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Salt Tolerance of Muskmelons as Affected by Various Salinities in Sand Culture[1]

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Summary

Muskmelons (*Cucumis melo* L.) were grown in sand to determine the salt tolerance as affected by salinization of sea water, NaCl, Na_2SO_4 and $MgCl_2$ in Experiment I, and $MgSO_4$ in Experiment II at osmotic potentials of −0.95 ($MgSO_4$ only), −1.20, −1.70 and −2.70 bars as compared to a control of −0.70 bars of base nutrient solution. Fruit fresh weight and whole plant dry weight were greatest in the control and decreased in each salinity with decreasing osmotic potentials of treatment solutions. At −2.70 bars fruit fresh weight in the control was 37.3, 31.4, 11.8, 24.8 and 17.0% in the sea water, NaCl, Na_2SO_4, $MgCl_2$ and $MgSO_4$ series, respectively. No plant died in the sea water and NaCl series. A few plants at −2.70 bars in the $MgCl_2$ series withered by harvest. All plants died within 60 days after transplanting at −2.70 bars in the Na_2SO_4 series and at −1.70 and −2.70 bars in the $MgSO_4$ series. The growth in decreasing order was control>sea water≒NaCl>$MgCl_2$> Na_2SO_4≒$MgSO_4$. The addition of single salts or sea water to the base nutrient solution increased the content of the respective added ions in leaves and soil solutions (SSa) and EC of SSa, and decreased osmotic potentials of SSa. Ca in leaves decreased in the Na_2SO_4, $MgCl_2$ and $MgSO_4$ series with decreasing osmotic potentials of treatment solutions. The result seemed to suggest specific effects of Mg and SO_4 ions on muskmelons.

Introduction

Salt tolerance of muskmelons (*Cucumis melo* L.) was studied, using sea water diluted with a base nutrient solution in sand, soil and nutrient solution cultures(10, 11). From this experiment(10) it was observed that the fruit fresh weight decreased with increasing sea water concentrations from 250 to 2,000 ppm Cl and that salt injury symptoms began to appear at 500 ppm Cl in sand culture. It has been considered(1, 13) that the primary cause was the low osmotic potential and the secondary cause was specific ion effects. However, in the previous experiments(10, 11) the salts in diluted sea water were mixtures of several cations and anions. It is difficult to ascertain the specific ion effects from a study of such mixtures. Therefore, the present study was conducted to determine the specific ion effect on the growth, salt injury symptoms, content of major elements in leaves and chemical properties of soil solutions (SSa).

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Materials and Methods

This study consisted of two experiments. Sea water, and single salts such as NaCl, Na_2SO_4 and $MgCl_2$, added to a base nutrient solution were used in Experiment I and $MgSO_4$ was used in Experiment II.

Experiment I Uniform muskmelon seedlings, cv. Spring No. 3 of Earl's Favourite in the 2.5 leaf stage were transplanted to wooden containers (40×40×20 cm) filled with Tenryu River sand and placed in the greenhouse, on April 11, 1977. There were 13 treatments, as shown in Table 1, consisting of control (base nutrient solution), and sea water, NaCl, Na_2SO_4 and $MgCl_2$ dissolved in the base nutrient solution at osmotic potentials of −0.50, −1.00 and −2.00 bars.

Table 1. Composition of treatment solutions and base nutrient solution.

Treatments No.	Salinities	π (bars)[z]	Added salt concentrations	EC (m℧/cm)
1.	Base nutr. soln.	−0.70	none	2.43
2.	Sea water[y]	−1.20	1.9%	3.45
3.		−1.70	3.8%	4.50
4.		−2.70	7.6%	6.60
5.	NaCl	−1.20	687 mgNaCl/l	3.38
6.		−1.70	1,374	4.65
7.		−2.70	2,748	7.05
8.	Na_2SO_4	−1.20	1,261 mgNa_2SO_4/l	3.66
9.		−1.70	2,521	5.18
10.		−2.70	5,042	8.08
11.	$MgCl_2$	−1.20	1,728 mg$MgCl_2 \cdot 6H_2O$/l	3.67
12.		−1.70	3,456	5.24
13.		−2.70	6,912	8.21

Composition of base nutrient solution		
1.	$Na_2HPO_4 \cdot 12H_2O$	1 mM
2.	K_2SO_4	3 mM
3.	$MgSO_4 \cdot 7H_2O$	2 mM
4.	$Ca(NO_3)_2 \cdot 4H_2O$	4 mM
5.	Fe	1 ppm (Fe-EDTA)
6.	Zn	0.05 ppm ($ZnSO_4 \cdot 7H_2O$)
7.	Cu	0.02 ppm ($CuSO_4 \cdot 5H_2O$)
8.	B	0.5 ppm (H_3BO_3)
9.	Mo	0.05 ppm ($Na_2MoO_4 \cdot 2H_2O$)
10.	Mn	0.5 ppm ($MnSO_4$)
	pH≒6.0	

[z] Osmotic potential. The π of treatment solutions includes −0.70 bars of base nutrient solution.

[y] Sea water contains 20,500 ppm Cl, 10,082 ppm Na, 2,632 ppm SO_4, 1,262 ppm Mg, 445 ppm K and 393 ppm Ca.

The osmotic potential of the base nutrient solution was −0.70 bars. The sea water was taken at Miho seaside. Each treatment had 5 replications, thus there was a total of 65 containers. Treatment solutions were applied to the sand medium from April 11 to harvest (late June). Applications (0.5 to 1 liter/container/time) were made twice on sunny

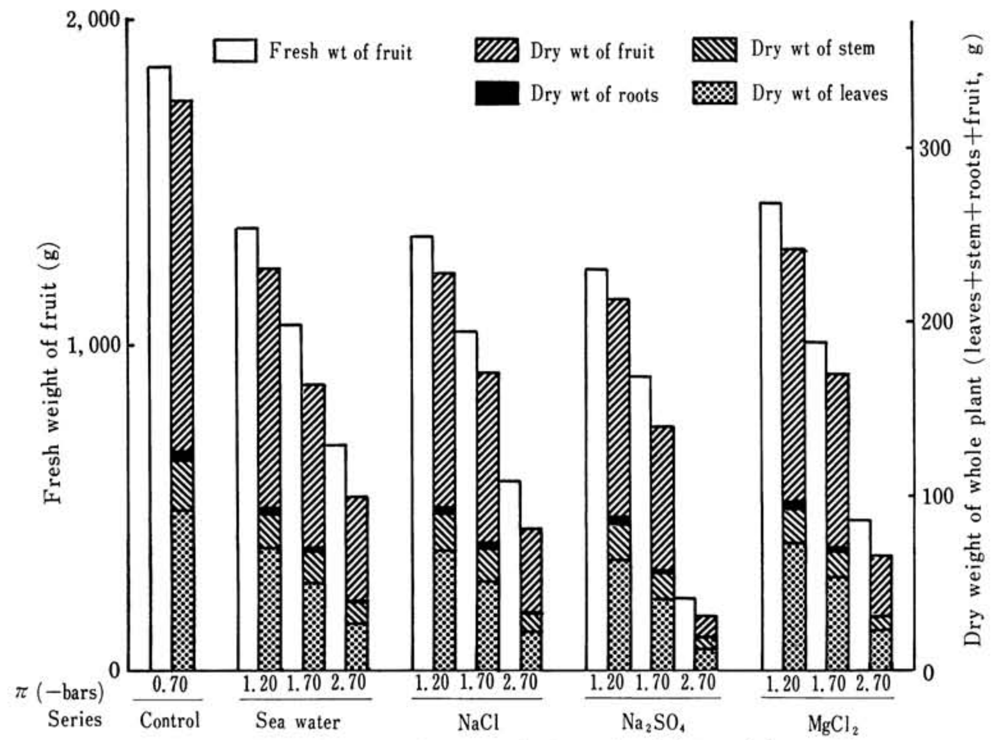

Fig. 1. Effect of various salinities on fresh weight of fruit and dry weight of whole plant (leaves+stem+roots+fruit). Figures below columns indicate osmotic potentials (−bars) of treatment solutions.

days, once on cloudy days and none on rainy days. At the end of the experiment, the fresh and dry weights of leaves, stem, roots and fruit were measured. SSa at pF 0 to 3.8 was extracted by the following method. Sand was put into a plastic tube (44 mm in diameter and 55 mm high) and then saturated with distilled water. After 24 hours the sand was centrifuged at 4,570 rpm for 30 min in a Marusan 9B-2 rotor. The other analytical methods on leaves, fruit and SSa were the same as described in an earlier paper(9).

Experiment II Uniform muskmelon seedlings, cv. Fall No. 1 of Earl's Favourite in the 2.5 leaf stage were transplanted to the wooden containers filled with Tenryu River sand and placed in the greenhouse, on Sept. 14, 1979. $MgSO_4$ was dissolved in the base nutrient solution at osmotic potentials of 0 (control), −0.25, −0.50, −1.00 and −2.00 bars. Treatment solutions, as shown in Table 6, were applied to the sand medium from Sept. 17 to harvest (early Dec.). The other experimental procedures, and methods of analyses on leaves and SSa were the same as in Experiment I.

Results

Experiment I

Growth and fruit quality (Fig. 1, Table 2) At the end of the experiment, the fruit fresh weight, and dry weight of the whole plant, leaves, stem and roots were greatest in the control and decreased significantly in each salinity as osmotic potentials decreased from −1.20 to −2.70 bars. At isosmotic concentrations except for −2.70 bars very similar suppression of the growth was observed in the sea water, NaCl and $MgCl_2$ series. However, the fresh weight of fruit and dry weight of the plant part were extremely less in the Na_2SO_4 series than in the other series. At −2.70 bars the fruit fresh weight expressed as percentage of the control (100%) was 37.3, 31.4 and 24.8% in the sea water, NaCl and $MgCl_2$ series, respectively, but was only 11.8% in the Na_2SO_4 series. Dry weight of the whole plant and leaves showed the same tendency. Soluble solids of fruit were significantly low at −1.70 and −2.70 bars in the Na_2SO_4 series and −2.70 bars in the $MgCl_2$ series. Fruit tastes reflected salt sources added to the base nutrient solution: saltness in the sea water and NaCl series; saltness, bitterness and astringency in the Na_2SO_4 series; and bitterness in the $MgCl_2$ series. Degrees of the tastes and scores of external appearance increased with decreasing osmotic potentials of treatment solutions as shown in Table 2.

Chlorosis and cupping of leaves were observed at −1.70 and −2.70 bars in the sea water and NaCl series. In the Na_2SO_4 series, at −1.20 bars marginal chlorosis appeared on the lower leaves, at −1.70 and −2.70 bars interveinal chlorosis was a typical symptom, and plants at −2.70 bars withered within 30 days after pollination. In the $MgCl_2$ series yellowish white spots appeared on lower leaves at the middle stage, and were observed on upper leaves at the late

Table 2. Effect of various salinities on fruit quality of muskmelons in sand culture.

Osmotic potential (bars)	Salinities			
	Sea water	NaCl	Na_2SO_4	$MgCl_2$
	Soluble solids (%)			
Control[y]	14.3abc[z]			
−1.20	15.0abc	14.5abc	15.2ab	15.7a
−1.70	14.4abc	14.6abc	13.6c	15.7a
−2.70	15.0abc	14.2bc	4.8e	10.8d
	Taste (degree[x])			
Control	0			
−1.20	1	1∼1.5	1	1.5
−1.70	2	3	2∼3	2∼2.5
−2.70	3∼4	4∼4.5	w	3∼4
	External appearance[v]			
Control	9.60a			
−1.20	9.04ab	7.50cd	8.26bc	9.38a
−1.70	5.86f	6.50ef	5.68f	6.80de
−2.70	1.74g	1.24gh	oi	0.62hi

z Mean separation in each item by Duncan's multiple range test, 5% level.

y Control does not contain any additional salts and is maintained at −0.70 bars of osmotic potential.

x The following tastes were evaluated from 0 (none) to 5 (very severe): saltness in sea water and NaCl; saltness, bitterness and astringency in Na_2SO_4; and bitterness in $MgCl_2$.

w Not evaluated because plants died before fruit maturation.

v Evaluated by net development and rind color. Full score=10.

Table 3-1. Effect of various salinities on Na, Mg, Cl and SO_4 content of leaves in sand culture (% of dry matter).

Osmotic potential (bars)	Salinities			
	Sea water	NaCl	Na_2SO_4	$MgCl_2$
	Na			
Control[y]	0.25fg[z]			
−1.20	0.38fg	0.59efg	0.85de	0.18g
−1.70	0.64ef	1.15d	1.90c	0.23fg
−2.70	1.63c	2.31b	3.48a	0.23fg
	Mg			
Conrtol	2.06e			
−1.20	2.07e	1.74f	2.04e	4.82c
−1.70	2.14e	1.53g	1.83f	5.57b
−2.70	2.36d	1.26h	1.37gh	6.50a
	Cl			
Control	0.50f			
−1.20	2.15de	2.35de	0.92ef	2.33de
−1.70	3.52cd	4.09c	0.37f	4.72c
−2.70	7.12b	7.13b	0.36f	10.23a
	SO_4			
Control	4.90d			
−1.20	4.38de	4.29de	6.95c	6.64c
−1.70	4.42de	2.85ef	10.25b	4.07de
−2.70	4.38de	2.12f	11.74a	3.36de

z,y Same as Table 2.

Table 3-2. Effect of various salinities on total-N, P, Ca and K content of leaves in sand culture (% of dry matter).

Osmotic potential (bars)	Salinities			
	Sea water	NaCl	Na_2SO_4	$MgCl_2$
	Total-N			
Control[y]	2.39ab[z]			
−1.20	2.25b	2.50a	2.29ab	2.22bc
−1.70	2.30ab	2.35ab	2.28ab	2.03c
−2.70	1.62d	1.62d	2.32ab	1.28e
	P			
Control	0.41abc			
−1.20	0.46a	0.45a	0.36bcde	0.46a
−1.70	0.38abcd	0.42ab	0.29ef	0.39abcd
−2.70	0.34bcdef	0.31def	0.33cdef	0.27f
	Ca			
Control	8.01a			
−1.20	7.47abc	7.83ab	7.01cd	6.59d
−1.70	7.26bc	8.08a	5.85e	5.75e
−2.70	7.02cd	7.89ab	4.87f	4.06g
	K			
Control	1.70cd			
−1.20	1.51cd	1.67cd	1.76cd	4.34a
−1.70	1.49cd	1.61cd	1.92cd	4.40a
−2.70	1.33d	1.32d	2.06c	3.78b

z,y Same as Table 2.

stage. A few plants withered at −2.70 bars in the $MgCl_2$ series by harvest.

Major elements in leaves (*Table 3*) Na, Mg, Cl and SO_4 content increased with decreasing osmotic potentials in their respective solutions. Na was highest in the Na_2SO_4 series (0.85 to 3.48%), less in the NaCl series (0.59 to 2.31%), and lowest in the sea water series (0.38 to 1.63%) in the sodium-salinity. Na in the $MgCl_2$ series (0.18 to 0.23%) was not different from Na in the control (0.25%). Mg was higher in the $MgCl_2$ series (4.82 to 6.50%) and lower in the NaCl (1.26 to 1.74%) and Na_2SO_4 (1.37 to 2.04%) series than in the control (2.06%). Cl was not significantly different at isosmotic potentials in chloride-salinity except for −2.70 bars in the $MgCl_2$ series. SO_4 was much higher in the Na_2SO_4 series (6.95 to 11.74%) and tended to decrease in the NaCl (4.29 to 2.12%) and $MgCl_2$ (6.64 to 3.36%) series with decreasing osmotic potentials of treatment solutions. Ca in the Na_2SO_4 (7.01 to 4.87%) and $MgCl_2$ (6.59 to 4.06%) series decreased with decreasing osmotic potentials of treatment solutions and was lower than that in the control (8.01%). K was higher in the $MgCl_2$ series (3.78 to 4.40%) than in the control (1.70%). There was no significant difference in K content between the control and sodium-salinity (1.32 to 2.06%).

Major elements in fruit (*Table 4*) Na, Mg and Cl content increased with decreasing osmotic potentials in their respective solutions. SO_4 was only a trace compared to other ions (data not shown). Ca was not significantly different among treatments except for −1.20 bars in the sea water. Variation of major elements except for Ca in fruit was similar to that in leaves, although the content was lower in fruit than leaves.

Chemical properties of SSa at the end of the experiment (*Table 5*) As osmotic potentials of treatment solutions decreased, Na, Mg, Cl and SO_4 concentrations tended to increase in sodium-, magnesium-, chlo-

Table 4. Effect of various salinities on Na, Mg, Cl and Ca content of fruit in sand culture (% of dry matter).

Osmotic potential (bars)	Salinities			
	Sea water	NaCl	Na_2SO_4	$MgCl_2$
		Na		
Control[y]	0.39g[z]			
−1.20	0.96f	1.01ef	1.13ef	0.30g
−1.70	1.34de	1.55cd	1.81c	0.28g
−2.70	1.71c	2.60b	3.51a	0.36g
		Mg		
Control	0.28de			
−1.20	0.29d	0.24de	0.22de	0.39c
−1.70	0.28de	0.21e	0.22de	0.47b
−2.70	0.26de	0.14f	0.23de	0.66a
		Cl		
Control	0.58e			
−1.20	1.76d	1.69d	0.59e	1.97d
−1.70	3.07c	3.22c	0.65e	3.11c
−2.70	3.56c	4.98b	0.78e	5.96a
		Ca		
Control	0.28b			
−1.20	0.67a	0.41b	0.25b	0.24b
−1.70	0.25b	0.30b	0.17b	0.23b
−2.70	0.30b	0.22b	0.37b	0.19b

z,y Same as Table 2.

Table 5-2. Chemical properties of soil solution (pF=0 to 3.8) at the end of the experiment.

Osmotic potential (bars)	Salinities			
	Sea water	NaCl	Na_2SO_4	$MgCl_2$
		EC(m℧/cm)		
Control[y]	5.27h[z]			
−1.20	6.95g	8.46ef	9.72bcd	7.97fg
−1.70	8.42ef	9.34cde	12.50a	9.73bcd
−2.70	9.38cde	10.34bc	10.76b	8.66def
		Osmotic potential (bars)[x]		
Control	−1.59			
−1.20	−2.38	−3.17	−3.36	−2.56
−1.70	−3.05	−3.29	−3.54	−3.05
−2.70	−3.54	−3.84	−3.29	−2.93
		pH		
Control	7.56ef			
−1.20	7.86abc	7.91ab	7.99a	7.86abc
−1.70	7.78bcde	7.93ab	7.71cde	7.42f
−2.70	7.62de	7.80abcd	7.58ef	7.40f

z,y Same as Table 2.

x Not subjected to statistical analysis.

Table 5-1. Chemical properties of soil solution (pF=0 to 3.8) at the end of the experiment.

Osmotic potential (bars)	Salinities			
	Sea water	NaCl	Na_2SO_4	$MgCl_2$
		Na(me/*l*)		
Control[y]	16.4h[z]			
−1.20	35.7g	54.0ef	76.3cd	11.5hi
−1.70	51.8f	66.8de	118.1a	8.4hi
−2.70	63.4e	85.2c	105.6b	5.2i
		Mg(me/*l*)		
Control	19.0d			
−1.20	17.5d	13.0de	13.2de	56.2c
−1.70	18.1d	9.1e	12.8de	80.3a
−2.70	17.3d	6.9e	7.1e	71.9b
		Cl(%)		
Control	0.016e			
−1.20	0.082d	0.107d	0.022e	0.216b
−1.70	0.134c	0.147cd	0.020e	0.332a
−2.70	0.193bc	0.249b	0.007e	0.314a
		SO_4(%)		
Control	0.18c			
−1.20	0.15d	0.19c	0.38b	0.15d
−1.70	0.14d	0.14d	0.43a	0.14de
−2.70	0.13de	0.11e	0.42a	0.04f

z,y Same as Table 2.

Table 5-3. Chemical properties of soil solution (pF=0 to 3.8) at the end of the experiment.

Osmotic potential (bars)	Salinities			
	Sea water	NaCl	Na_2SO_4	$MgCl_2$
		NO_3-N(ppm)		
Control[y]	33fg[z]			
−1.20	43def	55de	75c	57d
−1.70	27fg	36fg	131a	28fg
−2.70	20g	45def	94b	38ef
		P(ppm)		
Control	7.4bcd			
−1.20	8.4bc	7.2bcd	7.9bcd	8.4bc
−1.70	6.6cd	7.7bcd	6.1d	6.3d
−2.70	8.0bcd	10.7a	9.0ab	7.0bcd
		Ca(me/*l*)		
Control	15.3a			
−1.20	13.1b	12.5bc	12.1bc	13.0b
−1.70	11.3cd	10.3de	10.7de	12.6b
−2.70	9.9ef	9.1f	9.1f	9.1f
		K(me/*l*)		
Control	9.4ab			
−1.20	8.2bc	8.2bc	10.7a	8.0bc
−1.70	7.3c	7.5c	10.5a	7.4c
−2.70	8.4bc	7.5c	5.2d	4.7d

z,y Same as Table 2.

Table 6. Effect of $MgSO_4$ salinity on growth of muskmelons in sand culture.

Osmotic potential (bars)	Amount of added $MgSO_4 \cdot 7H_2O$ (mg/l)	EC (m℧/cm)	Dry weight (g)			Fruit	
			Leaves	Stem	Top plant	Fresh weight(g)	Soluble solids(%)
Control[z]	0	2.43	67.0a[y]	15.6a	203.8a	1,172a	13.8[x]
−0.95	1,922	3.20	53.0b	12.0b	161.0b	1,019b	14.1
−1.20	3,875	3.94	44.1c	11.5b	116.8c	797c	13.1
−1.70	7,750	5.52	40.1c	9.6b	74.0d	470d	[w]
−2.70	15,500	8.28	25.2d	6.3c	39.2e	199e	[w]

[z] Control does not contain any additional salts and is maintained at −0.70 bars of osmotic potential.
[y] Mean separation in columns by Duncan's multiple range test, 5% level.
[x] Not subjected to statistical analysis.
[w] Plants died before harvest.

Table 7. Effect of $MgSO_4$ salinity on major elements of muskmelon leaves (% of dry matter).

Osmotic potential (bars)	Total-N	P	K	Ca	Mg	Na	SO_4	Cl
Control[z]	2.95b[y]	0.65b	2.14a	4.21a	1.90d	0.13a	2.80b	0.37a
−0.95	2.95b	0.74ab	1.69ab	2.75b	4.45c	0.08b	5.42a	0.43a
−1.20	2.80b	0.84a	1.46b	1.87c	5.40a	0.10b	6.28a	0.44a
−1.70	4.03a	0.80a	1.21b	1.16d	5.12b	0.09b	5.86a	0.45a
−2.70	3.79a	0.84a	1.52b	0.60e	5.00b	0.09b	5.75a	0.67a

[z,y] Same as Table 6.

Table 8. Chemical properties of soil solution (pF=0 to 3.8) at the end of the experiment.

Osmotic potential (bars)	K (me/l)	Ca (me/l)	Mg (me/l)	Na (me/l)	SO_4 (%)	EC (m℧/cm)	pH
Control[z]	10.4a[y]	14.1a	8.4d	8.5a	0.15d	3.98c	7.40a
−0.95	10.1a	14.3a	33.8c	6.7ab	0.26c	5.44b	7.40a
−1.20	8.3a	13.2a	43.4c	5.8bc	0.38b	5.86b	7.15a
−1.70	5.8b	9.3a	56.8b	4.0cd	0.42b	6.18b	6.97a
−2.70	4.3b	8.4b	89.7a	3.5d	0.52a	7.16a	6.93a

[z,y] Same as Table 6.

ride- and sulfate-salinities, respectively. Na was relatively lower in the sea water series, higher in the NaCl series, and highest in the Na_2SO_4 series in the sodium-salinity. Cl was higher in the $MgCl_2$ series than in the sea water and NaCl series. EC values increased and osmotic potentials, pH and Ca decreased as osmotic potentials of treatment solutions decreased, EC values were similar at the isosmotic potential in each series, although they tended to be higher in the Na_2SO_4 series and relatively lower in the sea water series. NO_3-N and P were little affected by treatments except for NO_3-N in the Na_2SO_4 series.

Experiment II

Growth (*Table 6*) Dry weight of leaves, stem and plant top, and fruit fresh weight decreased with decreasing osmotic potentials of treatment solutions. The $MgSO_4$ symptom was first observed as an interveinal necrosis or necrotic spots on leaves, which expanded to the whole leaf as a necrosis. At −1.70 and −2.70 bars necrosis spread out over the plants. Thereafter, they withered by November 12, about 60 days after transplanting. The symptoms were observed even at −0.95 bars, and became much more severe as osmotic potentials of treatment solutions decreased.

Major elements in leaves (*Table 7*) Mg increased and SO_4 tended to increase up to −1.20 bars and Ca decreased with decreasing osmotic potentials of treatment solutions. Mg was lower at −1.70 and −2.70 bars than at −1.20 bars. Total-N was highest at −1.70 and −2.70 bars. K and Na were higher and P was lower in the control than the other treatments.

Chemical properties of SSa at the end

of the experiment (*Table 8*) Mg and SO_4 concentrations and EC values increased and Na tended to decrease with decreasing osmotic potentials of treatment solutions. Ca and K concentrations were low at relatively lower osmotic potentials of treatment solutions. Values of pH were not affected by treatments.

Discussion

Plants are known to respond to excess salts in the medium with growth depression, chlorosis or necrosis on leaves, decreased fruit quality and yield, and sometimes plant death. These responses may be due to osmotic stress caused by high salinity, or nutrient imbalance, or specific ion toxicity or a combination of these.

There have been many reports(2, 3, 4, 5, 6, 7, 8, 13) that different plant species and cultivars exhibit variable responses to isosmotic concentrations of different ions, such as chloride, sulfate, sodium and magnesium. It was observed(8) that sulfate salinity was more toxic to sugarcane than chloride salinity and the degree of toxicity of different ions in decreasing order was $SO_4 > Na > Cl > Mg$. Fisher(4) reported that the sulfate ion depressed both vegetative growth and fruit yield of tomatoes more than the chloride ion. Joolka *et al.* (7) found that the grape cultivars differed in their responses to Cl or SO_4 salts, 'Beauty Seedless' and 'Early Muscat' being relatively more tolerant to chloride-salinity, while 'Thompson Seedless' to sulfate-salinity. The greatly depressed growth of Red Kidney bean plants in the presence of $MgCl_2$ or $MgSO_4$, as compared to that in NaCl and Na_2SO_4, is attributed to the specific toxicity of Mg(5). Osawa(13) also reported that $MgCl_2$ was generally more toxic to spinach, turnip, celery, Welsh onion, kidney beans and chard than sea water salts and NaCl. Therefore, variable responses affected by various salinities need to be determined, even if the cause of reduced growth is primarily due to the osmotic effect(1, 13).

The comparison of muskmelon responses to various salinities, such as sodium- versus magnesium-salinity and chloride- versus sulfate-salinity, was made by using percentages of plant growth in Experiments I and II. The calculated osmotic potential of treatment solutions which caused a 50% loss in fruit fresh weight was −2.05, −1.95, −1.65, −1.85 and −1.52 bars, and the percentage of fruit fresh weight in the control (100%) at −2.70 bars was 37.3, 31.4, 11.8, 24.8 and 17.0% in the sea water, NaCl, Na_2SO_4, $MgCl_2$ and $MgSO_4$ series, respectively. Based on the above results and other observations the growth in decreasing order was control > sea water ≒ NaCl > $MgCl_2$ > Na_2SO_4 ≒ $MgSO_4$ series in sand culture. The Mg and SO_4 ions suppressed more severely the dry weight of leaves and stem, and the fresh weight of fruit than the Na and Cl ions, respectively, in the present experiment. This result in muskmelons did not agree with data from green soybeans, where Cl depressed the growth more than SO_4 and Mg did not show an adverse effect(12). This may be due to genetic difference, as observed by other investigators(2, 3, 13).

The addition of single salts or sea water to the base nutrient solutions resulted in increased content of the respective added cation and anion in leaves with concomitant reduction in one or more of the other ions. Ca was lower in the Na_2SO_4, $MgCl_2$ and $MgSO_4$ series than in the control and 88 to 61%, 82 to 51% and 44 to 14% at −1.20 to −2.70 bars in the respective series, but was little affected or not affected by the treatment in the sea water and NaCl series. Because muskmelons are a luxurious consumer of Ca, the decreased Ca absorption seemed to be highly correlated with poor growth and fruit quality. SO_4 was higher in the sulfate-salinity than in the control and 1.4 to 2.4 times and 2.2 to 2.1 times at −1.20 to −2.70 bars in the Na_2SO_4 and $MgSO_4$ series, respectively. Mg also increased in the magnesium-salinity. Therefore, increased Mg and SO_4 and decreased Ca absorption may be one of the causes which reduces growth more severely in the Na_2SO_4, $MgCl_2$ and $MgSO_4$ series than in the sea water and NaCl series. The result of the present experiment seemed to suggest specific ion effects of both Mg and

SO_4 ions on muskmelon growth when compared to Na and Cl ions.

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各種塩類が砂耕におけるメロンの耐塩性に及ぼす影響

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摘　要

メロンの耐塩性と塩の種類との関係を明らかにするため，砂耕により本実験を行った．実験Iでは，海水，NaCl，Na_2SO_4，$MgCl_2$ の塩類源を，実験IIでは，$MgSO_4$ を用いて，浸透ポテンシャルをそれぞれ −0.95 ($MgSO_4$ のみ)，−1.20，−1.70，−2.70bar とし，基本培養液で育てた対照区（−0.70bar）と生育を比較した．果実新鮮重と全植物体乾物重は対照区で最大となり，処理培養液の浸透ポテンシャルが低下するにつれて，それぞれの塩類源で減少した．対照区を100%とした場合，−2.70bar 区の果実新鮮重は海水で 37.3%，NaCl で 31.4%，Na_2SO_4 で 11.8%，$MgCl_2$ で 24.8%，$MgSO_4$ で 17.0% となった．海水と NaCl では枯死した株はなかったが，$MgCl_2$ では収穫時までに枯死する株もみられた．Na_2SO_4 の −2.70bar 区と $MgSO_4$ の −1.70，−2.70bar 区では，定植後60日までに全株が枯死した．本実験における生育は対照区で最大となり，以下海水≒NaCl>$MgCl_2$>Na_2SO_4≒$MgSO_4$ の順となった．基本培養液への各塩類源の添加は，それぞれ添加したイオンの葉中及び土壌溶液含量，土壌溶液の EC 値を増加させ，また土壌溶液の浸透ポテンシャルを低下させた．葉中 Ca 含量は，処理培養液の浸透ポテンシャルが低下するにつれて Na_2SO_4, $MgCl_2$, $MgSO_4$ で減少した．本実験の結果は，Mg と SO_4 イオンのメロンに対する特異作用を示唆した．