Pak. Jour. Agri. Sci.
24 (1) 56, 1987

SCREENING OF SOME CITRUS ROOTSTOCKS IN RESPONSE TO SALINITY

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The tolerance of seedings of six citrus rootstocks was measured at four salinity levels (control, 75, 150, 210 mm of NaCl).

Plant survival decreased with increasing salinity for all rootstocks. Leaf shedding and decrease in fresh and dry weight of roots and shoots also occured. The overall performance of Yuma citrange and Bitter sweet orange was better than the others.

Different rootstocks showed different trends in uptake of sodium and chloride. Yuma citrange accumulated significantly less chloride whereas Jatti khatti and Jamberi khati accumulated significantly higher chloride than other rootstocks.

INTRODUCTION

Salinity and waterlogging are posing a serious threat to agriculure in Pakistan where approximately 5.86 million hectares of the cultivable land are salt affected (Muhammad, 1983). This problem must be overcome through the reclamation of the salt-affected soils or by finding some salt tolerant species/ varieties.

Citrus is the most important winter fruit in Pakistan and is cultivated over an area of 144,200 hectares with an annual production of 1,373 metric tonnes (Akhtar, 1985). Failure of citrus in many parts of the country is apparently caused by soil salinization.

Most of the citrus fruits are found to be salt sensivive but varietal differences in this respect have been reported (Martin *et al.* 1953; and Ream and Furr, 1968, 1976). Joolka and Singh (1980) found Cleopatra mandarin and Rangpur lime to be salt tolerant and and Bhadri lemon and Jatti khati to be susceptible to salinity.

Salinity affects the leaf composition of plants differently and this may be related to their salt tolerance. Pearson *et al.* (1957) concluded that increasing levels of salinity decreasad the concentration of potassium in the leaves while of Jones *et al.* (1952 aod 1957) found that Na application increased leaf sodium level and redueed total growth of citrus rootstocks. Ayub and Minesary (1974) observed that increased salt levels reduced the vegetative growth and increased defoliation, as well as increasing the accumulation of Na, Cl, Ca and N levels in the leaves but not levels of P, K. and Mg. Douglas and Walker (1983) and Walker and Douglas (1983) grew various citrus rootstocks at at different Nacl concentrations and found that Rangpur lime was a better Cl excluderthan others. Grieve and Walker (1983) observed that Cleopatra mandarin and Rangpur lime accumulated significantly less chloride than rough lemon and *Poncirus trifoliata*. They also concluded that differences in chloride accumulation of different rootstocks were not related to vigour. Hayyim and Koch (1984) suggested that the toxic effect of NaCl in sweet orange was due to accumulation of chloride.

The response of various citrus rootstocks to different levels of salinity, and their tolerance is discussed in this paper. This information may be helpful to breeders for breeding salt tolerant rootstock varieties and horticulturist to extend citrus plantation to some salt-affected areas.

MATERIALS AND METHODS

The studies were conducted in the Depatment of Horticulture, University of Agriculture, Faisalabad, Pakistan during 1984-85. The following six citrus rootstocks were studied :

1. Jhatti khatti (*Citrus jambhiri* Lush.)
2. Volkamariana (*Citrus limon* Burm. (f.)
3. Red rough lemon (*Citrus jambhiri* Lush.)
4. Yuma citrange (*Poncirus trifoliata* x *Citrus sinensis*)
5. Jamberi khati (*Citrus jambhiri* Lush.)
6. Bitter sweet orange (*Citrus aurantium* Linn.)

About 3 months old seedlings of each rootstock (whose height and leaf number had been measured) were transferred to each of four plastic tubs containing 15 litters of specific nutrient medium as prepared according to Hoagland and Arnon (1950). Plastic foam was used for stuffing in the holes and hold the seedlings in the thermopol sheet floating on the medium to keep the seedlings (upright). The nutrient solution was aerated gently using an air compressor for 10 hours a day.

The plants were allowed to grow in this condition for two days. The salt concentration was then increased in a stepwise manner on every other day to final concentrations of 75, 150, 210 mM NaCl while Hoagland medium served as control. Commercial grade NaCl was used to make up the required salinity levels. Salinity levels were maintained througout the experiment and pH of the solution was kept between 6.0 and 6.5.

The plants were harvested 25 days after transplanting and the plant survival rate, plant height, average number of leaves, leaf area, fresh and dry weight of shoots (stem and leaves) and roots, were measured.

The experiment was laid out according to the Split Plot Design with three replications and four treatments having five plants per experimental unit of six rootstocks.

Leaf samples were dried in an oven at 60°C for chemical analysis. Determination of Na, K and Cl was undertaken as follows:

Oven dried ground plant samples (0.25 g) were taken in glass test tubes to which 1 ml of 1 N HNO was added and heated at 100°C in heating blocks. After about 15 minutes 6 ml of distilled water was added to each test tube. The test tubes were again heated for another 20 minutes, followed by shaking on the whirlimixer for one minute. The plant material was then transferred to plastic centrifuge tubes and centrifuged at 3000 rpm for 10 minutes. The solution was decanted into 50 ml volumetric flasks. The process was repeated three times after adding 6 ml of distilled water every time, and the combined extracts made to 50 ml. Na and K were determined in the extract with a Petracourt PFP-1 flame photmeter. Chloride was analysed with a Corning Chloride Analyzer 925.

The data were subjected to Analysis of Variance and individual comparisons among treatments were made according to Duncan's Multiple Range Test at 5% probability level (Duncan, 1955).

RESULTS AND DISCUSSION

Plant survival, plant height, number of leaves and leaf area.

The data in Table 1 show that the plant survival decreased from 100% (control) with increase in substrate salinity levels. The mean survival was dec-

Table 1 : *Effect of different sodium chloride concentration on plant survival plant height (% increase in height/plant as compared to control), change in number of leaves and leaf area (% reduction compared to control) of various citrus rootstocks.*

Root Stocks	Plant survival percentage				Plant height			
	Control	75mM	150mM	210mM	Control 0mM	75mM	150mM	210mM
Jatti Khatti	100	93.3	46.6	26.6	0.92	68.5	38.0	54.34
Volkamariana	100	80.0	60.0	46.6	1.77	56.44	50.4	43.58
Red rough lemon	100	100	60.0	33.3	1.57	54.8	43.3	44.6
Yuma citrange	100	100	80.0	86.6	0.81	90.1	87.7	76.54
Jamberi Khatti	100	93.3	46.6	46.6	1.02	73.5	39.2	38.3
Bitter sweet orang	100	100	80.0	53.3	0.66	95.5	78.8	81.8
Mean		94.4	62.2	48.8		73.12	56.23	56.18

	Number of leaves						Leaf area	
	Control In.	Control Fin.	Control In/dec.	75mM	150mM	210mM	Control Sq.cm.	Overall % reduction
Jatti Khatti	6.86	8.20	1.40	—2.2	—3.0	—3.83	94.7	58.93
Volkamariana	4.93	6.00	1.07	—0.44	—1.6	—1.57	82 3	67.20
Red rough lemon	6.26	7.40	1.14	—0.66	—2.34	—4.00	102.3	52.35
Yuma citrange	5.4	6.80	1.40	+0.13	—0.96	—0.60	62.3	43.88
Jamberi Khatti	5.8	7.06	1.27	—0.88	—3.92	—2.67	93.3	59.37
Bitter sweet orange	5.73	6.73	1.00	+0.67	—1.59	—1.33	106.0	44.87
								54.43

reased to about 50% at 210mM NaCl. Different rootstocks responded differently under various levels of salinity. At 210 mM NaCl Yuma citrange had the maximum survival (86.6%), followed by Bitter sweet orange (53.2% survival), while Jatti Khati (26.6%) and Red rough lemon (33.3%) had the lowest survival.

The height of citrus plants seems to be quite sensitive to salinity and even the lowest salinity level reduced growth for all the root stocks. In general, the mean relative increase in height was similar at 150 and 210 mM NaCl i. e. 56% as compared with control.

The reduction of plant growth by sility was also reported by Walker and Douglas (1983), and may be caused by the disturbed water relations of plants through osmotic effect of the added salts (Bernstein, 1963).

Leaf sheeding in response to salinity was minimum in Bitter sweet orange and Yuma citrange and showed a slight increase in the number of leaves at the lowest salinity level (75mM NaCl. Other rootstocks started showing decrease in number of leaves at this salinity level (75mM NaCl external salinity). Red rough lemon showed maximum reduction in the number of leaves followed by Jatti Khati Jamberi Khati, Volkameriana and Bitter sweet orange where mean reduction in number of leaves per plant was 3.83, 2.67, 1.57, 1.33 respectively. Yuma citrange showed the minimum decrease in number of leaves .60 per plant at 210mM NaCl Defoliation in response to salinity has also been reported by Ayub and Minessary (1974) and Cherif *et al.* (1982) in citrus. It appears that most of the salts are accumulated in older leaves which ultimately died and were shed. This may be considered an adaptive mechanism against high substrate salinity so that the young leaves are kept relatively free of salts. Varietal differences were also obvious with respect to leaf area reduction in response to salinity with minimum overal reduction in the case of Yuma citrange (43.88%) and maximum in Volkamariana (67.20%). Considering the effect of salinity on various growth parameters of citrus rootstocks, these values show that wide differences exist among various rootstocks with respect to salt tolerance, and that Yuma citrange and Bitter sweet orange are the most tolerant of the 6 rootstocks tested in this study.

Fresh and dry weight of shoots and roots

The data showing the effect of salinity on fresh weight of shoots are presented in Table 2. Analysis of various revealed that the effect of salinity is

Table 2. *Effect of salinity on freash and dry weight of shoots (steem and leaves)*

Root Stock	Control	NaCl concentrations			Overall percent	Overall percent
	Aontveel fresh Weight (g)	Fresh Weight percent of control			Reduction in fresh wt. (Means)	Reduction in dry wt. (Means)
		75mM	150mM	210mM		
Jatti Khatti	2.67bc	55.8ab	41.1bc	25.8a	59.1	56.6
Volkamariana	2.32ab	49.5a	38.3a	25.8a	62.2	55.89
Red rough lemon	3.24d	85.8c	42.5c	16.9a	51.6	54.18
Yuma Citrange	2.17a	79.2b	52.0bc	63.5b	34.8	19.78
Jamberi Khatti	2.71c	63.8b	43.3a	26.1a	55.6	55.81
Bitter sweet orange	3.15cd	97.7c	34.6bc	31.4ab	45.5	44.35

Table 3. *Effect of salinity on Sodium and Chloride content of leaves (Na%) Cl meq/100 gm.*

Root Stocks	Control	NaCl concentrations			Control	Cl contents NaCl concentrations		
		75mM	150mM	210mM		75mM	150mM	210mM
Jatti Khati	0.55bc	2.20c	2.06a	2.13a	25	150	100	150
Volkamariana	0.29a	2.52d	2.46b	2.70b	20	100	125	125
Red rough lemon	0.34ab	1.90a	2.40b	2.95c	30	75	100	150
Yum Citrange	0.58bc	1.94ab	1.98a	2.38a	35	50	75	100
Jamberi Khati	0.41ab	2.16bc	2.40b	2.38a	20	100	125	175
Bitter sweet orange	0.80bc	2,54b	3.45c	3.12c	35	75	125	120
Mean	.498a	2.21ab	2.459bc	2.611c	27.5a	91.66b	108.33c	137.50b
Variety Mean :	4_4 1,72ba	V_1 1.737a	V_5 1.840a	V_3 1.900ab	V_2 1.90ab	V_6 2.478c		

highly significant for individual treatments. It is obvious from the data that with the increasing the salinity levels the fresh weight of shoots among the tested rootstocks decreased. Varietal differences in the fresh weight of shoots among the tested rootstocks are evident from the data. At low salinity (75mM NaCl) Bitter sweet orange gave 97.7% fresh weight yield as compared with control, followed by Red rough lemon with 85.8% yield, while Volkamariana gave significantly lower yield at this level than all other rootstocks.

The dry weight yield pattern was similar to the fresh weight yields. The pattern of reduction in fresh weight yield of shoots was related to retarded seedling growth burning and defoliation of leaves (See Table 1) as was also noted by Jones *et al.* (1957) Ream and Furr (1968) and Cherif *et al.* (1982) in various citrus fruits. The fresh and dry weight of roots showed similar pattern to shoots.

Uptake of Na and Cl by various rootstocks

Difference in uptake of Cl by various rootstocks of Citrus has been related to their relative salt tolerance (Grieve and Walker, 1983). Such differences reflect the specific toxicity of Cl to Citrus. Plant leaves of rootstocks included in the study showed important differences in respect of Cl and Na accumulation (Table 3). The pattern of differences, however, changed with the level of substrate salinity. Never-the-less, Yuma citrange which was clearly the most tolerant rootstock showed the minimum Cl accumulation at all the salinity levels, and reflect a better control on Cl uptake at the root cell membrane level or subsequent transport to the shoot. Similarly, Bitter sweet orange also showed somewhat better control over Cl uptake, while Jatti Khati and Jambiri Khati were poor discriminators in this respect. However, the pattern was not as clear in the case of of Na uptake and might have been masked/obsured because of relative selectivity of the rootstocks for other cations such as K which may compete with Na for absorption sites.

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