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Effect of Soil Salinity on the Performance of Some Citrus Rootstocks at Seedling Stage

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Abstract: As salinity level of the soil was increased (EC_e 1.65 – 8.0 dS m^{-1}), survival percentage, plant height and number of leaves per plant were progressively decreased and toxicity symptoms (tip burning and defoliation) became more pronounced. The performance of Cleopatra mandarin was better at all the EC_e levels. Troyer citrange was the most affected rootstock while Red rough lemon, Bitter sweet orange and Volkameriana in the middle.

Key words: Citrus, rootstocks, salt tolerance, survival, salt toxicity

Introduction

Citrus fruits are the most important among fruit crops of Pakistan and grown on an area of 196.1 thousand hectares with a total annual production of 2037 thousand tones (Anonymous, 1998). Selection of suitable rootstocks in citrus has a vital importance as every aspect of a citrus tree, such as growth, longevity, performance, salt tolerance, diseases resistance, frost hardiness, fruit quality etc. are influenced by the rootstocks. Citrus rootstocks vary considerably in their tolerance to the salts present in soil. Grieve and Walker (1983) reported that the most salt-tolerant rootstocks included Cleopatra mandarin, Rangpur lime, followed by sweet orange, Carrizo citrange and Troyer citrange. Salt tolerance was lowest with trifoliate orange. Hassan and Galal (1989) found after a greenhouse study that the relative salt tolerance increased in the following order: Cleopatra mandarin, sour orange, *Citrus amblycarpa, C. volkameriana* and Rangpur lime. Salem and El-Khorieby (1989) reported that seedling growth was progressively depressed by all salt levels but the degree of growth suppression varied with the salt type. Cleopatra mandarin was the least affected rootstock and rough lemon and Troyer citrange were the most affected, with sour orange occupying an intermediate position. While, Srivastava *et al.* (1998) rated trifoliate orange and Cleopatra mandarin more salt-tolerant than Rangpur lime and rough lemon. The results of the previous studies are confusing. Moreover, most of the researchers have used water with various salts in different concentrations for irrigation instead of soil salinity. Therefore, the present investigations were planned to evaluate different available citrus rootstocks to soil salinity, so that these can be used in various regions with different salinity levels after evaluating their compatibility and performance for different scion cultivars.

Materials and Methods

Healthy and medium sized fruits of the following rootstocks were collected from Horticultural Research Station, Sahiwal and used for the present studies.

1 Red rough lemon (*Citrus limonia*)
2 Bitter sweet orange (*Citrus aurantium*)
3 Volkameriana (*Citrus volkameriana*)
4 Cleopatra mandarin (*Citrus reshni*)
5 Troyer citrange (*Poncirus trifoliata* x *Citrus sinensis*)

The seeds were extracted from the fruits at Horticultural Lab., University College of Agriculture, Bahauddin Zakariya University, Multan. Soil was thoroughly prepared by mixing well-rotted farm yard manure and silt in a lath house. Raised beds, 20 cm high and 2 meter in length were prepared at a distance of 1 meter. The seeds were treated with a fungicide (Tri-Miltox Forte) as a protection against seed-borne diseases and sown in rows on these beds. Water was applied immediately after sowing with a sprinkler. The beds were kept moist till the completion of germination by applying water regularly. When the plants were six months old, 20 seedlings of each rootstock with uniform height were transferred into plastic pots. The pots (30 cm deep and 30 cm diameter) were filled with plough layer, air-dried, passed through a 2 mm sieve and thoroughly mixed soil. Physico-chemical characteristics of the soil used are listed in Table 1.

Table 1: Physico-chemical characteristics of the soil used

Characteristics	Unit	Quantity
Textural class	-	Loam
Soil saturation	%	42.0
Electrical conductivity of the saturation extract (EC_e)	dS m^{-1}	1.65
pH of the saturation extract	-	8.2
Organic matter	%	0.83
P_2O_5	mg kg^{-1}	7.0
K_2O	mg kg^{-1}	125
CO_3^{--}	meq L^{-1}	Nil
HCO_3^-	meq L^{-1}	6.50
Cl^-	meq L^{-1}	4.90
SO_4^{--} (by difference)	meq L^{-1}	5.10
Ca^{++} + Mg^{++}	meq L^{-1}	10.40
Na^+	meq L^{-1}	1.80
K^+	meq L^{-1}	4.30

The soil used to fill the pots was salinized artificially by mixing Na_2SO_4, $CaCl_2$, NaCl and $MgSO_4$ in the ratio of 9:5:5:1, respectively (Ahmad *et al.*, 1995) to obtain various salinity levels (EC_e) of 4.00, 6.00 and 8.00 dS m^{-1} at 25°C. Normal soil (EC_e 1.65 dS m^{-1}) was used as control.

The pots were irrigated with canal water throughout the study period to keep the soil moisture near field capacity. The following responses were recorded after six months of transplanting in pots to evaluate the performance of these rootstocks under the mentioned levels of soil salinity.

1 Survival of seedlings (%)
2 Plant height (cm)
3 Number of leaves per plant
4 Toxicity symptoms (tip burning and defoliation)

Results and Discussion

Survival of seedlings: After six months of transplanting,

highest survival %age was recorded in control (95 to 100), followed by EC_e 4.0 dS m^{-1} (85 to 95). At EC_e 6.0 and 8.0 dS m^{-1}, it ranged from 55 to 75 and 25 to 65%, respectively, depending upon the rootstocks (Table 2). Results indicated that as the EC_e increased, survival percentage decreased. Qasim *et al.* (1992) have already reported that plant mortality generally increases with increase in substrate salinity level.
Highest survival percentage was recorded in Cleopatra mandarin, even at th highest EC_e level. This was followed by Bitter sweet orange rootstock. The performance of Red rough lemon and Volkameriana was intermediate, while the performance of Troyer citrange was the poorest in terms of survival percentage, recorded only 25% after six months of transplanting (Table 2). The rootstocks differed in survival percentage showing their response to salinity. This could be due to their genetic make. Several workers have already reported that the Cleopatra mandarin is a salt-tolerant and Troyer citrange is a salt sensitive citrus species (Banuls *et al.*, 1991; Bar *et al.*, 1996; 1997).

Table 2: Survival %age, growth of seedlings and toxicity symptoms appeared on the seedlings of various citrus rootstocks after six month of transplanting in pots containing soil with various levels of salinity

Rootstock used	EC_e (dS m^{-1})			
	Control	4.00	6.00	8.00
Survival %age				
Red rough lemon	100.00	80.00	60.00	35.00
Bitter sweet orange	100.00	90.00	70.00	40.00
Volkameriana	95.00	85.00	60.00	35.00
Cleopatra mandarin	100.00	95.00	75.00	65.00
Troyer citrange	100.00	85.00	55.00	25.00
Plant height (cm)				
Red rough lemon	37.0	31.4	23.6	19.4
Bitter sweet orange	35.4	33.2	23.1	20.3
Volkameriana	34.1	30.3	24.2	20.1
Cleopatra mandarin	32.3	30.9	28.7	27.9
Troyer citrange	33.7	27.7	23.8	18.0
Number of leaves per plant				
Red rough lemon	27.5	21.1	15.9	10.1
Bitter sweet orange	25.8	20.9	15.5	11.3
Volkameriana	24.0	19.8	15.1	12.1
Cleopatra mandarin	24.0	22.9	19.3	17.9
Troyer citrange	24.9	17.8	13.2	6.3
Toxicity symptoms				
Red rough lemon	-	-	+ x	+ x
Bitter sweet orange	-	-	+	+ x
Volkameriana	-	-	+ x	+ x
Cleopatra mandarin	-	-	-	x
Troyer citrange	-	-	+ x	+ x

- No symptom, + Tip burning, x Defoliation

Plant height: As salinity level of the soil was increased, growth of the seedlings in terms of plant height was decreased but its magnitude depended on the rootstock. Maximum plant height was recorded in seedlings transplanted in control or normal soil. This was followed by the seedlings in soil with EC_e 4.0 and 6.0 dS m^{-1}. While, seedlings transplanting in soil with EC_e 8.0 dS m^{-1} attained minimum plant height (Table 2). This was probably due to the adverse effects of salts present in the soil. Rate of increase in plant height decreased as the salinity level increased. Bieloria *et al.* (1988) has reported retardation of growth of main branches and root development by highest salinity levels in Shamouti orange trees grafted on a sweet lime rootstock and grown under various salinity levels. Similar results were reported by Dasberg *et al.* (1991) and Gracia-Lindon *et al.* (1998).

The rootstocks also differed in their response to salinity. At the highest level of salinity (EC_e of 8.0 dS m^{-1}), seedlings of Cleopatra mandarin performed better as compare to other rootstocks, despite the fact that its performance was not so good in nursery and the seedlings were dwarf in normal soil (control). After six months of transplanting, seedlings of Cleopatra mandarin were the tallest. The performance of Troyer citrange was poor resulting in the lowest plant height. While, all other rootstocks enjoyed intermediate position. At an EC_e of 6.0 dS m^{-1}, seedlings of Cleopatra mandarin also performed better as compared to other rootstocks and attained maximum plant height, while all other rootstocks behaved almost alike to this level of soil salinity. At an EC_e of 4.0 dS m^{-1}, the performance of the seedlings of all the rootstocks was similar, although their height was affected (Table 2). At higher EC_e, only salt-tolerant rootstocks gave better results than salt-sensitive ones. Higher salinity level causes more osmotic potential, which reduces the ability of plant roots to export water. Water taken up by the plants is relatively free of salts. The plants have to spend more extra energy to extract water from the saline solution, resulting in poor turgor pressure. Therefore, in addition to osmotic effects and inhibitory effects of high concentrations of Cl^- and Na^+, imbalance of essential nutrients may also contribute to the reduction in plant growth under saline conditions (Bar *et al.*, 1997). Boman (1993) recorded more growth on Cleopatra mandarin and the least on sour orange, when irrigated with waters having various EC_{iw} levels.

Number of leaves per plant: Maximum number of leaves per plant was recorded in plants growing in normal soil (control). Leaf number was decreased at EC_e 4.0 dS m^{-1} and as the EC_e increased, it was further decreased. At higher EC_e levels (6.0 and 8.0 dS m^{-1}), the effects of salts were more pronounced in plants resulting in lower leaf number (Table 2).
As far as rootstocks are concerned, leaf number differed in the rootstocks transplanted in normal soil (control) due to their growth rate and genetic make-up. At EC_e 4.0 dS m^{-1}, leaf number was lower in all the rootstocks as compared to control. Growth performance of the rootstocks differed at higher EC_e levels and their leaf numbers were reduced due to defoliation, showing toxic effects of salinity on plant growth. The performance of Cleopatra mandarin was better on all the EC_e levels with more retention of leaves and increase in leaf number due to further growth. While the performance of Troyer citrange was the poorest among the rootstocks studied with lowest number of leaves per plant (Table 2). As the plant height was low, leaf number was also low. The effects were more pronounced at highest EC_e levels, indicating the adverse effect of salts present in the soil.

Visual toxicity symptoms: After six months of transplanting, defoliation was recorded at EC_e 6.0 dS m^{-1} in Red rough lemon, Volameriana, and Troyer citrange and tip burning in Red rough lemon, Bitter sweet orange, Volkameriana, and Troyer citrange. At the highest EC_e (8.0 dS m^{-1}), plants of all the rootstocks resulted in defoliation and tip burning except Cleopatra mandarin plants where no tip burning was noticed (Table 2). In citrus damage caused by salinity is mostly due to accumulation of excessive concentrations of Na^+ and Cl^- ions in shoot tissues (Sykes, 1992). Dasberg *et al.* (1991) have also recorded relatively more leaf shedding in salinized citrus trees as compared to the control ones. Banuls and Primo-Millo (1995) recorded decrease in growth and defoliation in citrus plants grown at increasing levels of NaCl in external medium. Therefore, the results of present study are in conformity with previous workers.

As for as the rootstocks are concerned, Cleopatra mandarin showed higher level of salt tolerance as the plants did not show any sign of tip burning at EC_e 8.0 dS m^{-1}, and both defoliation and tip burning at EC_e 6.0 dS m^{-1} (Table 2). According to Storev and Walker (1999) salt damage in citrus is usually manifested as leaf burn and defoliation and is associated with accumulation of toxic levels of Na^+ and/or Cl^- in leaf cells. The greater salt resistance of rootstocks such as Rangpur lime and Cleopatra mandarin is due to their capacity to limit the accumulation of Cl^- in leaves.

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