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# Evaluation of Citrus Rootstocks for Salinity Tolerance at Seedling Stage

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## ABSTRACT

Citrus rootstocks i.e. Jatti khatti (*Citrus jambhiri*), Jambheri khatti (*C. jambhiri*), Gada dehi (*C. aurantium*), Kharna khatta (*C. karna*), Cleopatra mandarin (*C. reshni*) and Yuma citrange (*Poncirus trifoliata x C. sinensis*) were evaluated for salinity tolerance by transplanting their six months old seedlings in an artificially salinized soil. Four salinity levels i.e. 2.0, 4.0, 6.0 and 8.0 dS $m^{-1}$, were developed by mixing $Na_2SO_4$, $CaCl_2$, NaCl and $MgSO_4$ salts in the soil. Normal soil having $EC_e$ 1.65 dS $m^{-1}$ was also included in the experiment as control. All the rootstocks gave good survival (>85 %), seedling height (>32 cm) and number of leaves (>24) in control soil and the soil with $EC_e$ 2.0 dS $m^{-1}$. All these parameters were depressed with further increase in soil salinity. At $EC_e$ 8.0 dS $m^{-1}$, Cleopatra mandarin and Gada dehi resulted in higher seedling survival (more than 60%) as compared to other rootstocks studied. Similarly more plant height, higher number of leaves and minimum toxicity symptoms (tip burning and defoliation of leaves) were recorded in these rootstocks at the highest $EC_e$ level. Results divulged that Cleopatra mandarin and Gada dehi proved to be the most tolerant, while Kharna khatta was the least tolerant one and Jatti khatti, Jambheri khatti and Yuma citrange were moderately salt tolerant.

**Key Words:** Citrus; Rootstocks; Soil salinity; Salt toxicity

## INTRODUCTION

Soil salinity threatens crop production, particularly in irrigated areas of arid and semi-arid regions. According to an estimate about 6.3 million hectares of land in Pakistan is salt-affected (Khan, 1993) and is thus unsuitable for normal crop production. Salinity adversely affects plant growth by decreasing the availability of soil water to the plant and due to the inhibitory effects of major ions contributing to salinity, which also become toxic at high concentrations (Suarez & Lebron, 1993). In addition to these, an imbalance of essential nutrients may also contribute to the reduction in plant growth under saline conditions (Ruiz *et al.*, 1997). In this situation, selection and evaluation of salt tolerant cultivars seems to be the pertinent alternative in conjunction with the normal reclamation and management practices.

Citrus ranks among salt sensitive fruit plants (Bielorai *et al.*, 1988; Alva & Syvertsen, 1991). In Pakistan, it is grown on an area of 196.1 thousand hectares with total production of 2037 thousand tonnes annually (Anonymous, 1998). Its yield is not up to the mark as compared with other countries. Among several factors, soil salinity may be the major citrus yield constraint in the country. Boaz (1978) reported that the soil salinity for 0 and 50% reduction in yield of oranges and grapefruit were 1.7 to 1.8 and 4.8 to 4.9 dS $m^{-1}$, respectively. Literature indicates that salt tolerance varies among citrus rootstocks (Munir *et al.*, 1999). Significant work has been conducted abroad to select citrus rootstocks that could be grown satisfactorily on salt-affected soils (Grieve & Walker, 1983; Hassan & Galal, 1989; Cerda *et al.*, 1990; Srivastava *et al.*, 1998). Quantitative data concerning the effects of salts on the performance of citrus rootstocks is lacking in Pakistan, which necessitates evaluating the salt tolerance of different citrus species. The aim of the present study was to determine differences in salt tolerance of some promising local citrus rootstocks for appraising their suitability for using as rootstocks in the salt-affected soils.

## MATERIALS AND METHODS

The experiment was conducted at University College of Agriculture, Bahauddin Zakariya University, Multan during 1998-99. Healthy and medium sized fruits of six rootstocks were kindly supplied by the Horticulturist, Horticultural Research Station, Sahiwal. The rootstocks used were:

1. Jatti khatti (*Citrus jambhiri*)
2. Jambheri khatti (*C. jambhiri*)
3. Gada dehi (*C. aurantium*)
4. Kharna khatta (*C. karna*)
5. Cleopatra mandarin (*C. reshni*)
6. Yuma citrange (*Poncirus trifoliata* x *C. sinensis*).

The seeds were extracted from the fruits of these rootstocks, washed, air-dried in shade and sown in a lath house to raise nursery. Soil was thoroughly prepared by mixing well-rotted farmyard manure and silt in the soil. Raised beds, 2 m long and 20 cm high, were prepared at a distance of 1 m. Seeds were sown in lines on these raised beds. The water was applied immediately after sowing the seeds with a sprinkler. The beds were kept moist till completion of the germination by applying water regularly.
Bulk volume of soil was collected form plough layer from the University College of Agriculture Experimental Farm. The soil was air-dried, ground, passed through a 2 mm sieve and thoroughly mixed. Chemical analysis revealed that the soil was non-saline and non-sodic before the start of

experimentation (Table I). Four salinity levels (2.0, 4.0, 6.0 and 8.0 dS $m^{-1}$) were developed by mixing the calculated amounts of $Na_2SO_4$, $CaCl_2$, NaCl and $MgSO_4$ salts to the soil in 9:5:5:1 ratio (Ahmad *et al.*, 1995). Normal soil (without added salts) having $EC_e$ 1.65 dS $m^{-1}$ was included as a control in the experiment. Plastic pots, closed at the bottom to protect leaching, were filled with 10 kg soil for each treatment. There were five pots in each treatment for each rootstock. When seedlings were six months old, these were uprooted from the nursery and transferred to the pots. Four seedlings were transplanted in each pot. The pots were irrigated regularly with canal water throughout study period to keep the soil moisture near field capacity. The seedlings were grown for a period of six months and following responses were recorded; survival of seedlings (%), plant height (cm), number of leaves plant$^{-1}$ and toxicity symptoms i.e. tip burning and defoliation.

**Table I. Physico-chemical characteristics of the soil**

| No. | Characteristics | Unit | Quantity |
|---|---|---|---|
| 1 | Textural class | - | Loam |
| 2 | Soil saturation | % | 42.0 |
| 3 | Elect. cond. of saturation extract ($EC_e$) | dS $m^{-1}$ | 1.65 |
| 4 | pH of the saturation extract | - | 8.2 |
| 5 | Organic matter | % | 0.83 |
| 6 | $P_2O_5$ | mg $kg^{-1}$ | 7.0 |
| 7 | $K_2O$ | mg $kg^{-1}$ | 125 |
| 8 | $CO_3^{--}$ | meq $L^{-1}$ | Nil |
| 9 | $HCO_3^-$ | meq $L^{-1}$ | 6.50 |
| 10 | $Cl^-$ | meq $L^{-1}$ | 4.90 |
| 11 | $SO_4^{--}$ (by difference) | meq $L^{-1}$ | 5.10 |
| 12 | $Ca^{++} + Mg^{++}$ | meq $L^{-1}$ | 10.40 |
| 13 | $Na^+$ | meq $L^{-1}$ | 1.80 |
| 14 | $K^+$ | meq $L^{-1}$ | 4.30 |

## RESULTS AND DISCUSSION

**Survival of seedlings.** The soil salinity markedly affected the survival of seedlings, magnitude of which varied for each rootstock. The survival percentage of seedlings varied from 85 to 100 in control soil and with $EC_e$ 2.0 dS $m^{-1}$ (Fig. 1). These differences in survival percentage might be due to transplanting shock or disturbance of root system during transplanting of seedlings into the pots. Results divulged that survival percentage of all the rootstocks decreased with increasing $EC_e$ from 2.0 to 8.0 dS $m^{-1}$. At $EC_e$ 4.0 dS $m^{-1}$, Cleopatra mandarin showed highest survival (95%) followed by Gada dehi (90%), Jambheri khatti and Yuma citrange (85%), Jatti khatti (80%) and Kharna khatta (75%). However, at $EC_e$ 6.0 dS $m^{-1}$, Gada dehi and Cleopatra mandarin were at par and presented higher survival percentage over all other rootstocks. Similarly, at $EC_e$ 8.0 dS $m^{-1}$ the Cleopatra mandarin showed the highest survival percentage followed by Gada dehi, Jatti khatti, Jambheri khatti and Yuma citrange. The Kharna khatta showed lowest survival percentage at $EC_e$ 8.0 dS $m^{-1}$ (Fig. 1). It indicates that Cleopatra mandarin and Gada dehi were more salt tolerant than Jambheri khatti, Yuma citrange, Jatti khatti and Kharna khatta. Similar results have been reported by Munir *et al.* (1999). In their study, they found Gada dehi more tolerant as compared to other rootstocks. Several workers (e.g. Banuls *et al.,* 1991; Bar *et al.*, 1997) have also reported Cleopatra mandarin as a salt-tolerant rootstock. Therefore, the results of present study are in conformity with previous workers.

**Plant height.** Critical examination of Fig. 1 revealed that there were minor differences in plant heights of all the rootstocks in control soil and with $EC_e$ 2.0 dS $m^{-1}$, indicating that all the rootstocks tolerated $EC_e$ up to 2.0 dS $m^{-1}$. At $EC_e$ 4.0 dS $m^{-1}$, Gada dehi and Cleopatra mandarin showed more height over Kharna khatta, Jambheri khatti, Jatti khatti and Yuma citrange. Higher soil salinity depressed more plant height, magnitude of which varied for each rootstock. Plant height recorded for Jatti khatti, Jambheri khatti, Gada dehi, Kharna khatta, Cleopatra mandarin and Yuma citrange were 22.5, 21.0, 25.1, 21.4, 27.9 and 18.2 cm, respectively at the highest salinity level in the present investigations. Salts present in root environment adversely affect the growth of crop plants. Growth is more suppressed as the salt concentration increases. The shoot growth is usually affected more than root and hence plants become stunted probably due to reduced cell division (Maas, 1986). The results of present study indicated that Cleopatra mandarin was more tolerant, while Yuma citrange was more sensitive to higher soil salinity among the rootstocks studied. These results are consistent with the findings of Grieve and Walker (1983), and Hassan and Galal (1989).

**Number of leaves plant$^{-1}$.** Total number of leaves plant$^{-1}$ did not differ for all the rootstocks studied in control soil and with $EC_e$ 2.0 dS $m^{-1}$. Reduction in leaf number plant$^{-1}$ was more at higher salinity levels (Fig. 1). At $EC_e$ 6.0 dS $m^{-1}$, Cleopatra mandarin and Gada dehi had more total number of leaves than that other rootstocks. Least number of leaves (9.1) were recorded in seedlings of Yuma citrange at $EC_e$ 8.0 dS $m^{-1}$, indicating sensitivity to higher salinity level. While higher number of leaves were noted in Cleopatra mandarin (17.9) and Gada dahi (14.9) seedlings at $EC_e$ 8.0 dS $m^{-1}$. Thickened and fewer number of leaves plant$^{-1}$ are some common morphological symptoms of plants in saline medium. As plant height was decreased, leaf number was also reduced indicating harmful effects of salts present in the soil.

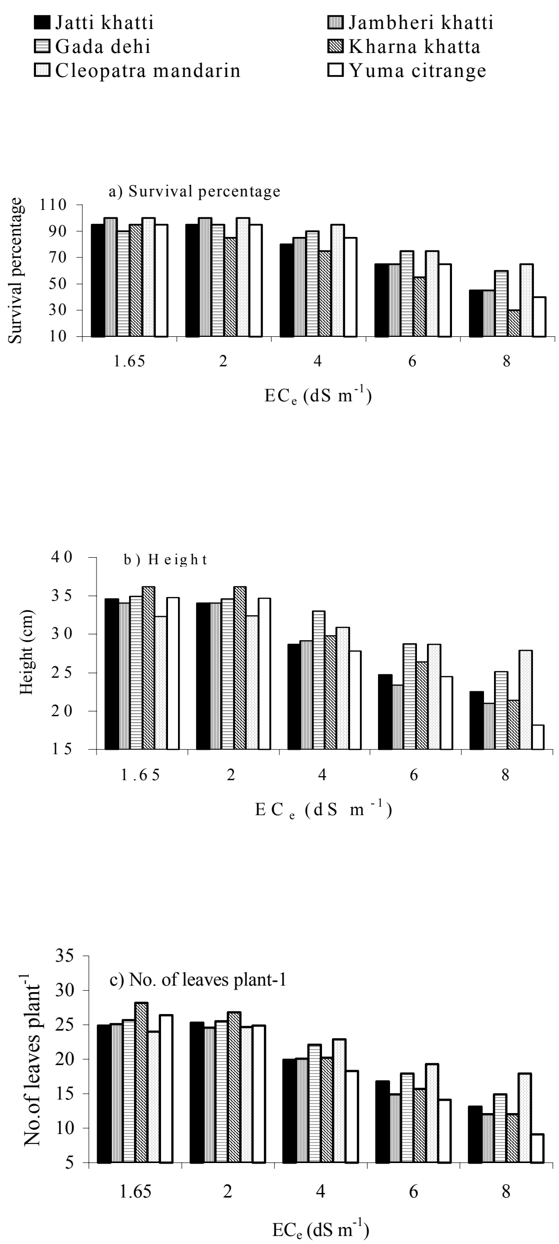
**Toxicity symptoms.** Results in Table II depicted that tip burning and defoliation of leaves did not occur up to $EC_e$ 4.0 dS $m^{-1}$. However, at higher soil salinity levels (i.e. 6.0 and 8.0 dS $m^{-1}$) tip burning and defoliation of leaves were noticed in some rootstocks indicating toxic effects of salts present in the soil. At $EC_e$ 6.0 dS $m^{-1}$ tip burning was recorded in Kharna khatta while defoliation occurred in Jambheri khatti and Yuma citrange. Plants of all the rootstocks resulted in defoliation and tip burning except Gada dehi and Cleopatra mandarin plants where no tip

**Table II. Toxicity and defoliation symptoms with various levels of soil salinity**

| Rootstock used | $EC_e$ (dS $m^{-1}$) | | | | |
|---|---|---|---|---|---|
| | Control | 2.00 | 4.00 | 6.00 | 8.00 |
| Jatti khatti | - | - | - | - | +x |
| Jambheri khatti | - | - | - | x | +x |
| Gada dehi | - | - | - | - | x |
| Kharna khatta | - | - | - | + | +x |
| Cleopatra mandarin | - | - | - | - | x |
| Yuma citrange | - | - | - | x | +x |

(–)= No symptom; (+)= Tip burning; (x)= Defoliation

**Fig. 1. Effect of soil salinity on seedlings of citrus rootstocks**




burning was observed at $EC_e$ 8.0 dS $m^{-1}$ (Table II). As far as the rootstocks are concerned, Cleopatra mandarin and Gada dehi showed high level of salt tolerance as these did not show tip burning even at higher level of soil salinity in the present investigations.

In general, soil salinity depressed all parameters of the rootstocks studied, magnitude of which varied for each rootstock. This might be due to osmotic effect of salts in the soil (Greenway & Munns, 1980), antagonistic/synergistic effects of Na, Ca, Mg, Cl and $SO_4$ ions (Staple & Toenniessen, 1984) or specific ion toxicity (Ayres & Westcot, 1985). High concentration of solutes has markedly affected the osmotic potential which in turn adversely influenced the availability of water which is largely a function of the difference between the osmotic potential of the plant root cell and sum of the osmotic potential of the soil solution (Suarez & Lebron, 1993). As a result of which plant could not maintain turgor. In addition to osmotic effects and inhibitory effects of high concentrations of $Cl^-$ and $Na^+$, an imbalance of essential nutrients might also have contributed to the reduction in plants growth (Bar *et al*., 1997; Ruiz *et al*., 1997).

Citrus is a salt-sensitive perennial plant and damage caused by salinity is mostly due to accumulation of excessive concentrations of $Na^+$ and $Cl^-$ ions in shoot tissues (Maas, 1986; Sykes, 1992). Results indicated that Ceopatra mandarin and Gada dehi were the least affected rootstocks and Kharna khatta and Yuma citrange were the most affected, while Jatti khatti and Jambheri khatti occupied an intermediate position in the present investigations. This might be due to high accumulation of $Cl^-$ and/or $Na^+$ ions in the leaves of Kharna khatta and Yuma citrange (salt-sensitive) and less in Cleopatra mandarin and Gada dehi (salt-tolerant). Bar et al. (1997) reported that high concentration of $Cl^-$ in leaves and branches of Troyer citrange resulted in scorching damage in leaves but not in Cleopatra mandarin. Salinity may also affect chlorophyll content, proline, nitrate reductase enzymes, stomatal conductance, etc. which in turn greatly hamper the growth of plants. Banuls et al. (1991), Nieves et al. (1991), Zekri (1993) and Munir et al. (1999) have also reported similar results.

## CONCLUSION

Cleopatra mandarin and Gada dehi rootstocks proved to be the most tolerant, while Kharna khatta was the least tolerant one and Jatti khatti, Jambheri khatti and Yuma citrange were moderately salt tolerant. Cleopatra mandarin and Gada dehi can be used as citrus rootstocks in saline soils after evaluating their compatibility and performance for different scion cultivars.

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