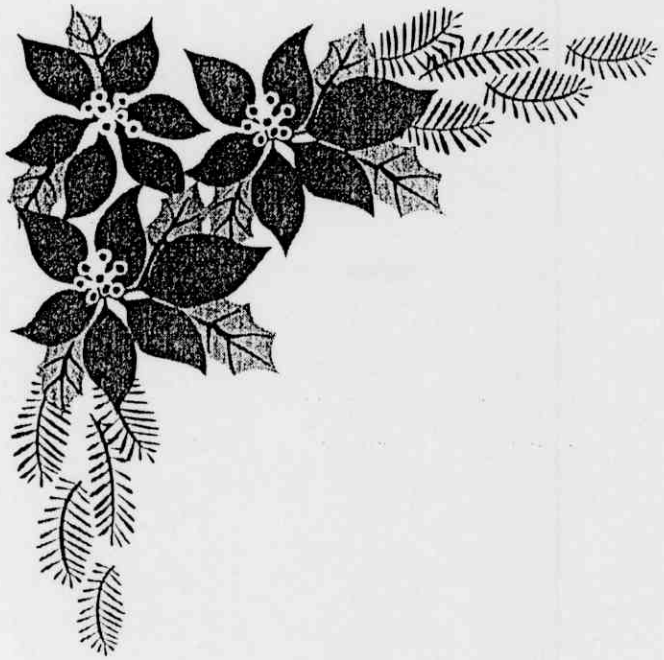
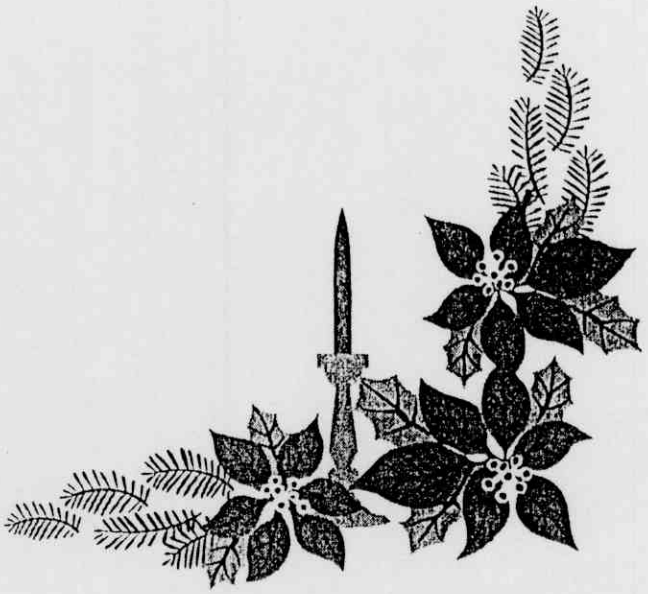


SUMMARY & CONCLUSION



V- SUMMARY AND CONCLUSION

The present study was carried out during two consecutive seasons of 2001 and 2002 in a greenhouse belonging to Desert Institute, Cairo, Egypt.

Uniform and Healthy two year old transplants of three apple rootstocks namely: Malus communis (MC); MM 106 and Baladi were the plant material used in this study, on February 1st during both seasons plastic pots of 35 cm. diameter that had been filled with about 10 kg sandy soil bought from eastern desert along Cairo, Esmailia rode (location about 60 km from Cairo). Soil type were taken from a depth of 0-30 cm; from ground surface was chemically and mechanically analyzed before period of equilibration. Then irrigation was done at the rate of one titre/ pot at two days intervals till 1st March, whereas irrigation with different investigated saline solutions was start during both seasons of study.

Saline solutions were prepared for irrigation at the concentration of tap water (0), 2000, 3000 and 4000 ppm of NaCl, Na_2SO_4, $CaCl_2$, $MgSO_4$, KCl and K_2SO_4 as well as each concentration was prepared with two levels of sodium adsorption ratios (S.A.R.) i.e., 3 and 6 and each level of sodium adsorption ratio have two Cl: SO_4 levels i.e., (low and high). The accumulated salts were removed every 21 days by irrigation with tap water, then followed by rewatering with the same salt solution the next day.

It was aimed to investigate salt tolerance of these apple rootstocks from one hand and possibility of minimizing the depressive effect of salt stress from the other.

Thus two experiments were conducted using the complete randomized block design with three replications, whereas each was represented by 2 plants (grown individually in 35.0 cm. diameter plastic pots).

V.I. Experiment I: Effect of salt concentration; SAR and Cl: SO_4 ratio, on three apple rootstocks transplants:

Thirty nine treatments represented the different possible combinations between four investigated factors namely; a) 3 apple rootstocks (M.C.; M.M. 106 and Balady); b) saline concentration (2000; 3000 and 4000 ppm); c) SAR (3 & 6) and d) Cl: SO_4 ratios (low & high), beside irrigation with tap water as control were investigated.

V.II. Experiment II: Effect of saline stressed apple rootstock transplants to P; K and Zn foliar sprays:

Salt tolerance of apple rootstocks was studied through investigating the influence of 24 treatments representative of various combinations between 3 apple rootstock transplants (M.C, MM106 and Baladi) grown under salt stress (4000 ppm) with SAR 6 and two levels of chloride (low & high) x 3 fertilizer kind (P & K each sprayed at 500 ppm and Zn at 100 ppm. Foliar spray were applied 7 times from March 15th up to September 15th in both seasons.

Specific and interaction effects of the investigated factors and their combinations included in the aforesaid 1st and 2nd factorial experiments were studed through the response of the following measurements:

I. Growth measurements:

Average stem diameter; average length of (stem, root and whole plant); number of (shoots & leaves per plant); (leaf & total assimilation area); fresh and dry weights of various transplants organs (stem, leaves, roots and total plant) were the investigated growth measurements in 1st and 2nd experiments.

II. Some physiological properties:

Leaf relative turgidity (L.R.T), leaf succulence grade (L.S.G.), hard leaf character. (H.L.C.), leaf osmatic pressure (O.P.) in bar, leaf transpiration rate (L.T.R.) and leaf water potential (L.W.P.) in response to investigated treatments were estimated.

III. Chemical analysis:

In this regard, foliar photosynthetic pigments (chlorophyll a & b); stem total charabohydrates and soluble sugars; leaf total free amino acids and proline contents, some enzymes activity (Catalaze & peroxidase) and nutritional status (Leaf, Cl, Na, N, P, K, Ca, Mg, Fe, Mn and Zn contents) in response to the included treatments of 1st and 2nd experiments were investigated.

IV. Anatomical structure:

Leaf and root structures of 3 apple rootstock transplants (Mc, MM 106 and Baladi) irrigated with saline water were investagted regarding the effect of salt concentration, SAR, chloride levels (experiment one).

Thickness of: cutical and epidermis of upper and lower leaf surfaces; mesophyll (paraside & spongy tissues) and number of xylem rows of vascular bundle were the leaf anatomatical

characteristics investigated through microscopic examination of leaf cross section.

Data obtained during both experimental seasons 2001 and 2002 could be summarized as follows:

V.I. Experiment 1: Effect of salt concentrations, SAR and chloride levels (Cl: SO_4 ratio) on three apple rootstock transplants:

V.I.I. Growth measurements:

In this regard 16 growth parameters namely: stem diameter; average length of (root, stem and total plant); average number of (laterals & leaves per plant); average area of individual (leaf & total assimilation area per plant) and fresh & dry weights of Various plant organs (leaves; stem ; root and total plant) in response to specific effect of four studied factors i.e., rootstock kind; salt concentrations, sodium adsorption ratio and chloride levels (Cl: SO_4 ratio) as well as interaction effects of their possible combinations were investigated during both 2001 and 2002 experimental seasons.

1. Regarding the specific effect of rootstock kind, data obtained during both seasons revealed that, Mauls communis (M.C.) rootstock was the superior descendingly followed by Malling Merton rootstock 106 (MM 106); and Baladi apple rootstock. Such trend was true in most cases pertaining the 16 investigated growth measurements during two seasons.
2. As for the specific effect of salt concentrations, results also declared a significant decrease in stem diameter; lengths of

(root; stem and total plant); average area of either individual leaf or total assimilation area /plant and fresh & dry weights of plant organs (leaves, stem, roots and total plant) all being progressively depressed by all the used salinity concentrations, but the depressive effect was more pronounced with the highest salts concentration during two seasons of study.

3. Results also declared a significant decrease in all vegetative growth parameters previously mentioned with increasing sodium adsorption ratio (SAR) from 3 to 6 during the 2001 and 2002 experimental seasons.

4. With respect to the specific effect of chloride level (Cl: SO_4 ratio), data obtained displayed that increasing chloride levels (Cl: SO_4 ratio) in irrigation water resulted in an obvious reduction of all investigated growth measurements except No of laterals / plant which didn't affect during the two seasons of study.

B. Interaction effect:

1. Data obtained revealed that specific effect of each investigated factor was directly reflected on its own combinations. Herein, the Malus communis (M.C.) rootstock seedlings irrigated with 2000 ppm X SAR 3 X lower chloride level (Cl: SO_4 ratio) exhibited statistically the greatest values of various vegetative growth parameters. Moreover, Malus communis (M.C.) X 2000 ppm X SAR 3 and higher chloride level also should the thickest stem diameter, No of laterals and assimilation area/plant and didn't significantly differ than the superior combination during the two seasons of study.

2. On the contrary, the least values of the investigated vegetative growth measurements were always in concomitant to those apple transplants representing the combination between Baladi apple rootstock X highest salt concentration (4000 ppm) X SAR 6 X higher Cl: SO_4 ratio whereas, the reverest decrease was detected during the two seasons of study. However, other combinations were in between the aforesaid 2 extremes.

V.I.II. Some physiological properties of leaf:

Leaf water potential (L.W.P); leaf osmotic pressure (L.O.P); leaf relative turgidity (L.R.T), transpiration rate (T.R.); leaf succulence grade (L.S.G.) and hard leaf character (H.L.C.) in response to rootstock kind; salt concentration; SAR and chloride levels (Cl: SO_4 ratio), as well as their combinations were the investigated leaf physiological properties.

A. Specific effect:

1. Regarding the specific effect of rootstock kind, data obtained revealed that the highest values of leaf water potential, leaf osmotic pressure, leaf relative turgidity and leaf succulence grade were always in concomitant to M.C. rootstock transplants while the reverse was true with Baladi apple rootstock. Differences were significant with the former aforesaid four physiological leaf characteristics. On the other hand, Baladi apple rootstock exhibited the highest values of both transpiration rate and hard leaf character while the opposite was found with Malus communis (M.C.) rootstock transplants. In addition, MM 106 rootstock was intermediate as compared to

two other apple rootstocks under study regarding the response of all investigated leaf physiological properties.

2. Concerning the specific effect of salt concentration, obtained results revealed that the lowest values of (L.W.P.); (L.R.T.); (T.R.) and (L.S.G.) were significantly exhibited by increasing salt concentration in irrigation water. On the contrary, increasing salt concentration in irrigation water, increased significantly values of both leaf osmotic pressure and hard leaf character during the two seasons of study.

3. Results also declared a significant decrease in leaf water potential (L.W.P.); leaf relative turgidity (L.R.T.); transpiration rate (T.R.) and leaf succulence grade (L.S.G.) with increasing both sodium adsorption ratio from 3 to 6 and or increasing chloride level in irrigation water, while both leaf osmotic pressure (L.O.P.) and hard leaf character (H.L.C.) took the other way around during two seasons of study.

B. Interaction effect:

1. Data obtained regarding the interaction effect of (rootstock kind X salt concentration X SAR X chloride levels) pointed out that the highest values of leaf water potential (L.W.P.); leaf relative turgidity (L.R.T.); transpiration rate (T.R.); and leaf succulence grade (L.S.G.) were statistically in concomitant to M.C. rootstock transplants irrigated with 2000 ppm saline solution of SAR 3 and lower Cl: SO_4 ratio. However the least value were coupled with irrigated transplants of Baladi apple rootstock with 4000 ppm saline solution of SAR 6 and higher Cl: SO_4 ratio

during the study. Other combinations were in between regarding the response of the aforesaid 4 leaf physiological properties.

2. On the other hand, the interaction effect between the 4 investigated factors i.e., rootstock kind; salinity concentration; SAR and Cl: SO_4 ratio in the irrigation water caused noticeable variances. Herein, the highest decrease in both leaf osmotic pressure and hard leaf character detected by Baladi apple X 4000 ppm X SAR 3 X higher Cl: SO_4 ratio, however the highest values were coupled with M.C. apple rootstock X 2000 ppm X SAR 6 X lower Cl: SO_4 ratio. In addition, other combinations were in between regarding such leaf physiological properties.

V.I.III. Chemical composition:

I. Photosynthetic pigments (foliar pigments);

Data obtained regarding apple leaf photosynthetic pigments contents (Chlorophyll A; B and carotenoids compounds) as influenced by the specific and interaction effects of apple rootstock kind; salt concentration; SAR and chloride levels (Cl: SO_4 ratio) as well as their possible combinations revealed the following:

A. Specific effect:

1. Malus communis leaves were statistically the richest followed in a descending order by MM 106 while Baladi apple rootstock was the poorest.

2. The obtained results revealed that leaf photosynthetic pigments i.e., Chlorophyll A & B and caratenoids, all progressively decreased by rising salinity concentrations. during the two seasons of study.

3. Increasing level of either sodium adsorption ratio (SAR) or Cl: SO_4 ratio in irrigation water significantly decreased leaf chlorophyll A, B and caratenoids compounds during the study.

B. Interaction effect:

1. The interaction between rootstock kind; salinity levels; sodium adsorption ratio and chloride level (Cl: SO_4 ratio) was obviously detected. Herein, irrigated transplants of Baladi apple rootstock with 4000 ppm saline solution of SAR 6 and higher Cl: SO_4 had the largest decrease in their leaf chlorophyll A, B and caratenoids, however the least decrease was in leaves of M.C. rootstock transplants irrigated with 2000 ppm saline solution of SAR6 and lower Cl: SO_4 ratio. In addition, combinations were in between the aforesaid 2 extremes.

II. Shoots total soluble sugars and total carbohydrates contents:

1. Data obtained during both seasons revealed that total soluble sugars and total carbohydrates of apple rootstock stem respond specifically to the 4 investigated factors. Hence, Malus communis was statistically the richest followed in descending order by MM 106 and Baladi apple rootstock during the two seasons of study.

2. However, both components followed two conflicted trends in response to either salt concentration or sodium adsorption ratio (SAR) as well as chloride levels (Cl: SO_4 ratio). Hence, rising any of salinity (concentration); SAR or Cl: SO_4 ratio resulted in increasing shoot total soluble sugars, while the reverse was true with total carbohydrates content.

B. Interaction effect:

Obtained results revealed that total soluble sugars and total carbohydrates each followed its own trend regarding the response to interaction effect of four investigated factors. Herein, the highest level of total soluble sugars associated with the lowest total carbohydrates from one hand was always in concomitant to the Malus communis rootstock transplants irrigated with 4000 ppm salinized water of SAR 6 and higher Cl: SO_4 ratio. The reverse (least total soluble sugars and highest total carbohydrate levels) was markedly coupled with Baladi apple rootstock transplants irrigated with 2000 ppm saline solution of SAR 3 and lower Cl: SO_4 ratio during the two seasons of study.

III. Leaf salinity hazard coefficient (L.S.H.C.)

Under the treatment of salinity L.S.H.C. (salinity hazard coefficient) significantly increased by increasing salt concentration and / or both SAR and chloride level (Cl: SO_4 ratio) in irrigation water. The highest L.S.H.C. was related to M.C. but Baladi apple rootstock had the lowest values.

IV. Effect on leaf total free amino acids and proline contents:

A. Specific effect:

1. Data obtained displayed that total free amino acids and prdine contents responded specifically to each of the four investigated factors (rootstock kind; salt concentration; SAR and Cl: SO_4 ratio) and both followed the same trend. Baladi apple rootstock had statistically the richest leaves followed in a descending

order by MM 106, and Malus communis (M.C.) where the later was the inferior in this concern.

2. The obtained results revealed that, total free amino acids and proline contents being progressively increased with salinity concentrations.

3. Results also declared a significantly increase in both total free amino acids and proline contents with increasing either SAR or chloride levels (Cl: SO_4 ratio) during two seasons of study.

B. Interaction effect:

The interaction effect of combinations between the four investigated factors i.e., rootstock kind; salinity concentration; SAR and Cl: SO_4 ratio data obtained revealed that the highest value of total free amino acids and proline contents were found by Baladi apple rootstock X highest salinity concentration (4000 ppm) X SAR 6 X higher Cl: SO_4 ratio while the reverse was detected by the tap water irrigated combinations followed in an increasing order by those seedlings of Malus communis (M.C.) X lowest salinity concentration (2000 ppm) X SAR 3 X lower Cl: SO_4 ratio.

V. Catalase and peroxidase enzyme activities:

Baladi apple rootstock showed the least level of activity for both enzymes. However, both catalase and peroxidase followed two conflicted trends regarding their response to either salinity concentration or sodium adsorption ratio (SAR), as well as chloride level (Cl: SO_4 ratio). In irrigation water. Herein, peroxidase activity was obviously increased in leaves of transplants subjected to salt stress up to 3000 ppm then the trend took the other way around at

the highest level i.e., (4000 ppm) while it showed a positive relationship with sodium adsorption ratio (SAR) and negatively responded to chloride level. Meanwhile, the trend took the other way around for catalase enzyme.

VI. Leaf mineral composition:

Data obtained during both seasons regarding the leaf Cl, Na, N, P, K, Ca, Mg, Fe, Mn and Zn contents of 3 apple rootstocks in response to specific and interaction effects of rootstock kind; salt concentration; SAR and chloride level (Cl: SO_4 ratio) and their possible combinations revealed that the results could be summarized as follows:

A- Specific effect:

1- Referring the specific effect of rootstock hind, data obtained during both season revealed that Malus communis (M.C.) transplants exceed statistically the tow other rootstock (MM106 and Baladi) regarding their leaves N, P, K, Mn and Fe contents. However, M.C. leaves had the least Cl; Na; Ca and Zn levels. However, Baladi apple rootstock leaves had the highest level of Cl; Na; Mg and Zn that associated with the least values of N; P and Fe contents. Meanwhile, MM 106 apple rootstock in most cases was intermediate as compared to two other apple rootstocks except with K; Mg and Mn where the least values were recorded in this concern.

2- As for the specific effect of salt concentrations, the leaves N, P, K, Mg, Zn and Mn contents decreased significantly and gradually with increasing salt concentration in irrigation water

while the reverse was found with leaf CL, Na, Ca and Fe contents during two seasons of study.

3- Increasing either sodium adsorption ratio (SAR) from 3 to 6 and /or chloride level (CL: So_4 ratio) in irrigation water significantly decreased leaf N, P, K, Mg, Mn and Zn contents, while the reverse was true with leaf Cl; Na; Ca and Fe contents, where raising either SAR or Cl: SO4 ratio increased them significantly during two seasons of study.

B- Interaction effect:

Regarding the interaction effect of various combinations between four investigated factors (rootstock kind; salt concentration; sodium adsorption ratio and Cl: So4 ratio), data obtained during 2001 & 2002 experimental seasons revealed that specific effect of each investigated factor was directly reflected on its own combinations. Herein, the irrigated apple transplants (especially Baladi & M.M.106 rootstocks) with the highest concentrated saline solution (4000 ppm) of higher SAR (6) and Cl: SO4 ratio had the richest leaves in their Cl; Na; Ca and Fe contents associated with the least levels of N; P; K; Mg; Mn and Zn. The trend took the other way around with control (continuously irrigated transplants with tap water) followed by those supplied with 2000 ppm saline solution of lower SAR (3) and lower Cl: SO_4 ratio where the least values of leaf Cl; Na; Ca and Fe contents with the higher N; P; K; Mg; Mn and Zn contents were recorded especially M.C. apple rootstock.

V- II- Experiment II: Effect of foliar spray with some nutrient foliar sprays on salinity stressed transplants of three apple rootstocks:

In this regard specific and interaction effects of three investigated factors i.e., apple rootstock kind (M.C., MM. 106 and Baladi apple rootstock); sprayed nutrient element (P & K each at 500 ppm and Zn at 100 ppm), levels of chloride (Cl: SO_4 ratio) and their possible combinations were studied regarding the response of saline stressed transplants (irrigated with 4000 ppm solutions of SAR6 and two Cl: SO_4 ratios. Whereas such influence was evaluated by the response of some vegetative growth; physiological characteristics; chemical composition and changes in their leaves and root anatomical examinations.

V- II- I- Growth measurements:

Stem diameter, length of (stem, root and total plant); number of (laterals & leaves per plant); average leaf area; total assimilation area /plant; fresh and dry weights of different plant organs (leaves, stem, root and total plant) were investigated regarding their response to the aforesaid 3 factors and their combinations.

A- Specific effect:

1- Concerning the specific effect of apple rootstock kind, data obtained during both 2001 and 2002 experimental seasons revealed that, Malus coumunis (M.C.) rootstock was the superior fallowed by Malling Merton 106 (MM.106) all regarding the 16th investigated growth measurements, while Baladi apple rootstock was the inferior.

2- Regarding the specific effect of sprayed nutrient element, results declared that all investigated growth measurements of the salinity stressed transplants were significantly increased by any of 3 sprayed elements, however, Zn at 100 ppm foliar spray proved to be the most effective in this regard followed in a descending order by K and p each at 500 ppm foliar spray during two seasons of study.

3- Results also declared a significant decrease in all investigated growth parameters as chloride level (Cl: SO_4 ratio) was increased during two seasons of study.

B- Interaction effect:

Data obtained revealed that specific effect of each investigated factors was directly reflected on its own combinations. Herein, zinc spray (100 ppm) of saline stressed transplants (irrigated with 4000 ppm solution of SAR6 and low Cl: SO_4 ratio) of Malus communis (M.C.) rootstock, exhibited statistically the greatest values of various vegetative growth measurements. On the contrary, the least values of these investigated growth parameters were always in concomitant to such combinations represented unsprayed transplants of Baladi apple rootstock irrigated with 4000 ppm salt concentration of SAR 6 and higher Cl: SO_4 ratio, during two seasons of study.

V- II- II- leaf physiological properties:

Six physiological characteristics (leaf water potential; leaf osmotic pressure; leaf relative turgidity; transpiration rate; leaf succulence grade and hard leaf character) were investigating regarding their response to specific and interaction effects of apple

rootstock transplants (M.C.; MM.106 and Baladi); sprayed nutrient element (P & K foliar spray each at 500ppm and Zn at 100ppm); chloride level (Cl: SO_4 ratio) and their combinations.

A. Specific effect:

1. Concerning the specific effect of the apple rootstock, data obtained displayed the leaves of Malus communis transplants had statistically the greatest values of leaf water potential (L.W.P.), leaf osmotic pressure (L.O.P.), leaf relative turgidity (L.R.T) and leaf succulence grade (L.S.G.) but the reverse was true with two other physiological characteristics i.e., hard leaf character (H.L.C.) and transpiration rate (L.T.R.) where the least value were significantly coupled with M.C. rootstock during two seasons of study. On the other hand, the trend of response for these 6 leaf physiological properties to apple rootstock took the other way around as Baladi and M.C. rootstocks were compared each other during both seasons. However, M.M.106 apple rootstock was in between.
2. With regard to specific effect of sprayed nutrient elements, data obtained revealed that two conflicted trends were detected. Herein, L.W.P; L.S.G.; L.R.T. and L.T.R. were significantly increased by any of 3 nutrient elements sprayed, but K foliar spray was more effective for (L.W.P & L.R.T.) and zinc spray showed the greatest increase in both L.S.G. and L.T.R. On the contrary, the trend of response for both L.O.P. and H.L.C. as influenced by 3 nutrient elements spray took the other way around, where both characteristics were significantly decreased by any foliar application (zinc was statistically the most depressive).

3. Concerning the specific effect of chloride levels (Cl: SO_4 ratio), data obtained displayed significantly the negative relationship for L.S.G.; L.R.T. and L.T.R. while the reverse was true with both L.O.P. and H.L.C. which were significantly in positc relationship with Cl: SO_4 ratio. Moreover, L.W.P. slightly respond to Cl: SO_4 ratio with a relative to be insignificantly increased by raising Cl: SO_4 ratio.

B. Interaction effect:

1. The interaction effect of the four investigated factors i.e., rootstock kind, the foliar sprayed nutrient elements and chloride level (Cl: SO_4 ratio) in the irrigation water on some leaf physiological properties, data obtained revealed that the highest values of L.W. P. and L.R.T. were in closed relationship to sprayed salt stressed (irrigated with 4000 ppm saline solution) apple transplants of Malus communis rootstock with the 500 ppm potassium sulphate, regardless of Cl: SO_4 ratio. On the other hand, the highest transpiration rate was markedly coupled with salt stressed Malus communis transplants sprayed with Zn at 100 ppm specially at low Cl: SO_4 ratio.

2. Data obtained revealed that the lowest values of (L.W.P.), (T. R.) and (L.R.T) were in closed relationship to unsprayed salt stressed transplants of Baladi apple rootstock during two seasons of study.

3. The unsprayed salt stressed transplants of M.C. and Baladi apple rootstocks exhibited statistically the highest values of leaf osmotic pressure and hard leaf character, respectively during two seasons. However, Zn foliar spray of salt stressed

transplants regardless of chloride level of M.C. and Baladi rootstocks showed the lowest values of H.L.C. and L.O.P., respectively during two seasons of study.

V.II.III. Chemical composition:

1. Photosynthetic pigments (Foliar pigments):

Leaf chlorophyll (A & B) and carotoines contents of salt stressed apple rootstocks in response to specific and interaction effects of 3 apple rootstock seedlings; sprayed nutrient elements; chloride levels (Cl: SO_4 ratio) and their combinations were investigated.

A. Specific effect:

1. Data obtained during both 2001 and 2002 experimental seasons displayed that 3 photosynthetic pigments followed the same trend regarding their response to specific effect of apple rootstock; sprayed nutrient element and chloride level (Cl : SO_4 ratio). Hence; Malus comsmunis (M.C.) leaves were statistically the richest in their 3 pigments contents followed in a descending order by MM 106 while Baladi apple transplants were the poorest in this respect.
2. The obtained results revealed that, both P & K foliar spray each at 500 ppm and Zn at 100 ppm increased 3 photosynthetic pigments, while Zn foliar spray was more effective descendingly followed in this respect by K and P foliar spray during the study.
3. Increasing chloride level (Cl: SO_4 ratio) in irrigation water significantly decreased leaf chlorophyll A & B and carotenoids compounds during two seasons of study.

B. Interaction effect:

The highest levels of chlorophyll A & B and carotenoids compounds were always in concomitant to leaves of 100 ppm Zn sprayed treatments of Malus communis (M.C.) irrigated with 4000 ppm saline solutions of lower chloride level.

The reverse was true with unsprayed salt stressed Baladi apple transplants regardless of chloride levels (Cl: SO_4 ratio). However, other combinations were in between the aforesaid 2 extremes.

II. Stem total carbohydrates and soluble sugars:

A. Specific effect:

1. Regarding the specific effect of apple rootstock, data obtained revealed that both stem total carbohydrates and total soluble sugars followed two conflicted trends. Herein, transplants of Malus communis (M.C.) rootstock had the richest stem of total carbohydrates but the poorest in their total soluble sugars content. The reverse was true with Baladi apple rootstock meanwhile, M.M.106 rootstock was intermediate regarding both total carbohydrates and sugars.

2. As for the specific effect of sprayed nutrient elements, (P & K and Zn), it is quite clear that both chemical constituents followed two conflicted trends, where total carbohydrates were increased but total sugars were decreased. Zn foliar spray at 100 ppm was more effective followed in a descending order by K and/or P each at 500 ppm as both increase and decrease in total carbohydrates and total sugars, respectively were concerned.

3. Increasing chloride level (Cl: SO_4 ratio) in irrigation water decreased total carbohydrates, but increased total sugars during two seasons of study.

B. Interaction effect:

Stem total carbohydrates and total soluble sugars each followed its own trend regarding their response to interaction effect of combinations between three studied factors (apple rootstock X sprayed nutrient elements X chloride level). Herein, the highest level of total carbohydrates was always in concomitant to salt stressed M.C. transplants sprayed with Zn at 100 ppm at low chloride level. However, the highest total sugars content was coupled to Baladi apple transplants irrigated with 4000 ppm saline solution of SAR6 and higher Cl: SO_4 ratio after they had been sprayed with 500 ppm K_2SO_4 solution. The reverse was true with unsprayed salt stressed transplants of Baladi apple rootstock and sprayed M.C. transplants with either P or Zn as total carbohydrates and soluble sugars were concerned, respectively.

III. Leaf salinity hazard coefficient (L.S.H.C.)

Data obtained revealed that L.S.H.C. differed from one rootstock to another, in this concern, M.C. had the greatest value while Baladi rootstock showed the least value. In addition, increasing chloride level in irrigation water or foliar spray of salt stressed transplants, with either P; K or Zn increased L.S.H.C. during two seasons of study.

IV. Leaf total amino acids and proline contents:

A. Specific effect:

With regard to specific effect of apple rootstock kind; sprayed nutrient elements and chloride level, data obtained revealed that both total free amino acids and proline contents followed the same trend. Herein, Baladi apple rootstock transplants, had statistically the richest leaves, followed in a descending order by MM106 and M.C. apple rootstocks. Meanwhile P; K or Zn sprays reduced significantly both chemicals constituents, however Zn foliar spray was statistically the most depressive in this concern. In addition, increasing chloride level (Cl: SO_4 ratio) in irrigation water significantly increased leaf total free amino acids and proline contents during the study.

B. Interaction effect:

Data obtained during both seasons displayed that unsprayed Baladi apple rootstock irrigated with 4000 ppm saline solution of SAR 6 and higher chloride level had statistically the highest value of both total free amino acids and proline contents. The reverse was true with the 100 ppm Zn sprayed Malus communis (M.C) apple rootstock transplants which exhibited the least values of both total free amino acids and proline contents. In addition other combinations were in between.

V. Leaf mineral composition:

In this regard specific and interaction effects of apple rootstock kind; sprayed nutrient elements (P; K and Zn); chloride levels and their combinations on leaf (Cl, Na, N, P, K, Ca, Mg, Fe,

Mn and Zn) contents of salt stressed apple rootstock transplants were investigated.

A. Specific effect:

1. Concerning the specific effect of apple rootstock kind, results obtained during both seasons revealed that Malus communis (M.C.) rootstock exceeded statistically the two other rootstocks (MM 106 and Baladi) regarding its richest leaves in their N, P, K, Mn and Fe contents from one hand which associated with the least values of leaf Cl, Na and Ca contents from the other side. Nevertheless, Baladi apple transplants had the richest leaves Cl, Na; Ca; Mg and Zn contents but the lowest N; Fe and Mn levels. In addition, MM 106 apple rootstock was intermediate as compared to two aforesaid apple rootstocks regarding their leaf mineral contents except with P; K and Zn levels where its leaves were statistically the inferior during two seasons of study.
2. As for the specific effect of sprayed nutrient elements (P; K and Zn) on leaf mineral composition of salt stressed apple transplants, data obtained revealed obviously that the response varied from one element to another. However, it could be safely concluded that, they followed one of the following 3 trends:
   a. Foliar spray of salt stressed apple transplants with P resulted in an obvious, reduction in some element level like as Cl; Na; N; K; Ca; Mg and Zn, while it increased others, i.e. both P and Fe.
   b. Foliar spray with potassium increased leaf N and K contents but decreased leaf- Cl; Na; P; Ca; Mg; Fe and Zn contents.

c. Foliar spray with zinc increased leaf –N, Fe, Mn and Zn contents while, leaf- Cl, Na, P, K, Ca, and Mg were decreased.

3. Increasing chloride level (Cl: SO_4 ratio) in irrigation water significantly decreased leaf, N, P, K, Mg, Mn and Zn. In addition, it was increased significantly leaf, Cl, Na, Ca and Fe contents during two seasons of study.

B. Interaction effect:

Concerning the interaction effect of various combinations of three investigated factors (apple rootstock kind; sprayed nutrient elements and chloride level), data obtained during 2001 and 2002 seasons revealed that :

1. The unsprayed with any of three nutrient elements salt stressed apple transplants especially Baladi rootstock under higher Cl: SO_4 ratio exhibited the highest leaf Cl, Na, Ca and Mg contents while M.C transplants of the same salinity and spray treatments had relatively higher level of these elements.

2. Sprayed M.C. apple rootstock (under salt stress of low chloride level) with potassium at 500 ppm had the highest leaf K% while sprayed with Zinc sulphate at 100 ppm exhibited the highest leaf level of nitrogen. Moreover, P foliar sprayed M.C. apple transplants had the least leaf Cl; Na and Ca contents during two seasons of study.

3. The lowest leaf- K content was always in concomitant to Zn sprayed MM 106 apple transplants (under salt stress of higher chloride level) during the study.

V.II.IV. Leaf anatomical structure:

Leaf anatomical structure of 3 apple rootstocks transplants (M.C.; Malling Morton and Baladi) as influenced by salt stress (irrigated with 4000 ppm saline solution of SAR 6 and lower or higher Cl: SO_4 ratio), besides the effect of P; K and Zn foliar sprays of salt stressed transplants of 3 apple rootstocks were investigated. Obtained results revealed the following:

A- Effect of salinity stress:

Salinity increased thickness of both cuticle and epidermis layers of two leaf surfaces as well as palisade tissue thickness. However, spongy tissue thickness and xylem rows in vascular bundle were decreased in salt stressed apple transplants of three apple rootstocks as compared to the analogous ones of tap water irrigated transplants (control).

B- Effect of P; K and Zn spray on leaf anatomy of salt stressed transplants:

Any of P; K or Zn sprayed solution succeeded at variable degrees to alleviate the harmful effect of salinity stress occurred in leaf anatomical characteristics. Herein, thickness of (cuticle & epidermis layers) of two leaf surfaces and palisade tissues were obviously decreased as compared to the corresponding ones of unsprayed salt stressed transplants for 3 apple rootstocks. However, spongy tissue and xylem rows in vascular bundle were decreased. Such trends were true with variable degrees of differences exhibited in rate of response that depended mainly on concerned anatomical character; sprayed element and apple rootstock itself.

From obtained results of the present dissertation it could be recommended for nursery men that under shortage of available fresh water that saline solution of relatively lower level of salt concentration (2000 ppm); SAR 3 and Cl: SO_4 could be safely used for irrigation purposes. Moreover, foliar sprays of salt stressed apple transplants with P; k and Zn solutions minimize to great extent the harmfull influence of salinity stress and consequently improve growth; nutritional status; enzyme activities and anatomical measurements characteristics.