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Salt Tolerance among Some Citrus Rootstocks

M. M. Hassan and **M. A. Galal**
Department of Horticulture, College of Agriculture,
Cairo University, Fayoum, Egypt

Abstract. The response of five citrus rootstocks was studied with respect to salt tolerance. The plants were grown in nutrient solution salinized with Karoun lake water salt of final concentration of 10000 ppm lake salts. The results demonstrated a wide variation in respect to salinity. The relative salt tolerance was in the following ascending order: Cleopatra mandarin (*C. reshni* Hort. ex Tan), sour orange (*C. aurantium* L.), Amblycarpa (*C. amblycarpa* Ochse), Volkamer lime (*C. volkameriana* Pasq.) and Rangpur lime (*C. limonia,* Osb.).

Growth of shoots was less affected by salinity than roots, so that shoot to root ratio increased for all five rootstocks, but to different degrees. The more tolerant the rootstock, the lower shoot to root ratio. Salt treatment increased Na and decreased K in all plant tissues of all studied rootstocks.

The five citrus rootstocks were similar in the extent of Cl^- loading in the roots, but differed in its accumulation in the leaves and to a lesser extent in the shoots. This indicated an upper limit to extent of Cl^- loading in roots and rootstock differences in root to shoot transport of chloride. The ability of citrus plant to tolerate salinity seems to depend on its ability for chloride exclusion.

Introduction

Among the several soil envrionmental conditions which can limit successful production or even survival of fruit bearing species is salinity. Increasing salinity in the Egyptian soil and rising level of water table represent a complicated problem which could face citrus production.

Differences among rootstocks in response to salinity exist with fruit species [1] and these differences are important when selecting plants adapted to this condition [2]. To increase salt tolerance, sufficient genetic variability must exist within the species [3].

Salt tolerance may depend on a capacity to maintain relatively low level of Na and Cl especially in the stem and the foliage [4]. Although, certain rootstocks of citrus have an ability for chloride and sodium exclusion, the restriction or exclusion process itself has not been defined [5].

The objective of this study was to determine whether differences in response to salinity could be detected among some citrus rootstocks currently used or newly introduced to Egypt. Also, the effect of salinity on shoot and root growth and uptake of Cl^-, Na^+ and K^+ were investigated in these citrus rootstock plants.

Materials and Methods

The present study was carried out during two successive years (1984 and 1985) on five citrus rootstocks namely Rangpur lime, Vokamer lime, Amblycarpa, sour orange and Cleopatra mandarin, under greenhouse conditions at the Faculty of Agriculture, Fayoum, Egypt.

Seeds of each rootstock were sterilized with 3% H_2O_2, washed with water several times, soaked in water for 24 hr. and then germinated in beds filled with washed sand. Then 2-weeks old, uniform plants of each rootstock were transferred into washed sand in plastic containers which were 30 cm diameter at the base, 50 cm at the top and 30 cm deep. Each container contained 20 seedlings. For each year, 2 containers for control and 5 containers for salinity treatment were used for each rootstock. Plants were irrigated with dilute nutrient solution [6] until the start of salinity treatment. Irrigation was applied by gravity from reservoirs to the base of the containers and solution was allowed to rise to 2.5 cm above the sand surface. Delivery tubes were then removed and the excess solution allowed to drain away [2]. The basic nutrient solution was salinized with Karoun lake water salt, which corresponded to 10000 ppm lake salts [7]. The composition of the saline solution was: Ca: 118 ppm; Mg: 264 ppm; Na: 2922 ppm; K: 135 ppm; CO_3: 12 ppm; HCO_3: 46 ppm; Cl: 2993 ppm, and SO_4: 3505 ppm. Salt treatment was initiated when the plants were 6-months old. The control received nutrient solution only. The survived plants were recorded every five days and the salt-affected plants were removed. Wilting or necrosis of all leaves was the index of plant damage. Plants were considered as non-survivors when either of these conditions developed.

Samples of plants representing different treatments were collected for growth measurements and nutrient determination. Each plant was divided into roots, shoots and leaves which were weighed and dried at 60°C for at least 72 hr. The dried materials were ground. Sodium and potassium were determined flamephotometry after dry ashing samples over night at 500°C [8]. Chloride was extracted from the ashed samples with hot water and was titrated with standard silver nitrate. [9].

Results

There was a great variability among citrus rootstocks in their response to salinity (Fig. 1). In this figure, the rootstocks are arranged from most sensitive to most tolerant. The relative salt tolerance followed this ascending order: Cleopatra mandarin, sour orange, Amblycarpa, Volkamer lime and Rangpur lime. The survival curves of the five rootstocks are essentially the same for the two seasons except that, in 1984 season (Fig. 1A), plants were affected more rapidly than did those in 1985 season (Fig. 1B). The survival curves declined rapidly with salt sensitive Cleopatra mandarin. In contrast, survival curves for Rangpur lime plants declined at a slower rate. Other rootstocks showed intermediate values. Salt injury symptoms appeared after 35 days, 40 days, 45 days and 55 days in 1984 season (Fig. 1A) and after 35 days, 40 days and 60 days in 1985 season (Fig. 1B) on Cleopatra mandarin, sour orange, Amblycarpa, Volkamer lime and Rangpur lime respectively. The survival curves declined rapidly for the sensitive rootstocks of Cleopatra mandarin, sour orange and Amblycarpa, where all plants had succumbed after 65 days, 75 days and 85 days respectively in 1984 season and after 80 days in 1985 season. Salt injury symptoms appeared on citrus Volkamer lime after 50 days and 45 days for 1984 season and 1985 season respectively and 17% and 13% of its plants survived at the end of the experiments. However, none of the tolerant Rangpur lime had shown injury before 60 days and about 40% of its plants had survived at the end of the experiment after 100 days from salt treatment.

Salt treatment decreased shoot and root growth for all five rootstocks (Table 1) and that reduction was higher in non-survivors than those of survivors. Salt treatment influenced roots more than shoots, so that shoot to root ratio of control plants was less than that of salt treatment plants. Moreover, in salt treated plants, this ratio was lower in survivors than in non-survivors. It is obviously clear from Fig. 1 and Table 1 that there was a relation between salt tolerance and shoot to root ratio. The lowest ratio was for the most tolerant Rangpur lime and the highest ratio was for the least salt tolerant Cleopatra mandarin.

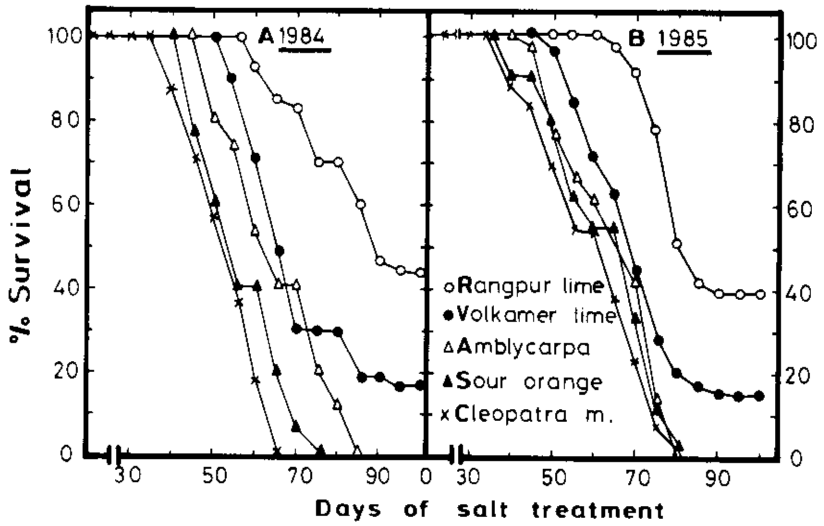

Fig. 1. Survival curves for five citrus rootstock plants in two successive years (1984 and 1985) during salt treatment

Table 1. Growth of five citrus rootstocks after treatment with nutrient solution salinized with Karoun lake water salt. The final concentration was 10000 ppm lake salts. Values represent means of 2 years (1984 and 1985)

Rootstock	Control			Salt-treated plants					
				Survivors			Non-survivors		
	Shoots	Roots	Shoots roots	Shoots	Roots	Shoots roots	Shoots	Roots	Shoots roots
	g dry	wt./plant		g dry	wt./plant		g dry	wt./plant	
Rangpur lime	1.14	2.14	0.53	1.05	1.30	0.81	0.70	0.85	0.82
Volkamer lime	1.34	2.04	0.66	1.18	1.28	0.92	0.82	0.83	0.99
Amblycarpa	1.25	1.84	0.68	0.83	0.87	0.95	0.68	0.54	1.26
Sour orange	1.14	1.58	0.72	0.67	0.70	0.96	0.62	0.41	1.51
Cleopatra m.	0.36	0.50	0.72	0.30	0.29	1.03	0.29	0.18	1.61
$LSD_{0.05}$	0.24	0.43		0.19	0.23		0.11	0.12	

Data of Cl^-, Na^+ and K^+ in roots, shoots and leaves for salt treated plants (survivors and non-survivors) as well as for control are shown in Table 2. In comparison with the control plants, salt treatment increased Cl^- and Na^+ and decreased K^+ in leaves, shoots and roots of all five rootstocks. Leaves and shoots of survived plants contained lower Cl^- and Na^+ and higher K^+ than those of non-survivors. However, there were no significant differences in root Cl^- between survivors and non-survivors. Although salt treatment increased both Na^+ and Cl^- in leaves and shoots, this increase did not exceed 2 times for Cl^-, in contrast to Na^+ accumulation which was more than 25 times that of the control. This indicated higher capacity of plant tissue to accumulate Na^+ than Cl^-.

Table 2. Cl^-, Na^+ and K^+ contents in dry tissues of leaves, shoots and roots of five citrus rootstocks treated with nutrient solution salinized with Karoun lake water salt. The final concentration was 10000 ppm lake salts. Values represent means of 2 years (1984 and 1985)

Rootstock	Leaves			Shoots			Roots		
	Cl (%)	Na (%)	K (%)	Cl (%)	Na (%)	K (%)	Cl (%)	Na (%)	K (%)
				Control					
Rangpur lime	0.22	0.15	1.27	0.20	0.18	0.65	0.15	0.24	0.41
Volkamer lime	0.24	0.14	1.59	0.21	0.18	0.49	0.16	0.24	0.38
Amblycarpa	0.22	0.12	1.46	0.26	0.16	0.44	0.19	0.22	0.40
Sour orange	0.23	0.10	1.54	0.23	0.11	0.46	0.17	0.24	0.58
Cleopatra m.	023	0.10	1.44	0.20	0.04	0.09	NS	NS	0.09
$LSD_{0.05}$	NS	NS	NS	NS	0.04	0.09	NS	NS	0.09
				Salt treated plants (survivors)					
Rangpur lime	0.26	1.50	1.12	0.23	0.63	0.47	0.25	0.64	0.34
Volkamer lime	0.36	1.79	1.45	0.25	0.79	0.45	0.22	0.79	0.38
Amblycarpa	0.38	2.16	1.41	0.31	1.10	0.40	0.24	0.81	0.30
Sour orange	0.41	2.55	1.41	0.34	1.11	0.40	0.24	0.87	0.35
Cleopatra m.	0.47	2.62	1.66	0.34	1.33	0.37	0.26	0.86	0.34
$LSD_{;.05}$	0.03	0.07	0.11	0.02	0.17	0.12	NS	0.13	0.03
				Salt treated plants (non-survivors)					
Rangpur lime	0.29	1.91	1.03	0.25	1.56	0.42	0.26	0.78	0.40
Volkamer lime	0.41	2.37	1.08	0.31	1.83	0.44	0.23	0.85	0.59
Amblycarpa	0.43	2.72	0.90	0.38	2.23	0.39	0.26	0.93	0.34
Sour orange	0.44	3.00	1.01	0.39	2.29	0.38	0.26	0.85	0.69
Cleopatra m.	0.52	3.83	0.87	0.35	2.51	0.33	0.25	0.86	0.43
$LSD_{0.05}$	0.04	0.09	0.08	0.08	0.21	0.10	NS	NS	0.09

Discussion

The results showed a marked difference in the ability of the five citrus rootstocks to deal with salinity environment. Cleopatra mandarin was the least tolerant rootstock, while Rangpur lime was the most tolerant one. Differences in salt tolerance exist not only between species but also between genotypes of a certain species [7,10] and screaning for differential salt tolerance is common with herbiceous species [11] and woody plants [2]. The present results confirmed the others [7,12] that the response of certain plants to a saline environment can be profitably evaluated by comparing varieties with differences in salt susceptibility.

Growth of shoots was less affected by salinity than roots, so that shoot to root ratio increased in the different treatments depending on the rootstock. That different parts of the plant are differently affected with salinity, falls in line with Hassan and Catlin [2] and West and Taylor [13].

The similarity between roots of all five rootstocks in their Cl^- content and its accumulation in leaves and shoots showed an upper limit of Cl^- loading in the roots. The differences of rootstocks in their ability to tolerate salinity were due to differences in their abilities to transport sodium and chloride to shoot.

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دراسة تحمل الملوحة في بعض أصول الموالح

مختار محمد حسن ومحمد على جلال

قسم البساتين، كلية الزراعة، جامعة القاهرة، الفيوم، مصر

ملخص البحث . استهدف هذا البحث مقارنة خمس نباتات من أصول الموالح من حيث مدى تحملها للملوحة حيث تم تنمية النباتات في محلول غذائي مملح بمياه بحيرة قارون ليصير التركيز النهائي ١٠,٠٠٠ جزء في المليون بالإضافة إلى نباتات المقارنة التي كانت تروى بالمحلول الغذائي فقط.

أظهرت النتائج أن هناك اختلافًا كبير بين نباتات الأصول المختلفة من حيث مدى تحملها للملوحة حيث كان ترتيبها من حيث زيادة التحمل تصاعديًا كالآتي:- اليوسفي كليوباترا - النارنج - الامبلكياربا - الفولكاماريانا - وأخيرًا الليمون الرانجبور الذي كان أكثر تحملاً.

كان تأثير المعاملة بالملوحة على الجذور أكبر منه على النمو الخضري وبذلك ارتفعت نسبة وزن الفروع إلى الجذور في النباتات المعاملة وكانت هذه النسبة أقل في حالة الأصل الأكثر تحملاً للملوحة.

أدت المعاملة الملحية إلى زيادة الصوديوم والكلوريد ونقص البوتاسيوم في جميع أجزاء نباتات الأصول الخمسة.

كان تأثير الأصل واضحًا حيث كان محتوى الصوديوم والكلوريد أقل في الأصل الأكثر تحملاً للملوحة وذلك في جميع أجزاء النباتات بالنسبة للصوديوم على عكس الكلوريد حيث كان التأثير أكثر وضوحًا في الأوراق عنه في الفروع بينما لم تكن هناك فروق معنوية من ناحية كميته في الجذور بالنسبة لجميع الأصول تحت الدراسة.

هذا يدل على أن هناك حدًا أعلى لتراكم الكلوريد في جذور نباتات الموالح بصرف النظر عن درجة تحملها للملوحة وعليه فإن درجة تحمل نبات الموالح للملوحة ترتبط بقدرته على الإقلال من انتقال الكلوريد من الجذور إلى الفروع.