7. SUMMARY

The objectives of this investigation were to study the effect of different saline irrigation water concentrations at different levels of SAR on growth , leaf and fibrous roots mineral contents, bud indoles and phenols content, leaf soluble and nonsoluble carbohydrates , stem starch and total carbohydrates, leaf chlorophyll A , B and carotene contents leaf osmotic pressure, salinity hazard coefficient , anatomical changes in leaves and roots. Lastly, the evaluation of four citrus rootstocks namely: sour orange (Citrus aurantium L.) Rangpur lime (Citrus limonia. osbeck) , Cleopatra mandarin (Citrus reticulata. Blanco) and Poorman orange (possibly of hybrid origin, Hodgson , 1967) for their salt tolerance. The study was carried out during the seasons 1985 and 1986 in the greenhouse of El-Kanater research station Kaliobia Governorate. Seedlings , of one-year-old of each rootstock nearly similar in their vigor were chosen for this study. These seedlings were planted in March 1983 in clay pots of 30 Cm. in diameter filled with a clay leam soil and irrigated with tap water till they became sutible for budding with Washington navel orange in September, 1983. In March, 1985 homogenous plants of about 70 Cm. height grown under partial shade condition were irrigated with solution of various levels of salinity and SAR treatments contaning sodium sulphate, calcium chloride, calcium nitrate and magnesim sulphate at the rate of one liter per each clay pot three times weekly. Salinity treatments were : 2000 ppm at SAR 6, 2000 ppm at SAR 12 , 4000 ppm at SAR 6, 4000 ppm at SAR 12, 6000 ppm at SAR 6 and 6000 ppm at SAR 12. Beside, other group of plants of

each rootstock were irrigated with tap water as a control. The saline solution were applied continuously for two seasons.

Moreover, in 1986 season, another group of budded rootstocks were left to grow under full sun light and irrigated with the same previous saline treatments.

Any way, these treatments were arranged in a complete randomized blocks design and each treatment was replicated three times with two pots per each replicate.

7.1- Growth measurements :

Which included top dry weight, root dry weight, total plant dry weight, top/root ratio, leaves and fibrous roots percentage, dry weight of 100 Cm^2 leaves and leaf area.

7.2- Chemical constituents :

1 - Samples from leaves and fibrous roots representing the treated plants as well as the untreated ones were chemically analysed for N, P, K, Ca, Mg, Na, CL, Zn, Fe and Mn nutrients.

2 - Samples of buds were chemically analysed for indoles and phenols contents.

3 - Samples of leaves were chemically analysed for soluble and nonsoluble carbohydrate, chlorophyll A, B, carotene contents and leaf osmotic pressure.

4 - Samples of stem were chemically analysed for starch and total carbohydrate contents.

7.3- Salinity hazard coefficient (S.H.C.) :

This coefficient was calculated using the following formula:

$$\frac{\text{Total soluble carbohydrates}}{\text{Chl A + Chl B}} \times \text{carotene}$$

7.4- Histological studies :

Samples of leaves of the same physiological age and fibrous roots were taken for histological studies.

7.5- Evaluation of different citrus rootstocks :

The different citrus rootstocks used in this study were subjected to evaluation concerning 6000 p.p.m. at SAR 12 treatment which was the highest level of salinity in this study. The various items for evaluation were : total plant dry weight, top/root ratio, salinity hazard coefficient, leaf osmotic pressure and root sodium and chloride contents.

The obtained results revealed the following:

7.1- Growth measurements :

1- Under both full sun light and partial shade conditions, different salinity and SAR treatments decreased total plant dry weight, top dry weight, root dry weight, leaves and fibrous roots percentage and leaf area.

2 - Under the same level of SAR, high level of salinity caused a reduction in total plant dry weight, top dry weight, root dry weight, leaves and fibrous roots percentage. That was true under either full sun light or partial shade conditions.

3 - Under the same level of salinity, SAR 12 decreased total plant dry weight , top dry weight , root dry weight , leaves and fibrous roots percentage as compared with those of SAR 6 under either full sun light or partial shade conditions.

4 - Under full lsun light condition, salinity and SAR treatments increased top/root ratio, while it took the reverse under partial shade condition.

5 - Top/root ratio and leaf area increased with increasing salinity level under both SAR levels and full sun light conditions , while under partial shade condition it took the other way around.

6 - Under full sun light condition, dry weight of 100 (Cm^2) leaves decreased with salinity. The same result was obtained also under

high level of salinity at both SAR levels. Moreover, under partial shade condition the reverse was observed.

7 - Under full sun light condition, high level of salinity at SAR 12 generally increased top/root ratio, dry weight of 100 (Cm^2) leaves and leaf area.

7.2- Chemical constituents:

7.2.1- Nutrients content :

7.2.1.1- Leaf nutrients constituent:

Under either full sun light and partial shade conditions leaf nutrients content indicated that :-

1 - Salinity and SAR treatments increased leaf Na, Cl, Fe and Mn contents , while it decreased leaf P, K and Ca.

2 - High level of salinity under the same level of SAR increased leaf N, P, Na, CL, Fe and Mn, as well as, decreased leaf Ca and Zn contents.

3 - SAR 12 treatment as compared with SAR 6 level under the same level of salinity increased leaf P, Na, and Cl contents whereas it decreased leaf N, Ca and Mn contents.

Furthermore, under full sun light condition, the following results were obtained:

1 - Salinity and SAR treatments increased leaf N, Mg and Zn contents.

2 - High level of salinity under the same level of SAR increased leaf Mg but decreased leaf K.

3 - SAR 12 treatment as compared with SAR 6 treatment under the same level of salinity increased leaf Mg but it decreased leaf K, Zn and Fe.

Moreover, under partial shade condition, data revealed that :

1 - Salinity and SAR treatments decreased leaf N, Mg and Zn.

2 - High level of salinity under the same level of SAR increased leaf K but decreased leaf Mg.

3 - SAR 12 treatment as compared with SAR 6 treatment under the same level of salinity increased leaf K, Zn and Fe while it decreased leaf Mg.

7.2.1.2- Fibrous roots nutrients constituent :

Under either full sun light or partial shade conditions, fibrous roots nutrients content pointed out that :

1 - Salinity and SAR treatments increased fibrous roots N, Ca, Na and Cl contents and decreased root P, K, Mg, Zn, Fe and Mn contents.

2 - High level of salinity under the same level of SAR increased fibrous roots Ca, Mg and Na contents and decreased root Kand Zn contents.

3 - SAR 12 level as compared with SAR 6 level under the same level of salinity increased fibrous roots P, Na contents, and decreased root K, Ca, Cl and Mn contents.

However , under full sun light condition the results indicated that :

1 - High level of salinity under the same SAR level increased fibrous roots N, P, CL and Mn contents but decreased root Fe content.

2 - SAR 12 level as compared with SAR 6 under the same level of salinity increased fibrous roots N, Mg and Fe contents.On the other hand it decreased fibrous roots Zn contents .

Beside , under partial shade condition data pointed out that :

1 - High level of salinity under the same level of SAR increased fibrous roots Fe content and decreased root N, P, Cl and Mn contents.

2 - SAR 12 level as compared with SAR 6 under the same level of salinity increased fibrous roots Zn content, but decreased fibrous roots N, Mg and Fe contents.

7.2.2- Bud indoles and phenols contents :

Bud indoles and phenols contents under full sun light condition was in accordance with that of partial shade condition and took the following trend:

1 - Salinity and SAR treatments increased bud phenols content and decreased bud indoles content and indoles/phenols ratio.

2 - Under the same level of SAR high level of salinity caused an increment in bud phenols and decreased bud indoles and indoles/phenols ratio.

3 - SAR 12 as compared with SAR 6 treatment under the same level of salinity increased bud phenols and decreased bud indoles and indols/phenols ratio.

7.2.3- Leaf soluble, nonsoluble carbohydrates, stem starch and total carbohydrates contents:

Under full sun light condition, leaves and stems of Washington navel orange plants budded on different citrus rootstocks and treated with different levels of salinity and SAR showed the following results:

1 - Salinity and SAR treatments decreased leaf soluble carbohydrates contents and stem starch and total carbohydrates contents but they fluctuated in their effect on leaf nonsoluble carbohydrates content according to the rootstock used.

2 - Under the same level of SAR high level of salinity decreased leaf soluble, nonsoluble carbohydrates contents and stem total carbohydrates, but increased stem starch.

3 - SAR 12 treatment as compared with SAR 6 treatment under the same level of salinity fluctuated in their effect on leaf soluble and nonsoluble carbohydrates contents according to the rootstock used. While it decreased stem starch and total carbohydrates. On the other hand, under partial shade condition the results could be summarized as follows:

1 - Salinity and SAR treatments increased leaf soluble carbohydrates and stem starch but decreased leaf nonsoluble carbohydrates and stem total carbohydrates contents.

2 - Under the same level of SAR , high level of salinity increased leaf soluble and nonsoluble carbohydrates, whereas it decreased stem starch and stem total carbohydrates contents.

3 - SAR 12 treatment as compared with SAR6 treatment under the same level of salinity increased leaf soluble carbohydrates and decreased stem starch and total carbohydrates . Leaf nonsoluble carbohydrates, however, their was no consistent trend.

7.2.4- Leaf chlorophyll A , B and carotene contents :

1 - Under full sun light condition, chlorophyll A increased greatly at 60 days from the initiation of salinity treatments then decreased till 120 days. Moreover, under partial shade condition, leaf chlorophyll A content took the same trend of full sun light till 60

days followed with a decrease afterwards till 90 days then increased slightly up to 120 days.

2 - Leaves of citrus plants grown under either full sun light or partial shade conditions increased in their content of chlorophyll B till 60 days then decreased slightly towards the last leaf sample at 120 days.

3 - Leaf carotene content of citrus plants grown under either full sun light or partial shade conditions increased slightly up to 60 days followed with a drastic decrease at 90 days and afterwards.

4 - Leaf chlorophyll A content decreased as plants treated with saline irrigation water and grown under either full sun light or partial shade conditions.

5 - SAR levels showed no clear trend on leaf chlorophyll A of citrus plants grown under full sun light but under partial shade high level of SAR 12 decreased leaf chlorophyll A content.

6 - High level of salinity increased leaf chlorophyll B of citrus plants grown under either full sun light or partial shade conditions.

7 - The effect of SAR levels on leaf chlorophyll B was fluctuated. Thus, while there was no clear effect on leaf chlorophyll B under full sun light, high level of SAR 12 caused an increase in leaf chlorophyll B under partial shade condition.

8 - No clear effect of salinity treatments was noticed on leaf carotene content of citrus plants grown under full sun light. In contrast, under partial shade, salinity treatments generally decreased leaf carotene content as compared to the control.

9 - High level of SAR 12 increased leaf carotene content of citrus plants grown under full sun light. On the other hand, no consistent effect for SAR levels on leaf carotene content of citrus plants grown under partial shade condition was observed.

7.3. Salinity hazard coefficient (S.H.C.) :

1 - Salinity hazard coefficient of all citrus rootstocks used in this study started with highest values at 30 days from the initiation of treatments and decreased stoutly towards 90 days then resumed its decrease smoothly till 120 days.

2 - Citrus plants suffered much from salinity early after 30 days from the initiation of treatments then adapted to salinity afterwards till 120 days.

3 - Citrus plants treated with SAR 12 suffered much from salinity than those received SAR 6 rate.

7.4- Leaf osmotic pressure :

1 - Under either full sun light or partial shade conditions, leaf osmotic pressure of Washington navel orange plants budded on various rootstocks generally increased as leaves get older.

2 - Salinity and SAR treatments had no clear trend on leaf osmotic pressure of citrus plants grown under full sun light condition but under partial shade it caused an increase in leaf osmotic pressure.

3 - Applying irrigation water with higher salinity for citrus plants increased leaf osmotic pressure grown under either full sun light or partial shade conditions.

4 - SAR treatments fluctuated in their effect on leaf osmotic pressure. Thus, while SAR 12 decreased leaf osmotic pressure under full sun light, it had no consistent effect under partial shade.

7.5- Anatomical changes in the leaves and roots :

7.5.1- Anatomical changes in leaves :

Leaf blade :

Leaf blade thickness was reduced.

The epidermis :

1- A marked reduction in the thickness of the cuticle.

2 - The epidermis cells became smaller and turgid.

The mesophyll :

1 - Both palisade and spongy cells became smaller with thin walls.

2 - The green plastids were noticeably reduced in the palisade and spongy tissues.

3 - The cells which contained the idioplasts increased and took different crystals shape, also they were observed in the spongy tissue upper the lower epidermis cells.

4 - The spongy cells had an isodiametric shape and the intercellular spaces were reduced.

5 - The length of spongy tissue cell layers decreased as well as the area of palisade and spongy tissues generally reduced.

The vascular bundle:

1 - The midrib might be increased in volume and contents.

2 - The size of the vascular bundle was increased in number of archs in both the large and small bundles.

3 - The phloem fibers were clearly observed.

7.5.2- Anatomical changes in roots :

1 - The root diameter was noticeably reduced and the root took an irrigular shape.

2 - The epidermal layer disappeared and the hypodermal layer replaced it.

3 - The hypodermal cells became suberized.

4 - The number of cortex layers was reduced.

5 - The radial walls of cortex were reduced.

6 - The endodermis was pressed in the tangential direction and the pericycle tissue became more disappearent.

7 - The vascular cylinder, radial length reduced.

8 - The vascular bundle had fewer vessels.

9 - The lignification in the vascular bundle vessel walls was not normal.

10 - Pith area was reduced and its cells had very thin walls.

7.6- Evaluation of different citrus rootstocks :

1 - Under full sun light condition the evaluation graded sour orange rootstock as the most tolerant rootstock to salinity followed by Rangpur lime, Cleopatra mandarin and Poorman orange in descending order.

2 - Under partial shade condition the evaluation graded Cleopatra mandarin as the highest rootstock in tolerance to salinity followed in descending order by Poorman orange , sour orange and Rangpur lime .