V- SUMMARY AND CONCLUSION

The present investigation was undertaken during the two successive seasons of 2004 and 2005 at the experimental farm in the Horticultural Research Station at El-Kanater, Kalyubeia Governorate. This work aimed mainly to investigated the effect of different salinity concentrations, sodium adsorption ratio and chloride levels ($Cl:SO_4$ ratio) in irrigation water on some vegetative growth measurements, physiological properties and chemical constituents of both betulaefolia and communis pear rootstocks transplants from one hand and both salt tolerance of these rootstocks and possibility of minimum the depressive effect of salt stress from the other. Two-year-old uniform and healthy transplants of both betulaefolia and communis pear rootstocks were the plant materials used in this investigation. In the first week of February during both seasons, transplants were transplanted individually each in plastic pot of 35 cm in diameter that previously had filled with specific weight of clay and sand at equal proportion (by volume). Then irrigation was carried out twice weekly at the first week of February, whereas irrigation with different investigated saline solutions was stared in the first week of May and extended to six months till the experimental season was terminated on the last week of October, during both seasons of study.

Saline irrigation water was prepared by mixing chloride salts of Na^+; K^+ and Ca^{++} and sulphate salts of Na^+; K^+ and Mg^{++}, and dissolved in tap water to give such

investigated saline solutions were representative of the different twelve combinations between three concentrations of saline solutions (2000, 4000 and 6000 ppm), two levels of sodium adsorption ratio (SAR 3 & 6) and two levels of chloride (low and high $Cl:SO_4$ ratio), besides irrigation with tap water as a control treatment. In order to prevent the excessive accumulation of salts, pots of all treatments were irrigated with tap water every three weeks then followed by rewatering each with its corresponding saline solution on the next day. Meanwhile, transplants of control treatment was continuously supplied with tap water at the same rate. Accordingly, during each season two factorial experiments were conducted. The randomized complete block design was used for arranging the treatments with three replications, whereas each replicate was represented by two transplants (grown individually in plastic pots of 35 cm in diameter).

V-I- The first experiment: Effect of salinity concentrations, SAR and chloride levels ($Cl:SO_4$ ratio) on two pear rootstocks transplants:

Thirteen treatments represented the possible combinations between three factors i.e., watering with the salt concentrations (2000, 4000 and 6000 ppm) containing two levels of both SAR (3 & 6) and (low & high $Cl:SO_4$ ratio), besides the control treatment (transplants irrigated with tap water only) were

investigated on both betulaefolia and communis pear rootstocks transplants.

V-II- The second experiment: Effect of some growth regulators spray on two pear rootstocks transplants grown under salt stress:

This experiment was conducted to study the effect of three kinds of growth regulators i.e., BA; CCC and PP_{333} and each of them was sprayed on the two pear rootstocks (betulaefolia and communis) transplants grown under salt stress (6000 ppm x SAR 6 x high $Cl:SO_4$ ratio), beside water spray as control. Moreover, growth regulators foliar spray were sprayed five times from the first week of June up to the first week of October and at the concentrations of (25), (500) and (500) for BA, CCC and PP_{333}, respectively, in both seasons.

Since, those treatments abovementioned were evaluated regarding the specific and interaction effects of the investigated factors and their combinations were studied through the response of the following parameters:

1- Growth measurements.

Average length of (stem, root and total plant length); stem height and diameter; both number of leaves and branches per transplant; both leaf and total assimilation area and both fresh and dry weights of different transplant organs (leaves, stem, root, total weight of transplant and top/root ratio) were the investigated growth measurements in the first and second experiments under study.

2- Some physiological properties.

Leaf succulence grade (L.S.G); leaf osmotic pressure (L.O.P.) in bar; leaf water potential (L.W.P.) and leaf relative turgidity (L.R.T.) were estimated as a physiological properties in response to the investigated treatments in two seasons of study.

3- Some chemical constituents.

In this respect, leaf photosynthetic pigments i.e., (chlorophyll A, B and carotenoids) content; stem total carbohydrates, leaf proline content and leaf nutrient composition (N, P, K, Ca, Mg, Na, Fe, Zn and Mn) in response to the included treatments of the two experiments were studied.

V-I. The first experiment:

- **Effect of salts concentrations, sodium adsorption ratio (SAR) and chloride levels ($Cl:SO_4$ ratio) in irrigation water.**

V-I-1. Some growth measurements:

Some growth parameters namely stem height, stem diameter, root length, total length of transplant, number of both leaves and branches per transplant and both leaf area and area assimilation of plant as well as fresh and dry weights of different plant organs (leaves, stem, root & total plant weight) and top/root ratio were evaluated pertaining their response to both specific and interaction effects for three investigated factors i.e., salinity concentrations, sodium adsorption ratio (SAR) and chloride levels ($Cl:SO_4$ ratio) during both 2004 and 2005 seasons of study.

A- Specific effect

1) Referring the specific effect of salts concentrations on all growth measurements abovementioned, data obtained during both seasons displayed obviously that a significant decrease in stem length, stem diameter, root length, total length of transplant, both leaf area & total assimilation area per transplant and number of both leaves & branches per transplant as well as fresh and dry weights of transplant organs (leaves, stem, root and total weight of plant) and top/root ratio, all being progressively depressed by all the sued salinity concentrations in irrigation water. Moreover, increasing salts concentrations in the irrigation water resulted in a significantly gradual decrease in all growth measurements. In addition, the depressive effect was more pronounced with the highest salts concentration. Such trends was detected for both betulaefolia and communis pear rootstocks transplants during both 2004 and 2005 of study.

2) With respect to the specific effect of sodium adsorption ratio (SAR), data revealed that a significantly decreased in all investigated growth measurements observation with increasing sodium adsorption ratio (SAR) from lower ratio (SAR3) to higher one (SAR6) in the two pear rootstocks transplants under study during the two experimental seasons.

3) As for the specific effect of chloride levels ($Cl:SO_4$ ratio), data obtained declared that the higher ratio of chloride level (high $Cl:SO_4$ ratio) in irrigation water

resulted in a significantly reduction of all aforesaid studied growth measurements than lower one i.e., ($Cl:SO_4$ ratio) in both studied pear rootstocks transplants throughout first and second seasons of study.

B- Interaction effect

Regarding the interaction effect between the investigated three factors i.e., salts concentrations (SAR) and chloride levels ($Cl:SO_4$ ratio) in irrigation water, obtained results showed that all combinations treatments resulted in a significant reduction in all investigated in majority of cases. This reduction increased with increasing the salinity concentrations, SAR and $Cl:SO_4$ ratio together i.e., (6000 ppm of saline solution x SAR6 x high $Cl:SO_4$ ratio), however this treatment exhibited the highest significantly decreased in growth parameters. Moreover, both pear rootstocks transplants irrigated with (2000 ppm x SAR3 x lower $Cl:SO_4$ ratio) resulted in statistically the least reduction in values of different growth measurements follow the tap water irrigated ones as compared to the analogous rates of other saline combinations which were in between the aforesaid two extremes during the two seasons of study.

V-I-2- Effect of salts concentrations, sodium adsorption ratio (SAR) and chloride levels ($Cl:SO_4$ ratio) in irrigation water on some leaf physiological characteristics:

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.) were the investigated as the

leaf physiological characteristics. Data showed the specific and interaction effects on the abovementioned four physiological properties as influenced by the three studied factors i.e., salts concentrations, SAR and chloride level ($Cl:SO_4$ ratio).

A- Specific effect

1) Regarding the specific effect of salts concentrations, data obtained revealed that the lowest significant values of both leaf water potential and leaf relative turgidity were resulted by the highest salinity concentration i.e., (6000 ppm) in irrigation water. On the other hand, increasing salts concentrations in irrigation water exhibited the highest statistical values of both leaf osmotic pressure and leaf succulence grade during 1st and 2nd seasons of study.

2) Concerning the specific effect of sodium adsorption ratio (SAR) on leaf physiological properties under study, results obtained declared that increasing sodium adsorption ratio (SAR) from lower to higher ratio i.e., from SAR3 up to SAR6 resulted in a significant decrease in the percentages of both leaf water potential and leaf relative turgidity. On the contrary, the trend took the other way around with both leaf osmotic pressure and leaf succulence grade as specific effect of SAR was concerned during 2004 and 2005 seasons.

3) With respect to the specific effect of chloride levels ($Cl:SO_4$ ratio) on some leaf physiological characteristics, data obtained displayed obviously that the highest values of the percentages of both leaf water potential and leaf relative turgidity were always in

concomitant to transplants irrigated with saline solutions contain the lower level of chloride (low $Cl:SO_4$). However, the reverse was true with both betulaefolia and communis pear rootstocks transplants irrigated with saline solutions contain the higher level of chloride (high $Cl:SO_4$ ratio) which had leaves with lowest values of both leaf osmotic pressure and leaf succulence grade percentages. Furthermore, the differences were significant with the former abovementioned four leaf physiological properties. Such trends were detected during the two experimental seasons.

B- Interaction effect

The obtained results concerning the interaction effect between the three investigated factors i.e., salinity concentrations, sodium adsorption ratio (SAR) and chloride levels ($Cl:SO_4$ ratio) in the irrigation water, revealed that the highest values of the percentage s of leaf water potential and leaf relative turgidity were statistically in concomitant to the two pear rootstocks transplants irrigated with either tap water or (2000 ppm saline solution x SAR3 x lower $Cl:SO_4$ ratio). Meanwhile, the least value was coupled with transplants irrigated with (6000 ppm saline solution x SAR6 x higher $Cl:SO_4$ ratio). The other combinations treatments were in between regarding the response of the two aforesaid leaf physiological characteristics throughout the 1st and 2nd seasons of study.

On the other hand, data obtained concerning the interaction effect of (salts concentration x SAR x $Cl:SO_4$ ratio) in the irrigation water pointed out that, the highest

values of both leaf osmotic pressure and leaf succulence grade were completed with transplants irrigated with (6000 ppm) saline solution of SAR6 and higher Cl:SO_4 ratio). Whereas, the least values of both leaf osmotic pressure and leaf succulence grade were related with irrigated transplants of two rootstocks with either tap water or saline solution of 2000 ppm concentration combined with the lower level of both SAR (SAR3) and chloride (low Cl:SO_4 ratio). In addition, the other combinations treatments were intermediate concerning the response of such investigated leaf physiological characteristics during 2004 and 2005 seasons of study.

V-I-3- Effect of salts concentrations, sodium adsorption ratio (SAR) and chloride levels (Cl:SO_4 ratio) in irrigation water on some chemical constituents.

V-I-3-1- Effect on leaf photosynthetic pigments:

A- Specific effect

Data obtained during both seasons of study indicated that both chlorophyll A and B as well as caroteinoids content in both betulaefolia and communis pear rootstocks transplants leaves progressively decreased by the three investigated salts concentrations were used in this study.

Moreover, increasing salinity concentrations in the irrigation water resulted in significantly decreased in leaf pigment contents during the two seasons of study.

As for the specific effect of both sodium adsorption ratio (SAR) and the chloride levels (Cl:SO_4

ratio), the obtained results revealed that both chlorophyll A and B as well as caroteniods contents in the leaves were significantly decreased with increasing both SAR from 3 to 6 and chloride level from lower to higher $Cl:SO_4$ ratio. Such trend was true during both 2004 and 2005 seasons of study.

B- Interaction effect

Regarding the interaction effect between the three investigated factors i.e., salinity concentrations, sodium adsorption ratio (SAR) and chloride levels ($Cl:SO_4$ ratio) in irrigation water data obtained revealed that a significantly decreased was detected with the leaf chlorophyll A and Chlorophyll B as well as caeotenoids content in leaves of both betulaefolia and communis pear rootstocks transplants during the two experimental seasons of study. Herein, the combination between the highest salinity concentration and the higher ratio of both SAR and $Cl:SO_4$ ratio i.e., (6000 ppm x SAR6 x high $Cl:SO_4$ ratio) treatment gave the greatest significantly decrease in leaf content of chlorophyll A, B and carotenoids. On the other hand, the reverse trend was observed with transplants irrigated with the lowest salts concentrations and lower levels of both SAR and $Cl:SO_4$ ratio i.e., (2000 ppm x SAR3 x low $Cl:SO_4$) which showed the lowest decrease in leaves content of studied pigments meanwhile, the other combinations were in between the extremes. Such trends were true with both pear rootstocks transplants during the two seasons of study.

V-I-3-2- Effect on leaf proline content:

A- Specific effect

Concerning the specific effect of salts cncentations in the saline solutions used for irrigation on leaf proline content of both betulaefolia and communis pear rootstocks transplants, data obtained displayed that proline content in the leaves increased significantly and gradually with increasing salinity concentrations in irrigation water. Moreover, transplants irrigated with the saline solutions of 6000 ppm had statistically the richest leaves of proline content followed in descending order by those irrigated with 4000 ppm saline solutions, whereas transplants irrigated with the lowest salts concentrations i.e., (2000 ppm) was the inferior in this concern.

Referring the specific effect of both sodium adsorption ratio and chloride levels ($Cl:SO_4$), data obtained revealed that increasing either sodium adsorption ratio from SAR3 to SAR6 and/or chloride levels from low to high $Cl:SO_4$ ratio in irrigation water significantly increased leaf proline contents during both 2004 and 2005 seasons of study.

B- Interaction effect

Considering the interaction effect of different combinations between three investigated factors i.e., (salts concentrations sodium adsorption ratio and $Cl:SO_4$ ratio), data obtained during the two experimental seasons revealed that the specific effect of each investigated factor was reflected directly on its own combinations. However, transplants irrigated with the highest

concentrated saline solutions (6000 ppm) with higher levels of both SAR (SAR6) and chloride level (high $Cl:SO_4$ ratio) had statistically the richest leaves in their proline contents, whereas the trend took the other way around with the control (transplants irrigated continuously with tap water) followed by those supplied with saline solution of 2000 ppm combined content were recorded during both seasons of study.

V-I-3-3- Effect on total carbohydrates content in stem:

A- Specific effect

Data obtained during the two seasons of study displayed obviously that total carbohydrates contents in stem responded specifically to the three investigated factors i.e., salts concentrations, sodium adsorption ratio and chloride levels ($Cl:SO_4$ ratio). Hence, increasing of salinity concentration and raising of any ratio of either SAR or $Cl:SO_4$ ratio resulted in decreasing the total carbohydrates contents in the stem.

B- Interaction effect

Obtained results indicated that total carbohydrates contents in stem responded to interaction effect of three investigated factors aforesaid. However, the lowest value of total carbohydrates in stem from one hand was always in concomitant to the pear rootstocks transplants irrigated with 6000 ppm salinized water of SAR6 and higher $Cl:SO_4$ ratio. The opposite trend was markedly with transplants irrigated continuously with tap water (control) followed by those irrigated with 2000 ppm saline solution of SAR3 and lower $Cl:SO_4$ ratio during the first and second seasons of study. In addition, the other

combination treatments were in between the abovementioned two extremes with variable tendency of variance as combinations of such intermediate category were compared each either during the two experimental seasons.

V-I-3-4- Effect of salts concentrations, sodium adsorption ratio, chloride level and their combinations of irrigation water on leaf nutritional status (leaf mineral composition):

Considering the leaf N, P, K, Ca, Mg, Na, Fe, Zn and Mn contents of both betulaefolia and communis pear rootstocks transplants in response to specific and interaction effects of the differential salts concentrations, sodium adsorption ratio (SAR), chloride level ($Cl:SO_4$ ratio) and their possible combinations. It could be summarized the obtained data throughout the two seasons of study as follows:

A- Specific effect

Regarding the specific effect of salts concentrations on the leaf mineral content, data obtained during both seasons indicated clearly that all nutrient elements were significantly affected by the specific effect of salts concentrations in irrigation water solutions. However, the leaf N, P, K, Mg, Fe, Zn and Mn contents were significantly decreased and gradually with increasing salt concentrations in irrigation solutions. On the other hand, the reverse trend was observed with leaf Ca and Na contents in the two seasons of study.

With respect to the specific effect of sodium adsorption ratio (SAR) of saline solution used for irrigation, obtained results displayed obviously that increasing SAR from 3 to 6 resulted in significantly decreased leaf N, P, K, Mg, Fe, Zn and Mn contents, while increased leaf Ca and Na contents.

Concerning the specific effect of chloride level ($Cl:SO_4$ ratio), data revealed that raising chloride level ($Cl:SO_4$ ratio) from low to high level in the irrigation water caused significantly decreased leaf N, P, K, Mg, Fe, Zn and Mn contents. Contrary to that, both leaf Ca and Na contents were increased significantly with increasing chloride level ($Cl:SO_4$ ratio). In addition all these trends were detected with both betulaefolia and communis pear rootstocks transplants during both seasons in this investigation.

B- Interaction effect

As for the interaction effect of different combinations between the various variables of the three investigated factors in leaf mineral contents i.e., (N, P, K, Ca, Mg, Na, Fe, Zn and Mn) of both betulaefolia and communis pear rootstocks transplants, data showed obviously that the specific effect of each tested factor (salts concentrations, sodium adsorption ratio (SAR) and chloride level ($Cl:SO_4$ ratio) was directly reflected on their combinations during both 2004 and 2005 seasons of study. In the other words, the irrigated both pear rootstocks transplants with the highest salt concentration and higher ratio of SAR and $Cl:SO_4$ ratio i.e., (saline solution of 6000 ppm x SAR 6 x high $Cl:SO_4$ ratio) had the poorest leaves in their N, P, K, Mg, Fe, Zn and Mn

contents related with the richest values of leaves in their saline solutions during the two experimental seasons. However, the lowest decrease in leaf N, P, K, Mg, Fe, Zn and Mn contents and the least increase of leaf Ca and Na contents were detected by those transplants irrigated with (2000 ppm saline solution x SAR 3 x lower Cl:SO_4 ratio) as compared to those continuously irrigated with tap water only (control), where least values. Such trend was true during both 2004 and 2005 seasons of study for both betulaefolia and communis pear rootstocks transplants.

V.II. Experiment II:

- **Effect of foliar spray with three growth regulators (CCC, BA and PP_{333}) sprays on salinity stressed transplants of two pear rootstocks:**

V- II-1- 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 treatments.

Regarding the effect of sprayed growth regulators, results declared that all investigated growth measurements of the salinity stressed transplants were significantly increased by any of three growth regulators however, BA at 25 ppm foliar spray proved to be the most effective in this regard followed in a descending order by CCC and PP_{333} each at 500 ppm foliar spray during two seasons of study.

V- II-2- Leaf physiological properties:

Four physiological characteristics (leaf water potential; leaf osmotic pressure; leaf relative turgidity and leaf succulence grade) were investigating regarding their response to effects of sprayed three growth regulators (CCC, PP_{333} foliar spray each at 500ppm and BA at 25 ppm).

With regard to specific effect of sprayed three growth regulators (CCC, BA and PP_{333}), data obtained revealed that, two conflicted trends were detected. Herein, L.W.P; L.S.G. and L.R.T. were significantly increased by any of 3 growth regulators sprayed, but CCC foliar spray was more effective for (L.W.P & L.R.T.) and BA spray showed the greatest increase in L.S.G. On the contrary, the trend of response for L.O.P. as influenced by 3 growth regulators spray took the other way around; where characteristic was significantly decreased by any foliar application.

V.II.3. Chemical composition:

1. Photosynthetic pigments (Foliar pigments):

Leaf chlorophyll (A & B) and carotenes contents of salt stressed pear rootstocks in response to effects of sprayed growth regulators were investigated.

The obtained results revealed that, both (CCC and PP_{333}) foliar spray each at 500 ppm and BA at 25 ppm increased 3 photosynthetic pigments, while BA foliar spray was more effective descendingly followed in this respect by (CCC and PP_{333}) foliar spray during the study.

2. Stem total carbohydrates:

As for the effect of sprayed growth regulators, (CCC, BA and PP_{333}), it is quite clear that total carbohydrates was increased. BA foliar spray at 25 ppm was more effective followed in a descending order by CCC and/or PP_{333} each at 500 ppm as increase in total carbohydrates.

3. Leaf proline contents:

With regard to effect of (CCC, BA and PP_{333}) sprays reduced significantly proline; however BA foliar spray was statistically the most depressive in this concern during the study.

4. Leaf mineral composition:

In this regard, effect of sprayed growth regulators (CCC, BA and PP_{333}) on leaf (Na, N, P, K, Ca, Mg, Fe, Mn and Zn) contents of salt stressed pear rootstock transplants were investigated.

As for the effect of sprayed growth regulators on leaf mineral composition of salt stressed pear transplants, data obtained revealed obviously that the response varied from one element to another. However, it could be safely concluded that:

a. Foliar spray with both CCC and BA as well as PP_{333} solely increased leaf N, P, K, Fe; Mg, Mn and Zn contents, but decreased leaf- Na and Ca contents.