11	0.11	0.04	0.31	0.34	0.011	57	27

levels of NaCl, while Shimose (1973), reported that salinity resulted in a reduction in N content in rice. Phosphorus content in test plants increased with increased salinity levels in both sand and gravel medium except at 60 days sampling when it decreased. A suppression in P uptake due to salt stress has been reported by Ravkovitch & Porath (1967). On the other hand Cooper & Dumbroff (1973) observed increase in P content due to salt stress. Leaf K content decreased with salinity irrespective of growth medium, and this is in agreement with results obtained by Kaddah & Ghowail (1964) with maize. Calcium content in test plants decreased due to salt treatment, which indicates a suppressing effect of Na on Ca uptake (Lessani & Marschner, 1978). Magnesium content also decreased with salinity in all test plants. Similar results have been reported in various other plants (El-Shourbagy & Missak, 1975).

Table 7. Effect of salinity on the chemical composition of peanut grown in desert sand.

Salinity levels (ppm)	Na	N	P	K	Ca	Mg	Fe	Mn
	% dry wt.						=μg/g dry wt.	
40 days								
Control	0.16	2.91	0.43	2.71	3.02	0.183	649	101
2000	0.23	3.13	0.44	2.38	2.48	0.105	505	49
3000	0.33	2.66	0.37	2.40	2.28	0.085	497	99
4000	0.37	3.14	0.36	2.13	2.33	0.064	496	52
LSD 5%	0.05	0.08	0.04	NS	0.10	0.009	32	10
LSD 1%	0.07	0.11	0.05	NS	0.14	0.012	44	15
60 days								
Control	0.09	1.65	0.27	1.80	2.52	0.338	654	87
2000	0.19	4.70	0.27	2.16	2.53	0.274	432	59
3000	0.41	4.50	0.17	3.68	2.49	0.195	429	58
4000	0.52	2.24	0.21	1.90	2.01	0.186	343	75
LSD 5%	0.05	0.06	0.04	0.28	0.08	0.015	19	7
LSD 1%	0.07	0.08	0.05	0.39	0.12	0.021	26	10
108 days								
Whole leaf								
Control	0.13	1.66	0.18	1.07	3.06	0.092	146	73
2000	0.21	1.84	0.29	1.91	3.04	0.068	492	38
3000	0.30	2.50	0.29	1.39	3.19	0.071	329	21
4000	0.38	1.67	0.24	1.29	2.83	0.060	428	38
LSD 5%	0.03	0.03	0.04	0.12	0.17	0.025	25	13
LSD 1%	0.04	0.05	0.06	0.17	0.24	NS	35	18
Stem								
Control	0.10	1.68	0.28	1.36	1.68	0.071	305	29
2000	0.20	1.29	0.26	1.86	2.65	0.056	416	17
3000	0.35	1.24	0.28	1.88	2.48	0.044	234	13
4000	0.40	1.26	0.27	1.37	2.99	0.030	485	8
LSD 5%	0.02	NS	NS	0.14	0.15	0.006	35	4
LSD 1%	0.03	NS	NS	0.20	0.21	0.008	49	6

Both Fe and Man contents decreased with increases salinity levels in all the analyzed portions of the test plants. Strogonov (1964) observed a decrease in Fe content due to NaCl salinity. Similarly Mass *et al.*, (1972) observed decrease in Mn content in tops of squash due to salinity treatment. On the other hand an increase in Fe and Mn in the tops of NaCl treated tomatoes, squash, soybean and pea has been reported (Mass *et al.*, 1972).

It would appear that the response of different plants to salinity depends on the degree of salt tolerance of these plants and the extent of salinization of the growth medium. Our studies have indicated that 2000 ppm salinity level had a stimulatory effect on the growth of snake melon and it could very well tolerate salinity level upto 3000 ppm. The salinity level of 4000 ppm reduced the growth regardless of the growth media.

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