4. RESULTS AND DISCUSSION

4.1. Effect of salinity and/or sodicity on dry matter yield:

The dry matter yield of sunflower varieties grown on the soils affected by salinity and/or sodicity (normal non saline-non sodic, saline-non sodic, saline-sodic and non saline-sodic soils) is presented in Table (2) and illustrated graphically in Fig. (1). A comparison of the dry matter yields of the three varieties at vegetative, flowering and fruiting stages of growth shows that Fedok gave higher yield than Iroflor and Giza 2 when the plants were grown on the normal soil (non saline-non sodic). This holds true at the different studied stages of growth. However, the dry matter yields of the different varieties at different stages of growth were adversely affected by soil salinity or sodicity. These results are in agreement with those reported by **Ouerghi *et al.* (1991)** and **Francois (1996)** who found that salinity reduced dry matter production of sunflower. Also, **Cheng (1984)** reported that dry matter yield of the above ground parts at three growth stages of sunflower decreased with increasing salinity. This decrease in the dry matter yield of the three varieties may be attributed to the water imbalance which results in "physiological drought" and/or ionic imbalance which causes depletion of the energy required for metabolism. **Bernstein (1964)** stated that the presence of excessive concentrations of salts in the root zone of plant may affect plant growth in a number of ways:

- ✓ The increased osmotic pressure of saline soil solution tends to restrict the uptake of water by plants.
- ✓ On the other hand, when the plants absorb the constituent ions of a saline solution, this may result, in some cases, in toxic accumulation of a particular ion or decreased absorption of some essential elements.

Leidi and Lips (1990) attributed the decrease in yield of the plants grown on the saline soils to the osmotic pressure. He stated that plants exerts energy to extract water from the soil (the soil water potential). This energy should be greater than that with which soil retains water. Salts in the soil solution increase osmotic potential. Thus, in saline soils, the energy required for water absorption by plants should exceed the soil water potential plus the osmotic potential.

Data also show that the non saline sodic soil was most effective on decreasing the dry matter yield of all varieties, then saline-sodic soil and finally the saline- non sodic soil. The corresponding relative decrease in dry matter yield of the plants grown on the non saline- sodic soil reached approximately as mean averages of all the studied varieties of sunflower 32, 22, and 43% at the vegetative, flowering and fruiting stages, respectively. The corresponding decreases in the saline-sodic soil (mean averages) reached approximately 25, 16 and 32% in the same respective order. Corresponding lower values were attained for the plants grown on the non sodic-saline soil, where the decreases reached approximately 22, 14 and 22% at the vegetative, flowering and fruiting stages, respectively. This means that, the dry matter yield of sunflower varieties was mainly affected with Na ions, especially at fruiting stage. In fact, **Helal *et al.* (1975)** suggested the negative influence of NaCl stress on growth to be due to a detrimental effect of Na on certain metabolic processes.

Several experiments were offered for declaring the adverse effect of Na on plant growth. **Poonia and Jharer (1974)** reported that exchangeable Na^+ raises the pH of the soil causing precipitation of Ca^{2+} and thus induces Ca^{2+} deficiency in sodic soils. **Leidi and Lips (1990)** pointed out that plants suffer from the excessive exchangeable Na^+ in two manners. The first is due to its competition with other nutrient cations e.g. K. The second is due to its deleterious effect.

To give a clear picture about the growth behaviour of the three examined varieties of sunflower plant, yields of dry matter at the different stages of growth expressed as relative percentages of the corresponding ones of the plants grown on the normal soil which so-called "tolerance index" were calculated and given in Table (3) and illustrated graphically in Fig. (2). Data reveal that, generally, at all stages of growth dry matter yield of Giza 2 was less affected by soil salinity and/or sodicity than Iroflor and Fedok. Where, Giza 2 variety gave higher tolerance index values than Fedok and Iroflor at the different stages of growth. This holds true for all soils under the study, indicating that Giza 2 variety was more tolerant to salinity and/or sodicity than both Fedok and Iroflor. These variations in responses of the three studied varieties are in agreement with those of **Leidi and Lips (1990)** who reported that dry mater yield of relatively salt-resistant plants was less affected by salinity than relatively salt-sensitive ones. .In general, the different varieties showed the following order with respect to their salt tolerance: Giza 2> Iroflor> Fedok.

4.2. Effect of salinity and/or sodicity on some growth parameters:

Some growth parameters of sunflower varieties, i.e., stem diameter (mm), plant height (cm) and leaf area index (cm^2), grown on soils affected by salinity and/or sodicity are presented in Table (4). A comparison considering these parameters among the three varieties at vegetative, flowering and fruiting growth stages shows that Fedok variety gave higher stem diameter, plant height and leaf area index than Iroflor or Giza 2 varieties when the plants were grown on normal soil. This hold true at the different growth stages.

However, these parameters for different varieties were adversely affected by salinity or sodicity, where, these parameters markedly decreased when the plants were grown on any of the salt affected soils. Sodicity seemed to be more adversely effective on the studied growth parameters than salinity. In this concern, **Rawson and Munns (1984)** found that salinity reduced relative leaf expansion rate/plant. **Ouerghi *et al.* (1991)** showed that salinity reduced stem length by 37%. The decrease in these parameters are mainly attributed to the reduction in plant growth as a result of physiological drought. **El-Midaoui *et al.* (1999)** reported that leaf area was most affected by increasing salinity followed by the plant height. Also, **El-Kheir *et al.* (2000)** reported that the increase in salinity of the irrigation water significantly decreased plant height, number and area of leaves per plant.

On the other hand, varietal differences were also observed, where Giza 2 gave higher relative values of stem diameter, plant height and leaf area index than Iroflor and Fedok varieties when these plant varieties were grown on saline, saline-sodic and sodic soils. For example, at vegetative stage, the values of relative decrease for the stem diameter of Giza 2 were 12, 38 and 50% for saline, saline-sodic and sodic soils, respectively. The corresponding values of relative decrease were 23, 45 and 67% for Iroflor and 30, 40 and 60% for Fedok at the same order. For plant height, the relative decrease values for Giza 2, Iroflor and Fedok were 15, 25 and 46; 22, 23 and 52 and 18, 30 and 47% when these varieties were grown on the saline, saline-sodic and sodic soils, respectively. For leaf area index, the relative decrease values were 6, 14 and 37% for Giza 2; 16, 24 and 53% for Iroflor and 12, 24 and 52% for Fedok grown on saline, saline-sodic and sodic soils, respectively. Similar findings were obtained at the other two stages of growth, indicating again that Giza 2 was more tolerant for salinity and/or sodicity than Fedok and Iroflor varieties.

4.3. Effect of salinity and/or sodicity on plant content of Na and Cl:

4.3.1 Sodium :

Data in Table (5) and Fig. (3) show that Na content expressed as percentage in sunflower varieties at different stages of growth increased as a result of soil salinity and/or sodicity compared with normal soil. However, this increase was more obvious at the fruiting stage than other stages of growth. This holds true for the saline, saline-sodic and sodic soils. Similar results were observed by **Santos *et al.* (1999)** who reported that salt stress increased Na content in the whole plant of sunflower. Also, data revealed that Na contents in the different varieties grown on the non saline-sodic soil were higher than the corresponding contents of the plants grown on saline and saline-sodic soils. However, Na contents of all the varieties grown on the saline and saline-sodic soils were still higher than the corresponding ones of the plants grown on normal soil.

A comparison of Na content of the three varieties, the obtained data reveal that Na contents of Fedok and Iroflor varieties were higher than that of Giza 2 at the different stages of growth and in all the studied soils. The higher Na content in Fedok and Iroflor varieties seemed to be due to the much more pronounced adverse effects of salinity on their growth as compared with Giza 2. These results indicate that Giza 2 variety is more resistant to soil salinity than Fedok and Iroflor varieties. In other words, it can be said that the differences between the Na content of relatively salt-sensitive verities (Fedok and Iroflor) on one hand and the corresponding Na content of the relatively salt resistant variety (Giza 2) are mainly due to the differences in the rate of Na uptake and its translocation to the above ground parts. Where, Giza 2 plants (salt-resistant) were able to withstand the unfavourable effect of high Na on growth through higher accumulation of proline (as shown in Table, 5). Data in Table (5) and illustrated graphically in Fig. (4) also indicate that Na uptake by all varieties increased when plants were grown on salt affected soils. Such a finding agrees well with those of **Padole (1991)** who found that uptake of Na increased with increasing salinity and/or sodicity of soil and irrigation water. The comparison between the salt-resistant variety and the salt-sensitive ones, reveals that Na uptake by Giza 2 plants was less than that of Fedok and Iroflor plants at all stages of growth and in all the studied soils. However, Na uptake by the different varieties grown on the sodic soil was higher than the corresponding ones taken up by the plants grown on saline and saline-sodic soils though uptake values of the later plants were still higher than those of the plants grown on the normal soil. This result supports the previous finding that salt-resistant varieties had taken up less amount of Na than salt-sensitive ones.

As a conclusion, growth of relatively salt tolerant plants seemed to be less responded to salinity compared to those relatively salt sensitive varieties, in spite of their relatively lower Na- content. This suggests the more possibility of better growth for sequestery of Na in specific tissues or cell compartments more efficiently with more osmotic adjustment and thus avoid Na toxicity.

A calculation of Na concentration in plant water might give a rather true picture about the actual concentration of Na in plant, since the concentration of Na in plant water is more or less independent on the diluting effect of dry matter production.

As can be seen from Table (6), the Na concentration in plant water of Fedok and Iroflor varieties was usually higher than that of Giza 2 at all the studied growth stages. The data of the ratio of Na concentration in plant water to Na concentration in external solution of the soils clearly show that all varieties were able to accumulate Na against concentration gradient at the different stages of growth. However, these varieties greatly differed in their accumulated Na and consequently their relatively tolerant to Na in the soils. Fedok and Iroflor varieties were more able to accumulate Na rather than Giza 2, especially at the flowering stage. These results may lead to suggest that the relatively salt-sensitive varieties (Fedok and Iroflor) accumulate higher amount of Na to facilitate rapid osmotic pressure adjustment whereas the relatively salt-resistant variety (Giza 2) produce higher proline in plant tissues (as shown in Table, 9) to reduce the adverse effect of Na on plant growth. The results of Na concentration in plant water also suggest that the relative salt-resistant variety took up less amount of Na than the salt-sensitive varieties (as shown in Table, 6).

4.3.2. Chloride:

Data presented in Table (7) and illustrated graphically in Figs. (5 and 6) show Cl content and uptake by different varieties of sunflower plants grown on soils affected by salinity and/or sodicity. Chloride content increased in the salt affected soils compared with that of the normal one. This truth was observed at the different stages of growth. These results are in agreement with those obtained by **Santos *et al.* (1999)** and **Sayed and Gadallah (2002)** who reported that salt stress increased Cl content in the whole plant of sunflower. Data also revealed that Cl content of the different varieties was higher in saline soil than the corresponding Cl content of saline-sodic and sodic soils whose values were still higher than the corresponding ones of the normal soil.

Varietal differences were also observed for Cl content in sunflower varieties and were very similar to those obtained for Na content. In Giza 2, Cl content was lower than the corresponding Cl contents of Fedok and Iroflor varieties at the different growth stages and in the studied different soil, possibly due to variations in osmotic adjustment **(Gorham *et al.* 1985)**.

As in case of Na, Cl uptake by different varieties was high, especially in saline soil. Irrespective of the results in Table (7), it is quite clear that the relatively salt-sensitive varieties (Fedok and Iroflor) absorbed more Cl than the relatively salt-resistant one. However, the varietal differences tended to be relatively minute. This might be due to the fact that the adverse effect of salinity was more obvious in relatively salt-sensitive than in relatively salt-resistant plant.

A comparison for Cl content among different verities, can be best made if expressed on plant water basis. Chloride concentrations in plant water expressed as m mol_c/L of the three varieties at different stages of growth are presented in Table (8). It is quite clear that Cl concentrations in plant water of Fedok and Iroflor were always higher than in Giza 2 at all stages of growth. These results indicate that Fedok and Iroflor varieties take up higher amounts of Cl from external soil solution than that of Giza 2 (see the ratio between inner Cl/outer Cl). Also, data reveal that the concentrations of Cl in plant water of different varieties grown on all the studied soils were higher than that of Cl concentration in the external soil solution. This was observed at all stages of growth.

4.4. Effect of salinity and/or sodicity on the content of free proline amino acid:

Proline plays an adaptive role in the tolerance of plant cells to salinity by increasing the concentration of cultural osmotic components in order to equalize the osmotic potential of the cytoplasm **(Watd *et al,* 1983)**.

Accordingly free proline contents of the studied varieties of sunflower plants as affected by soil salinity and/or sodicity at different growth stages were shown in Table (9) and Figs. (7 and 8). Proline content in sunflower varieties grown on the different salt affected soils particularly those grown on the sodic soil at the different growth stages increased as compared with the corresponding proline contents of the same varieties upon growing on the normal soil. This increase in proline content may be due to retardation of protein synthesis and consequently accumulation of free amino acids, such as proline **(Wareing and Phillips, 1978)**. Such results are confirmed by those of **Yurekli *et al* (1996)** who found that proline concentration in leaves of sunflower increased significantly with increasing NaCl concentration.

Also, data reveal that at the vegetative stage, proline contents in the three varieties of sunflower i.e. Fedok, Iroflor and Giza 2 grown on saline, saline-sodic and sodic soils were; 1.5, 2.5, 2.9; 1.7, 2.5, 2.9 and 2.8, 3.0 and 3.3 times, respectively higher than the proline contents of the same varieties upon growing them on the normal soil. The corresponding values at the flowering stage were; 2.7, 3.3, 3.7; 3.0, 3.3, 3.8 and 3.5, 4.2 and 5.1 times higher than the normal soil in the same respective order. At fruiting stage, the proline values were; 1.3, 2.3 and 2.8; 1.4, 2.3 and 2.9 and 3.0, 3.0 and 3.4 times higher than the proline contents of Fedok, Iroflor and Giza 2 grown on the normal soil. These results are cope with those reported by **Anjum *et al*. (2005)** who found that proline accumulation in the leaves of plants grown on salt affected soil was 8 times higher than in the control.

Varietal differences were also observed for proline content in sunflower varieties whereas, proline content in the relatively salt tolerant variety (Giza 2) was higher than that in relatively sensitive varieties (Fedok and Iroflor). This result indicates that there was a relationship between proline content and the relative salt tolerance of plant. Such results agree with those of **Ashraf and Tufail (1995)** who reported that the salt tolerance varieties of sunflower accessions had greater proline in the leaves than the salt sensitive ones. Also, these results may suggest the accumulation of proline to be an adaptive mechanism for osmoregulation in plant cells to cope with salinity problems **(Wated *et al.*, 1983)**. **Ouerghi *et al.* (1991)** mentioned that the proline accumulation contributed only to osmotic adjustment.

4.5. Effect of salinity and/or sodicity on macronutrients content:

4.5.1. Nitrogen:

Values of nitrogen content and uptake by the studied sunflower varieties grown on soils affected by salinity and/or sodicity are shown in Table (10) and Fig. (9). Data indicate that values of N content and uptake by all varieties decreased when they were grown on saline, saline-sodic and sodic soils compared with the corresponding ones of the same varieties grown on the non saline- non sodic (Normal) soil. Sodicity seemed to have more pronounced effect on decreasing both N% and uptake. This reduction effect of salinity and/or sodicity on N content and uptake has been observed by many workers such as **Gorham *et al.* (1985)** and **Santos *et al.* (1999)** who reported that salinity decreased NO_3 content in the whole plant of sunflower. Also, **Singh *et al.* (1992)** found that the uptake of nitrogen by wheat plants significantly decreased with increasing salinity. Such reduction could be attributed to a disturbance in water absorbed and a decrease of root permeability.

Comparing the N content between different varieties of sunflower, data indicated a general higher depressive effect salinity and/or sodicity on Fedok and Iroflor varieties than Giza 2 variety, which may reflect differences in salt tolerance between the three varieties. Therefore, N content in Fedok and Iroflor varieties (relatively salt-sensitive) was less than of Giza 2 variety (relatively salt-resistant). This may be attributed to the higher Cl uptake by those two varieties, which restricts nitrate uptake. Such results are agreeable with those obtained by **El-Shazly (2001)**.

On the other hand, the increase in content of proline amino acid in different varieties was associated with an increase in amount of N content where Giza 2 contained higher amounts of N and proline, while Fedok and Iroflor contained lower amounts of N and proline amino acid. This finding holds true at the different stages of growth and for all the studied soils. These results reflect the effect of proline amino acid on plant growth. However, this effect was more obvious with sodic soil than with saline and saline-sodic soils where, the relative decrease in N content of Giza 2 at vegetative stage was 36, 9 and 6% for sodic, saline-sodic and saline soils, respectively. The corresponding values for Fedok were 53, 31 and 25% in the same respective order. For Iroflor, the corresponding relative decrease in N values were 43, 17 and 11% for sodic, saline-sodic and saline soils, respectively. Similar trends were also observed at flowering and fruiting stages. These results support the previous finding that Cl uptake by plants restrict nitrate uptake and are in agreement with that of **Jones and Gorham (1986)** who reported that high Cl in nutrient media restrict nitrate uptake.

4.5.2. Phosphorus:

Data presented in Table (11) and illustrated graphically in Fig. (10) reveal that the P content and uptake by the concerned varieties decreased when they were grown on saline, saline-sodic and particularly sodic soils compared with the non saline -non sodic soil.

These results are in agreement with those reported by **Farghali and Gadallah (1996)** who found that concentration of P in sunflower was adversely affected significantly by salinity. Also, **Sharma and Swarup (1988)** and **Padole (1991)** reported that uptake of P was adversely affected with increasing salinity and/or sodicity of soil. This reduction in P content and uptake may be attributed to the competitive effect of Cl ions.

On the other hand, P content in relatively salt-resistant sunflower variety (Giza 2) was higher than those of the relatively salt-sensitive ones (Fedok and Iroflor), mainly due to the capacity of the plants to maintain a high P content (**Wilson *et al.*, 1970**).

Moreover, the results of proline content in different varieties of sunflower grown on saline, saline-sodic and sodic soils showed that Giza 2 contained higher amounts of P and proline, while Fedok and Iroflor varieties contained lower amounts of P and proline amino acid. These results reflect the effect of proline amino acid on plant growth and consequently its uptake of P where, the relative decreases in P content of Giza 2 at vegetative stage were; 43, 39 and 4% for sodic, saline-sodic and saline soil, respectively. The corresponding values for Fedok were; 61, 55 and 33% in the same order. For Iroflor, the corresponding values were; 55, 48 and 19% for sodic, saline-sodic and saline soils, respectively. Similar trends were also obtained at flowering and fruiting stages. This results support the previous finding that Cl uptake by plants restrict P uptake, agrees with that of **Padole (1991)** who reported that the reduction in P uptake may be attributed to the competitive effect of Cl ions.

4.5.3. Potassium:

Under saline conditions, potassium plays an essential role in membrane transport processes along with establishment for the cell ionic and osmotic equlilbria **(Clarkson and Hanson, 1980)**. Accordingly, K content and uptake by different varieties of sunflower grown on saline, saline-sodic and sodic soils are shown in Table (12) and Fig.(11). Data indicated a general depressive responses due to salinity and/or sodicity occurred in the salt-affected soils particularly the sodic one. This may be due to the antagonistic phenomenon which is known to frequently take place between K ions and Na ones (**Abdel-Aziz *et al.* 1978).** These results are in agreement with those of **Farghali and Gadallah (1996)** and **Santos *et al.* (1999)** who reported that salinity decreased K content in sunflower plants. Also, **Padole (1991)** showed that uptake of K by wheat plants was adversely affected with increases in salinity and/or sodicity of either soil or irrigation water.

Moreover, varietal differences could be observed, since the content of K in relatively salt-resistant variety (Giza 2) was higher than in the relatively salt-sensitive varieties (Fedok and Iroflor). This finding holds true at all stages of growth and was more obvious in sodic soil than in saline and saline-sodic soils. This is mainly attributed to high Na uptake by Fedok and Iroflor varieties which restrict K uptake as shown by **Abdel-Aziz *et al.*, (1987)**.

Also, data showed that increased contents of proline amino acid were found in the different varieties of sunflower grown on saline, saline-sodic and sodic soils was associated with the increased content of K where Giza 2 variety contained higher amounts of both K and proline, while Fedok and Iroflor varieties contained lower amounts of both K and proline amino acid. This finding holds true at the different stages of growth and for all the studied soils. The depressive effect on K was more obvious in sodic soil than in saline and saline-sodic soils, where, the relative decrease in K content in Giza 2 at the vegetative growth stage was 1, 17 and 38% for saline, saline-sodic and sodic soils, respectively. The corresponding values for Fedok were 15, 25 and 47% in the same respective order. For Iroflor, the corresponding values were 8, 22 and 44% for saline, saline-sodic and sodic soils, respectively. Similar trends were also obtained at both the flowering and fruiting stages. The decrease in K content was more obvious in sodic soil than in saline and saline-sodic soils and in Fedok and Iroflor varieties than in Giza 2 variety. These results support the previous finding that Na uptake by plants restrict K uptake as shown by the data of **Abdel-Aziz *et al.*, (1987)** who reported that the high Na uptake by sunflower plants was associated with low K uptake.

4.6. Effect of salinity and/or sodicity on micronutrients content:

Micronutrients content and uptake values by sunflower varieties grown on soils affected by salinity and/or sodicity are shown in Tables (13 - 16) and Figs. (12-15). Soil salinity and/or sodicity caused decreases in Fe, Mn, Zn and Cu content in the different varieties of sunflower at all the studied growth stages. Similar trends were also obtained by **Nirlep *et al.*, (1990)** who showed that the leaf Zn, Cu, Mn and Fe contents generally decreased with increasing soil exchangeable Na. Also, **Santos *et al.* (1999)** found that salinity decreased the levels of Fe and Zn in whole plant of sunflower. The decreases in micronutrients content and uptake values are probably due to the decrease in the dry matter yield rather than the antagonistic effect between Na and other ions.

Also, data revealed that more depressive effect on the micronutrients content by sunflower varieties occurred when these varieties were grown on sodic soil than when they were grown on saline and saline-sodic soils. This effect was more obvious in Fedok and Iroflor varieties (relatively salt-sensitive), probably due to the adverse effect of salinity and/or sodicity on plant growth where, Fe, Mn, Zn and Cu contents of Giza 2 were higher than the corresponding ones of Fedok and Iroflor. Generally, Fedok and Iroflor varieties which had lower Fe, Zn, Mn, and Cu contents were found to be more salt-sensitive and had markedly lower amounts of dry matter production than those of Giza 2 variety which has higher Fe, Zn, Mn and Cu contents. This variation can be mainly attributed to the tendency of Giza 2 variety (relatively salt-resistant) to accumulate more proline amino acid than Fedok and Iroflor varieties (relatively salt-sensitive). In this connection, **Ashraf and Tufail (1995)** reported that the salt resistant varieties of sunflower accessions had greater proline in the leaves than the salt-sensitive ones.

4.7. Effect of salinity and/or sodicity on seed yield:

Data presented in Table (17) and Figs. (16 and 17) reveal that values of seed yield of sunflower varieties grown on the saline, saline-sodic and sodic soils were significantly decreased compared with the corresponding values of the plants grown on the non saline-non sodic soil. The values of seed yield were 165.51, 167.15 and 169.23 g/pot for Fedok, Iroflor and Giza 2 varieties grown on saline soil, respectively. The corresponding values were 157.08, 158.19, and 160.14 g/pot when Fedok, Iroflor and Giza 2 varieties were grown on the saline-sodic soil, respectively. For sodic soil, the values of seed yield of different varieties were 147.43, 150.21 and 153.17 g/pot for Fedok, Iroflor and Giza 2, respectively. These results indicate that the lowest seed yields of sunflower varieties were recorded when they were grown on the sodic soil. The decreases in seed yields of sunflower varieties as a result of soil salinity and/or sodicity were also observed by many investigators such as **Francois (1996)** who cleared that each unit increase in salinity above 4.8 dS/m reduced sunflower yield by 5%. Also,

Padole *et al.* (1995) found that the grain yield was adversely affected with highly saline or sodic water. **El-Kheir *et al.* (2000)** and **Sharma *et al.* (2005)** reported that the increased salt concentration in the irrigation water significantly decreased sunflower yield.

Data also reveal that the sodic soil had more depressive effect on seed yield of sunflower varieties, than the saline and saline-sodic soils. The corresponding relative decreases were; 11, 7 and 4% lower than the non saline-non sodic soil for Fedok, Iroflor and Giza 2, respectively grown on the saline soil. The corresponding relative decreases for Fedok, Iroflor and Giza 2 varieties grown on the saline-sodic soil were; 15, 12 and 10%, respectively. For sodic soil, these decreases were; 20, 16 and 13% for Fedok, Irofolr and Giza 2, respectively. These results indicate that the greatest reduction in seed yield was recorded in sodic soil compared with the other soils. This is mainly attributed to a detrimental effect of Na ions on plant growth and consequently certain metabolic processes. Also, it can be seen from Table (17) that the seed yield of Giza 2 variety was less affected with salinity and/or sodicity than Fedok and Iroflor varieties, indicating again that Giza 2 variety was more tolerant to salinity and/or sodicity than Fedok and Iroflor varieties. Generally, the different varieties showed the following descending order with respect to their tolerance to salinity and/or sodicity: Giza 2> Iroflor> Fedok.

4.8. Effect of salinity and/or sodicity on yield components:

Yield components of sunflower varieties, i.e., disc diameter (cm), 1000 seed weight (g) and seed oil content (g/pot), grown on soil affected by salinity and/or sodicity are presented in Table (18) and Fig. (18). Data indicated that Fedok variety gave higher yield components (disc diameter, 1000 seed weight and seed oil content) than Iroflor and Giza 2 when these varieties were grown on the normal soil. However, yield components of the three varieties decreased as a result of soil salinity and/or sodicity as compared with their yield components when they were grown on the normal soil. These results are confirmed with those obtained by **El-Kheir *et al.* (2000)** who reported that the increase of salt concentration in the irrigation water significantly decreased head diameter, 1000 seed weight and seed oil content of sunflower. These decreases in yield components can be mainly attributed to the adverse effect of salinity and/or sodicity on plant growth as shown by the data presented in Table (2).

On the other hand, data also showed that sodic soil was of more depressive on yield components of the three sunflower varieties than both the saline and saline-sodic soils. The relative decrease of disc diameter was; 57, 61 and 63% for Giza 2, Iroflor and Fedok varieties grown on sodic soil as compared with the values of the disc diameter of these varieties when were grown on the normal soil. The corresponding values when these varieties were grown on the saline-sodic soil were; 29, 40 and 51% for Giza 2, Iroflor and Fedok, respectively. When these sunflower varieties were grown on the saline soil, the decrease values were; 8, 18 and 27% in the same respective order. Also, the relative decrease of 1000 seed weight was; 37, 42 and 48% for Giza 2, Iroflor and Fedok varieties grown on sodic soil compared with the corresponding 1000 seed weight values of these varieties when they grown on normal soil, respectively. The relative decreases were; 14, 25 and 33% for Giza 2, Iroflor and Fedok varieties, respectively grown on the saline-sodic soil. The corresponding values for the same varieties grown on the saline soil were; 12, 16 and 24% for Giza 2, Iroflor and Fedok, respectively. For seed oil content, the relative decrease was; 14, 16 and 21% for Giza 2, Iroflor and Fedok varieties grown on sodic soil as compared to the corresponding contents of the respective sunflower grown on the normal soil. However, the decrease values were; 10, 13 and 19% for Giza 2, Iroflor and Fedok varieties respectively grown on the saline-sodic soil. The corresponding values for the respective varieties grown on the saline soil were; 3, 4 and 9% for Giza 2, Iroflor and Fedok varieties, respectively. These results suggest the negative influence of NaCl stress on growth which was due to a detrimental effect of Na on certain metabolic processes (**Helal *et al.,* 1975)**.

Moreover, the obtained data also revealed that the disc diameter, 1000 seed weight and oil content of Giza 2 were less affected by soil salinity and/or sodicity than Iroflor and Fedok varieties. This holds true for all soils under the study, indicating that Giza 2 was more tolerant to salinity and/or sodicity than Fedok and Iroflor. This variation can be mainly attributed to the higher content of proline amino acid in Giza 2 than Iroflor and Fedok. In this connection, **Shahbazi and Doust (1996)** suggested that there was a significant relationship between proline content and the relative salt tolerance. Also, **Ashraf and Tufail (1995)** reported that the salt tolerance varieties of sunflower accessions had greater proline in the leaves than the salt sensitive ones.

4.9. Effect of salinity and/or sodicity on macronutrients content in seeds:

4.9.1. Nitrogen :

Nitrogen contents in seeds of sunflower varieties grown on the soil affected by salinity and/or sodicity are presented in Table (19) and Fig. (19). Data reveal that N content in seeds of Fedok variety was slightly higher than that in Iroflor and Giza 2 varieties grown on the normal soil. However, N contents in seeds decreased when these varieties were grown on the saline, saline-sodic and sodic soils. Decreasing N content in seeds of sunflower varieties as a result of soil salinity and/or sodicity was also obtained by **Santos *et al.* (1999)** who reported that salinity decreased NO_3 content in the whole plant of sunflower. This decrease may be attributed to the adverse effect of salinity or sodicity on plant growth as well as the high Cl uptake which restrict the nutrient uptake as shown by **El-Shazly (2000)**.

On the other hand, the obtained data also reveal that sodic soil had more depressive effect on N content of seeds of the three studied varieties than saline-sodic and saline soils. The relative decreases in N content were; 20, 28 and 32% for Giza 2, Iroflor and Fedok varieties grown on the sodic soil as compared with the corresponding contents in seeds of the aforementioned varieties when they were grown on the normal soil. The corresponding values when the varieties were grown on the saline-sodic soil were; 14, 21 and 24% in the same order. For saline soil, these values were; 7, 16 and 18% for Giza 2, Iroflor and Fedok varieties, respectively. These results suggest the negative influence of Cl ions on the NO_3 uptake and of the high Cl on certain metabolic processes. In this concern, **Jones and Gorham (1991)** showed that high Cl in nutrient media restricted nitrate uptake.

Data also indicate that N content in seed yield of Giza 2 was less affected by salinity and/or sodicity than Iroflor and Fedok varieties. This true was observed in all the studied soils, indicating again that Giza 2 was more tolerant to salinity and/or sodicity than Iroflor and Fedok varieties.

4.9.2. Phosphorus :

Data in Table (19) and Fig. (19) show that P content in seeds of the concerned varieties decreased when they were grown on the saline, saline-sodic and sodic soils compared with the normal soil.

These results are in agreement with those of **Farghali and Gadallah (1996)** who found that concentration of P in sunflower was affected significantly by salinity. This effect is probably due to the interaction effect between Cl and P. Similar suggestion was also reported by **Padole (1991)** who found that the reduction in P uptake may be attributed to the competitive effect of Cl ions.

Data also reveal that the sodic soil was more effective on P content in seed of the different varieties than saline-sodic and saline soils. The relative decrease in P contents in seeds of the different varieties grown on sodic soil compared to the corresponding contents when these varieties were grown in normal soil were found to be; 37, 39 and 43% for Giza 2, Iroflor and Fedok, respectively. The corresponding relative decreases for different varieties grown on the saline-sodic soils were; 18, 28 and 37% for Giza 2, Iroflor and Fedok, respectively. For saline soil, these decreases were; 3, 10 and 16% for Giza 2, Iroflor and Fedok, respectively. These results indicat that P content in seeds of the studied varieties grown on sodic soil was more affected than P contents in seeds of those grown on saline-sodic and saline soils, probably due to antagonistic effect between P and Cl ions. In this concern, **Padole (1991)** reported that the reduction in P uptake may be attributed to the competitive effect of Cl ions.

On the other hand, data also revealed that P content in seeds of Giza 2 was less affected by soil salinity and/or sodicity than Iroflor and Fedok varieties where it was higher in Giza 2, than Iroflor and Fedok varieties. This holds true for all the studied soils, mainly due to the capacity of plants to maintain a high P content (**Wilson *et al.* 1970)**.

4.9.3. Potassium :

Data presented in Table (19) and Fig. (19) show that values of K content in seeds of sunflower varieties were significantly affected by soil salinity and/or sodicity where they decreased for all varieties grown on the saline, saline-sodic and sodic soils as compared with the corresponding K contents of the varieties grown on the non saline – non sodic soils. This decreases mainly attributed to the antagonistic effect between Na ions and K ones. **Padole (1991)** found also that K uptake by plants was adversely affected with soil salinity and/or sodicity. Also, the decrease in K content in sunflower plants due to salinity and or sodicity was observed by **Santos *et al.* (1999)**.

Data also reveal that sodic soil was more effective on K content in seeds of the different sunflower varieties as compared with other soils. The relative decreases in K content for the three varieties of sunflower grown on the sodic soil compared to the corresponding K contents in seeds of sunflower varieties grown on normal soil were; 30, 41 and 48% for Giza 2, Iroflor and Fedok, respectively. The corresponding decrease values were; 17, 33 and 39% for Giza 2, Iroflor and Fedok varieties respectively grown on saline-sodic soil. For saline soil, these values were; 5, 21 and 30% for Giza 2, Iroflor and Fedok, respectively. These results indicate that K contents in seeds of the three varieties of sunflower grown on sodic soil were more affected than K contents in seeds of these varieties grown on saline-sodic and saline soils, probably due to the antagonistic phenomenon which is known to frequently take place between K ions and Na ones (**Abd El-Aziz *et al.*, 1978)**.

Moreover, varietal differences was also observed, since the content of K in seeds of Giza 2 (relatively salt-resistant) was higher than in K contents in seeds of Iroflor and Fedok (relatively salt-sensitive). This variation is mainly attributed to the high Na uptake by Iroflor and Fedok varieties that caused the variation in K uptake as shown by **AbdEl-Aziz *et al.* (1987)** and also due to the high content of proline amino acid in Giza 2 which increases the ability of plants to tolerate salts.

4.10. Effect of salinity and/or sodicity on micronutrients content in seeds:

Micronutrients contents in seeds of sunflower varieties grown on saline, saline-sodic and sodic soils are shown in Table (20) and Fig. (20). Data reveal that soil salinity and/or sodicity was accompanied with a decrease in Fe, Mn, Zn and Cu contents in seeds of sunflower varieties grown on the salt-affected soils compared with the corresponding micronutrients contents in seeds of the same varieties grown on the normal soil. Such decreases as a result of salinity and/or sodicity are presumably due to the antagonistic effect rather than the decrease in the dry matter yield. These results are confirmed with those of **Nirlep *et al.* (1990)** and **Santos *et al.* (1999)**.

Also, the obtained data show that micronutrients contents in seeds of the different varieties grown on the sodic soil were more affected by salinity and/or sodicity than the corresponding micronutrients contents of sunflower varieties grown on the saline and saline-sodic soils. Also, the decreases were more obvious in Fedok and Iroflor varieties (relatively salt-sensitive), presumably due to the adverse effect of salinity and/or sodicity on plant growth. Therefore, the micronutrients contents (Fe, Mn, Zn and Cu) in Giza 2 were higher than in seeds of Fedok and Iroflor varieties. In general, Fedok and Iroflor varieties which were of lower micronutrients contents had lower amounts of dry matter than Giza 2 variety which was of higher micronutrients content and higher amount of dry matter. This effect may be due to the tendency of

Giza 2 variety (which is of relatively higher salt- resistance) to accumulate and produce more amount of proline amino acid than Iroflor and Fedok varieties which are relatively salt- sensitive. These results are resembled with those obtained by **Ashraf and Tufail (1995)** who found that the salt resistant varieties of sunflower accessions had greater proline in the leaves than the salt-sensitive ones.