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SOURCES OF SALINITY TOLERANCE IN *LYCOPERSICON* SPECIES

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ABSTRACT

Irrigating 15-days-old 'VEN 8' tomato seedlings grown in a biotron at 24 C/21C (day/night) for one month with saline water measuring 15 mS/cm led to death of nearly 50% of the plants. This test was used in evaluating 106 *Lycopersicon* accessions of 7 species for salt tolerance. Based on death rate in wild accessions relative to tomato cvs control *L. esculentum* ssp. *cerasiforme* LA 1310 and *L. pimpinellifolium* LA 1579 and P.I. 365967 were rated as tolerant accessions of *L. pimpinellifolium*. *L. Hirsutum*, *L. peruvianum*, and *L. chmielewskii* were rated as relatively tolerant.

INTRODUCTION

Soil and irrigation water salinity is a serious problem affecting tomato (*Lycopersicon esculentum* Mill.) production in many parts of the world. including the United Arab Emirates. Evaluation for salinity tolerance in *Lycopersicon* species has been tried in the germination stage on agar containing 100 mM NaCl

(Jones, 1986) and in 0.85 % NaCl solution (Sinel'nikova et al., 1983). Others (Rush and Epstein, 1981a; Hassan and Desouki, 1986) selected for tolerance by irrigating tomato plants grown in sand culture with nutrient solutions in 50-75 % seawater.

Some *Lycopersicon* accessions were found to be relatively salt-tolerant including *L. esculentum* CVS 'Edkawy' (Hassan and Desouki, 1982; Mahmoud et al., 1986a, 1986b), 'Yusupovskii' and 'Karlik' (Sinel'nikova et al., 1983) and P.I. 17423; *L. esculentum* ssp. *cerasiforme* line CER 2022 (Anastasio et al., 1988), *L. pimpinellifolium* accessions PIM-2350, PIM-1135, PIM-85 and PIM-847 (Costa et al., 1989) and some accessions of *L. cheesmanii* and *L. pennellii* including *L. peruvianum* P.I. 12435, *L. cheesmanii* ssp. *minor* LA 1401 and *L. pennellii* P.I. 124502 and LA 716 (Dehan and Tal, 1978; Sacher, 1983; Tal and Shannon, 1983; Rush, 1986; Jones, 1986; Saranga et al; 1987). Criteria used for tolerance were faster (Jones, 1986) or higher Sinel'nikova et al., 1983) seed germination, vigorous and succulunet growth (Dehan and Tal, 1978; Hassan and Desouki, 1982; Tal and Shannon, 1983; Mahmoud et al., (1986b) and survival under saline conditions (Hassan and Desouki, 1986). However, *L. Cheesmanii* ssp. *minor* LA 1401 was found to be more sensitive to high salinity than tomato CVS (Hassan and Desouki, 1982; Mahmoud et al., 1986b), while CV. 'Heniz 1350' was as tolerant as *L. cheesmanii L. peruvianum* and *L. pennellii* at the intermediate salinity levels on the basis of relative decreases in vegetative dry weight with increased salinity (Shannon et al., 1987). Salinity tolerance was always associated with accumulation of Cl^- and Na^+ ions and reduction of K^+ ions in plant leaves (Dehan and Tal, 1978; Rush and Epstein, 1981b; Tal and Shannon, 1983; Mahmoud et al., 1986b; Rush, 1986; Saranga et al., 1987; Zamir and Tal, 1987).

The objectives of this study were: a) to develop an easy evaluation method for salinity tolerance in the seedling stage, and b) to use the developed method in screening for tolerance in 5 *Lycopersicon* species.

MATERIALS AND METHODS

The study was performed at the Agricultural Experimental Station of the Faculty of Agricultural Sciences , U.A.E. University in Al-Oha, near Al-Ain, U.A.E. Experiments were conducted under controlled conditions in a biotron (LH-200-RDCD). Plants were grown in jiffy pots (4x4x5 cm depth) filled with a potting compost. Temperature was maintained at 24 C for the first 2 weeks after seed sowing and at 24 C/21 C (12 hrs day/ 12 hrs night) thereafter.

Evaluation Method:

Ten tomato seeds of CV. VFN 8 were sown in each peat pot in November, 1987 and irrigated with tap water (EC= 0.57 MS/cm, pH = 7.9) for 2 weeks. Then, plants were thinned to 4/pot and saline treatments were applied for one month. Treatments were daily irrigated with about 20 ml/pot of saline water measuring 1,6,9,12 or 15 mS/cm. Each treatment was repeated in 4 pots. High salinity water (EC = ca. 100 mS/cm) was sampled at Ain Al-Faydah (near Al-Ain) and was diluted to each of the salinity levels used. Dead and withered (nearly dead) plants were counted every 10 days, and dry weight of plants which survived the saline treatments was measured at the end of the experiment. EC and pH of the saturation extract of the root media were measured after romoving plants. The experiment was repeated once more in February, 1988, but salinity levels used in irrigation water were changed to 1,12,15, or 18 mS/cm, and each treatment was applied to 5 pots, each containing 3 plants. Major cations and anions in irrigation water were also determined for the 15 mS/cm salinity treatment.

Screening of *Lycopersicon* species:

The evaluation method described above was used for screening 106 *Lycopersicon* accessions listed in Table (4). The list includes 9 tomato cultivars, 1 line of each of *L. esculentum* ssp, *cerasiforme*, *L. chmielewskii* and 10 of *L. peruvianum*. Seeds were kindly provided by local dealers for tomato cultivars, Dr. C.M. Rick, University of California, Davis for LA accessions, and the U.S.D.A. for the P.I. accessions. Acessions were evaluated in 5 tests performed in the biotron during the period from October, 1988 to June, 1989. Five jiffy pots were used for each entry. Seedlings were thinned 2 weeks after sowing to 2-5/pot. Irrigation with saline water (EC = 15 mS/cm) started after thinning and lasted for 1 month. Data were recorded on death rate every 10 days.

RESULTS AND DISCUSSION

Evaluation Method:

Table (1)shows the effect of salinity treatments in seedlings death rate and on dry weight of surviving seedlings. Increasing irrigation water salinity from EC 1 mS/cm (control treatment) to EC 6 mS/cm did not affect seedlings survival, though it caused 31.5% increase in seedlings dry weight. Further increases in slinity caused a gradual increase in seedlings death rate which reached about 50 % with 15 mS/cm treatment after the beginning of the salinity treatment. Increasing salinity of irrigation water to EC 15 mS/cm (as in the second test) was accompanied with a reduction of death rate to 33.3% . This inconistency in death rate is unexplainable. However, this treatment reduced seedlings dry weight to 77.3% of the control.

EC and pH of saturation extract of potting soil at the end of the salinity treatments are presented in Table (2). Salinity of the saturation extract coincided closely with salinity treatments. A slight reduction in pH (about 0.2-0 pH units) was observed with increasing salinity of irrigation water.

These results indicated that irrigating 15-days-old seedlings for 1 month with 15 mS/cm saline water could be used for identifying sensitive genotypes,

Table 1. Effect of salinity treaments on seedlings death rate and on dry weight of surviving seedlings.

ECiw of irrigation water (mS/cm)	No. of dead plants after[a,b] 10 days	20 days	30 days	% dead plants	Dry weight (mg/plant)
		First Test			
1 (Control)	0	0	0	0	20.0
6	0	0	0	0	26.3
9	0	1	1	6.3	20.0
12	0	3	3	18.8	20.0
15	5	7	8	50.0	15.0
		Second Test			
1 (Control)	0	0	0	0	23.3
12	1	2	2	13.3	26.9
15	1	4	7	46.7	23.8
18	4	5	5	33.3	18.0

[a] Each treatment was represented with 16 plants (4/pot) and 15 plants (3/pot) in the first and second tests, respectively.

[b] Number of days indicated are from the beginning of the aline treatment.

Table 2. EC and pH of the saturation extract of potting soil at the end of the saline treatments.

ECiw of irrigation water(mS/cm)	Saturation Extract	
	EC(mS/cm)	pH
First Test		
1	1.31	8.0
6	4.89	7.8
9	6.61	7.8
12	10. 9	7.7
15	12. 1	7.7
Second Test		
1	2.12	7.2
12	11.19	7.1
15	15.70	6.9
18	14.20	7.0

Table 3. Major cations and anions content of irrigation water used for screening for salinity tolerance (EC = 15 mS/cm).

Ion	Concentration (meq/l)
Cations:	
Ca^{++}	35.3
Mg^{++}	20.3
Na^{+}	98.9
K^{+}	1.7
Total	156.2
Anions:	
CO_3^{--}	0.5
HCO_3^{-}	0.9
Cl^{-}	156.4
SO_4^{--}	6.4
Total	164.1

which showed nearly 50% death rate. Hence, entries showing less than 50% death rate under similar conditions may be considered as relatively salt-tolerant. This procedure may be used in screening large collections of accessions in a small area and in a short time span as compared to other methods which involved older plants (Rush and Epstein, 1981a; Hassan and Desouki, 1982, 1986).

The first increase in dry weight of surviving plants with the increase in irrigation water salinity (Table 1) coincided with study growth induced by moderate salinity levels. Further increases in salinity gradually limited plant growth and coincided with reductions in dry weight at the high salinity levels. The relatively higher seedlings dry weiger in the second. test was probably due to the larger available space for their growth as they were grown 3 plants/pot as compared with 4/pot in the first test. The slight reduction of pH of the saturation extract with increasing salinity levels (Table 2) was probably due to the substitution of Ca^{++}, Mg^{++}, and Na^{+} ions present in high concentrations in irrigation water (Table 3) for H^{+} ions on peat humus.

Screening of *Lycopersicon* species.

Results of the evaluation tests are presented in Table(4). Seedlings death rate varied greatly (from 0.0% to 79%) among tomato cvs. Likewise, wide variations in death rate were also observed for the same cvs in various tests (e.g. 0.0% to 44% for each of cvs 'Monte Carlo' and Peto 98, and from 38% to 68% for cv. Zircon'. cultivar 'VFN8' showed 5% death rate in each of the third and fourth tests (Table 4), though it was consistent at nearly 50% death rate with the 15 mS/cm salinity treatment in experiments on the evaluation method (Table 1). This inconsistency in response to salinity is unexpected and unexplainable for the test was conducted under controlled conditions, and cvs used were either true-breeding or hybrids. Both types are presumably homogenous, non-segregating populations. Nevertheless, tomato

Table 4. Effect of irrigation with saline water (EC = 15 mS/cm) on seedlings death rate of Lycopersicon accessions evaluated.

Species and accession	Total no. of plants evaluated	No. of dead plants after[a] 10 days	20 days	30 days	% Dead plants
		First Test			
L. esculentum:					
Bornia (F_1)	23	3	4	8	35
Joaqium (F_1)	22	2	6	14	64
Peto 95	25	0	4	19	79
Primeur (F_1)	25	5	6	10	40
Turquesa (F_1)	25	7	12	19	76
Zircon (F_1)	21	1	1	8	38
L. esculentum ssp. cerasiforme:					
LA 1310	24	2	2	3	13
L. pimpinellifolium:					
LA 373	21	7	9	12	57
LA 1579	20	0	1	6	30
P.I. 306216	25	14	20	21	84
P.I. 309907	25	2	4	14	44
P.I. 313943	25	12	12	16	64
P.I. 340905	25	12	20	21	84
P.I. 344102	25	10	12	16	64
P.I. 344103	25	13	14	16	64
P.I. 346340	25	13	15	18	72
P.I. 365909	23	8	8	15	65

(Continued)

Table 4. Continued

Species and accession	Total no. of plants evaluated	No. of dead plants after[a] 10 days	20 days	30 days	% Dead plants
		First Test (Continued)			
L. hirsutum:					
LA 1361	14	6	6	9	64
L. pennellii:					
LA 716	14	7	9	11	79
		Second Test			
L. esculentum:					
Peto 98	25	1	1	3	12
L. pimpinellifolium:					
P.I. 365915	10	1	4	6	60
P.I. 365916	14	0	1	5	36
P.I. 365917	15	3	9	11	73
P.I. 365957	25	0	6	13	52
P.I. 365958	22	0	6	9	41
P.I. 365959	25	0	1	3	12
P.I. 365960	23	0	6	12	52
P.I. 365961	20	1	9	11	55
P.I. 365962	15	0	3	4	27
P.I. 365963	21	4	12	16	76
P.I. 365964	23	18	23	23	100
P.I. 365965	13	0	8	10	77
P.I. 365967	25	0	0	0	0
P.I. 375937	19	0	1	3	16
P.I. 379019	25	9	20	23	92
P.I. 379020	25	17	18	20	80

(Continued)

Table 4. Continued.

Species and accession	Total no. of plants evaluated	No. of dead plants after[a] 10 days	20 days	30 days	% Dead plants
		Second Test (continued)			
L. pimpinellifolium (continued):					
P.I. 379021	14	5	12	12	86
P.I. 379022	25	1	9	11	44
P.I. 379023	24	0	4	5	21
P.I. 379024	22	1	5	7	32
P.I. 379025	20	0	2	4	20
		Third Test			
L. esculentum:					
Monte Carlo (F_1)	25	0	2	11	44
Peto 98	16	0	1	7	44
VFN 8	22	0	1	1	5
Zircon (F_1)	25	0	2	17	68
L. pimpinellifolium:					
P.I. 379028	22	0	7	15	68
P.I. 379057	12	1	5	10	83
P.I. 379058	25	2	10	19	76
P.I. 379059	25	2	12	20	80
P.I. 390688	25	12	23	23	92
P.I. 390689	25	1	8	18	72
P.I. 390690	25	3	7	17	68
P.I. 390691	25	3	12	18	72
P.I. 390692	25	4	12	22	88
P.I. 390693	25	2	14	20	80
P.I. 390694	12	1	7	9	75

(Continued)

Table 4. Continued

Species and accession	Total no. of plants evaluated	No. of dead plants after[a] 10 days	20 days	30 days	% Dead plants
		Third Test (Continued)			
L. pimpinellifolium (Continued):					
P.I. 390695	24	3	11	19	79
P.I. 390696	25	5	18	23	92
P.I. 390697	25	1	12	19	76
P.I. 390698	15	0	6	12	80
P.I. 390699	22	2	8	19	86
P.I. 390700	25	13	22	25	100
P.I. 390703	10	3	7	10	100
P.I. 390706	12	0	10	12	100
P.I. 390707	23	14	21	23	100
P.I. 390708	14	3	12	14	100
P.I. 390709	19	10	16	19	100
		Fourth Test			
L. esculentum:					
Monte Carlo (F_1)	25	0	0	0	0
Peto 98	23	0	1	1	4
VFN 8	22	0	1	1	5
L. pimpinellifolium:					
P.I. 390711	20	9	11	14	70
P.I. 390712	16	8	12	13	81
P.I. 390713	12	2	7	10	83
P.I. 390715	17	3	5	7	41
P.I. 390716	14	0	1	2	14
P.I. 390718	15	7	10	11	73

(Continued)

Table 4. Continued

Species and accession	Total no. of plants evaluated	No. of dead plants after[a] 10 days	20 days	30 days	% Dead plants
		Fourth Test (Continued)			
L. pimpinellifolium (Continued):					
P.I. 390721	13	4	8	11	85
P.I. 390723	16	10	16	16	100
P.I. 390724	22	12	15	16	73
P.I. 390725	19	4	7	11	58
P.I. 390727	24	1	5	6	25
P.I. 390729	23	2	10	17	74
P.I. 390730	22	1	6	14	64
P.I. 390731	17	2	4	8	47
P.I. 390732	16	4	7	9	56
P.I. 390735	19	3	11	15	79
P.I. 390737	17	2	9	11	65
		Fifth Test			
L. esculentum:					
Monte Carlo (F_1)	20	0	0	0	0
Peto 98	25	0	0	0	0
L. hirsutum:					
P.I. 308182	25	17	20	23	92
P.I. 365903 (f. glabratum)	15	5	6	7	47
P.I. 365904	25	9	12	19	76
P.I. 365905	22	4	8	11	50
P.I. 365906	16	3	5	12	75
P.I. 365907 (f. glabratum)	25	0	0	3	12
P.I. 365908	21	10	3	10	48

(Continued)

Table 4. Continued

Species and accession	Total no. of plants evaluated	No. of dead plants after[a] 10 days	20 days	30 days	% Dead plants
		Fifth Test (Continued)			
L. hirsutum (Continued):					
P.I. 365934	21	1	3	5	24
P.I. 365936	15	2	5	8	53
P.I. 379010	23	5	10	16	70
P.I. 379013	18	2	5	12	67
L. peruvianum:					
P.I. 303814	25	4	4	12	48
P.I. 306811	19	2	3	4	21
P.I. 308183	24	0	0	9	38
P.I. 326173	19	2	4	11	58
P.I. 365938	24	6	14	20	83
P.I. 365939	24	7	18	18	75
P.I. 365945	16	7	10	11	69
P.I. 365947	23	6	17	21	91
P.I. 365948	19	3	8	10	53
P.I. 365950	20	6	6	7	35
L. chmielewskii:					
P.I. 379030	16	1	1	3	19
L. parviflorum:					
P.I. 379031	24	0	2	8	33
P.I. 379033	17	2	3	7	41

[a]Number of days indicated are from the beginning of the salinity treatment.

cultivars performance in individual tests may provide preliminary indication of the relative tolerance of other accessions evaluated with them in the same tests.

When examining data obtained for each screening test separately (Table 1), the following accessions may be considered as salt-tolerant: first test: *L. esculentum* ssp.*cerasiforme* LA 1310 and *L. pimpinellifolium* LA 1579; second test *L. pimpinellifolium* P.I. 364967: third to fifth tests:none.Additionally, the following accessions were relatively tolerant as their death rate was generally low; *L. pimpinellifolium* P.I. 309907 (first test). P.I. 365959 P.I. 375937, P.I. 379023, P.I. 379025 (second test); and P.I. 390716 (fourth test); *L. hirsuthum* P.I. 365907 and P.I. 365934 (fifth test); *L. peruvianum* P.I. 306811 (fifth test) and *L. chmielewskii* P.I. 379030 (fifth test). To our knowledge none of the above-listed accessions has been previously reported as salt-tolerant.

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