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EFFECT OF IRRIGATION WATER SALINITY LEVELS ON GROWTH, CHEMICAL COMPOSITION AND YIELD OF SOME NEW SWEET POTATO CULTIVARS WHICH THEIR SOURCE IS TRUE SEEDS

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ABSTRACT

Two pot experiments were carried out during the summer seasons of 2006 and 2007 to investigate the effect of irrigation with diluted saline water; i.e., 10, 30 and 50% in addition to Tap water as a control on growth, chemical composition, yield and tuber quality of three new sweet potato cultivars (Minufiya 6/96, Minufiya 2/96 and Minufiya 171/96) as well as the local cultivar (Mabrouka). The obtained results revealed that, saline water at 10 and 30% levels stimulated growth of sweet potato plants represented by plant height, number of leaves and branches, dry weight of shoots as well as the contents of photosynthetic pigments, proline, total carbohydrates, N, P, K^+ and Ca^{++} in sweet potato leaves were also increased. Moreover, total water content (TWC), bound water (BW), bound / free water ratio (BW/FW) and relative water content (RWC) increased under these conditions. All these parameters decreased at the level of 50% salinity. Yield and its quality significantly increased at saline water at 10% level. Also, chemical composition of tuber roots; i.e., total carbohydrates, soluble sugars, carotene, starch and dry matter contents were enhanced under these conditions. All previous parameters decreased with increasing saline water up to 50%. Saline water levels increased Na^+ content in the leaves. As for the tested cultivars, generally Minufiya 6/96 had the best growth and yield, was more stable in the chemical components and its roots had the highest nutrients value under the control and salt stress conditions, followed by Minufiya 2/96 then Minufiya 171/96. The tuber roots yield of Mabrouka cultivar was completely depressed at 30 and 50% salinity levels. As for interaction between cultivars and salinity levels. The highest level of salinity (50%) lead to a significant decrease in all growth parameters, RWC, TWC, bound water (BW), bound water / free water (BW/FW), chemical composition, yield and its quality in all new tested cultivars. While, Mabrouka cultivar showed a significant decrease in these parameters under the all salinity levels. Accordingly, Minufiya 6/96 was the highest tolerant to the tested salinity stress, followed by Minufiya 2/96 and Minufiya 171/96. On the other hand, Mabrouka cultivar sensitive to salinity.

INTRODUCTION

Due to tremendous increase of population on a limited cultivated area in Egypt, efforts have been made to increase the agricultural production which is sufficient for man. It may hope that the coastal deserts must be enough in cultivation using saline with relatively little expenditure. Previous research works have been receiving recent considerable attention on the response of salinity on irrigation various food plants, oil and fodder crops **(He and Cramer, 1996** on *Brassica species* as well as **Ghallab and Nesiem, 1999** on wheat**).**

The advice effects associated with increasing salinity on the flowering plants are well documented i.e. **(He and Cramer, 1996 and Ghallab and Nesiem, 1999).** It is known that salinity decreases plant growth and development; photosynthis, nutrient uptake and leaf expansion **(He and Cramer, 1996; Turhan and Eris, 2004 and Namich, 2008).** Salinity, reduces nitrogen and protein contents in wheat (**Nesiem and Ghallab, 1999)** and decrease in the rate of carbohydrate accumulation **(Bruns and Caesar, 1990 and Namich, 2008).**

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Sweet potato (*Ipomoea batatas* L.) is considered the sixth most important food crops in the world **(Morrison *et al* 1993).** It is widely grown in many countries and produces a considerable yield under a wide range of environments. It is also considered the dominant food crop in the tropical and subtropical countries. On the world scale, sweet potato provides significant amounts of energy and protein, it contains carbohydrates, protein, vitamin C, carotene and some minerals. Its production efficiency of edible energy and protein is outstanding in the developing world. Sweet potato comes the 8th of important developing-world crops in terms of the quality of energy per hectare per day which they can produce. Sweet potato also has higher energy than the cereals. The average energy output / input rations for rice and sweet potato on Fijian farms were 17 : 1 and 60 : 1, respectively **(Woolfe, 1992).**

Hence, this investigation was carried out to study, salinity tolerance of some new sweet potato cultivars with respect to growth characters, physiological aspects and yield attributes.

MATERIALS AND METHODS

Two pot experiments were carried out during the two successive seasons of 2006 and 2007 at the Experimental Farm, Faculty of Agriculture, Shibin El-Kom, to examine salt tolerance of three new sweet potato cultivars (Minufiya 6/96, 2/96 and 171/96) and local cultivar (Mabrouka). These cultivars were obtained by breeding programs carried out in the Vegetable Research Departments, Horticulture Research Institute, Giza, Egypt (**Salem, 1999)**. The soil used was silty clay loam in texture with pH 8 and 7.98, EC = 0.66 and 0.64 (dSm^{-1}) and contained 0.14 and 0.13% N, 0.041 and 0.04% P and 0.31 and 0.28% K in the first and second seasons, respectively.

Selected cuttings (25 cm) in length of sweet potato were transplanted in plastic pots 50 cm diameter filled with 14 kg silty clay soil on the 18th of April in both seasons (tow plants for each pot). The experiment included 16 treatments (4 cultivars × 4 levels of salinity). A split – plot design in Randomized Complete block with 10 replicates was used. Cultivars were arranged as the main plots, while the salinity levels treatments were considered as the sub-plots. Four weeks from transplanting, pots were irrigated with 0.0 (control), 10, 30 and 50% of saline water. The EC values of the irrigation water were measured before each application by "Myron LDS meter". The average values of EC were 450 (control), 4959, 12100 and 19235 ppm for the concentrations, respectively. Synthetic sea-water 100% (as suggested by **Lunin *et al* 1961)** is composed of NaCl (473 me/L), $MgCl_2 . 6 H_2O$ (102 me/L), $CaSO_4$ (20 me/L) and K_2SO_4 (12 me/L).

Plant samples (5 plants) were randomly selected after 105 days from transplanting. The following characters were determined.

1) Growth characters: Plant height (cm), number of leaves and branches / plant and dry weight of shoots (g / plant) were determined after drying in an oven at 70°C.

2) Leaf water relations: Total water content (TWC, %), bound water percentage (BW, %), free water percentage (FW, %), leaf water deficit (LWD %) and relative water content (RWC, %) were measured according to the methods described by **Kreeb (1990) and Kalapos (1994).**

3) Some chemical contents of potato leaves: Photosynthetic pigments were determined in the fresh leaves using the method described by **Wettestein (1957)** and total carbohydrates in dry leaves were estimated colorimetrically using the phenol sulfuric acid according to the method of **Dubios *et al* (1956).** Free proline in fresh leaves was measured using the method described by **Bates *et al* (1973).** Mineral contents: Nitrogen was estimated by using Microkjeldahl method according to **Ling (1963),** P and K were determined as mentioned in **A.O.A.C (1990),** Na^+ and Ca^{2+} were determined in the leaves using digital clinical flamephotometer **(Allen *et al.,* 1986).**

4) Yield and its components: After 150 days from transplanting in both seasons of the study, storage roots of sweet potato were harvested and the following data were recorded. Average root weight (gm / plant), average root length (cm), average root diameter (cm) and root dry matter content (%).

5) Some chemical constituents of tuber roots: Tuber roots samples at the harvest, were collected, washed, dried, ground and used to determine total carboydyrates and total soluble sugars concentrations according to **Dubios *et al* (1956)** and starch content (%) was measured in freshly harvested tuberous roots as mentioned by **Somogyi (1974).** Total carotene and vitamin C concentrations of tuber roots were determined as outlined by **Bureau and Bushwey (1986) and A.O.A.C. (1975),** respectively.

All obtained data were subjected to statistical analysis with the help of COSTAT-C program, and L.S.D. at 5% level was calculated according to **Gomez and Gomez (1984).**

RESULTS AND DISCUSSION

1. Growth characters

Data In **Table (1)** shows generally, that, plant height, number of leaves and branches per plant and dry weight of shoots were increased at 10 and 30% diluted water salinity and thereafter decreased. Similar results were obtained for several plant species **(He and Cramer, 1992** on *Brassica species* and **Fouda, 1999** on mungbean). The stimulation of growth aspects due to low and moderate salinity levels may be attributed to the increase in Ca^{++} uptake **(Lynch *et al* 1989).** Ca^{++} may improve plant growth under saline conditions **(Cramer *et al* 1987). Salama *et al* (1996)** reported that, the low and moderate sea-water salinity (12.5 and 25.0%) increased Ca^{++} concentration in kochia root and shoots. Ca^{++} plays an important role in reducing permeability of Na through the plasma membrane and prevent loss of K / Na selectivity **(He and Cramer, 1992).** The rate of cell production in salt-stressed cotton root was increased due to Ca^{++} **(Kurth *et al* 1986).** Ca^{++} also is essential for maintenance of selectivity and integrity of the cell membrane **(Fageria, 1983),** by the combination with pectic substances **(Inanga *et al* 1988).**

The depressing effect of high salinity level on plant growth may be attributed to the decrease in water absorption **(Table 2),** meristematic activity and cell enlargement **(Khadr, *et al* 1994).** Moreover, this reduction may be due partially to excess accumulation of Na^{+} and Cl^{-} in the leaves. These might be attributed to the process of building up the osmotic potential of the developing cell, by osmotic adjustment of salt accumulation to meet the increasing osmotic potential of rooting media. Similar results have been observed by **El-Deeb (2002)** who emphasized these results. Reduction in stem length as a results of water salinity might be attributed to reduction in cell size or the cells number **(El-Deeb *et al* 2004).** The other possible reason of reduction in dry matter accompanied with increasing level of salinity may be the reduced of leaf emergence, leaf expansion and final leaf area **(Namich, 2008).** As for the effect of the cultivars on growth characters, data presented in **Table (1)** indicated that, there were significant differences among them. Minufiya 6/96 and Minufiya 2/96 recorded the highest values of growth followed by Minufiya 171/96 meanwhile Mabrouka cultivar recorded the lowest values. Generally, the recorded data of the second season had similar trends as shown in the first season.

Data given in **Table (1)** indicated that, the interactions between salinity and cultivars were found to be significant for all growth characters. In this regard, the highest values of plant height and dry weight of shoots recorded with Minufiya 6/96 under 10% water salinity, meanwhile Minufiya 2/96 gave the highest values of leaf number and branches. In this respect, **Selim and El-Gamal (2004)** revealed that, a significant interaction between barley genotypes and salinity for plant height, number of leaves and dry weight of shoots as a result of genotypes responded differently to salinity.

2. Leaf water relations

The data concerning effect of salinity on the characters of leaf water relations are illustrated **Table (2).** It can be observed that, generally total water content (TWC), bound water (BW) / free water (FW) and relative water content (RWC) increased under low and moderate salinity levels (10 and 30%), The leaf water deficit (LWD) was decreased under the same conditions. It is clear from the mean values given in **Table (2)** that there are significant differences among the cultivars, generally, Mabrouka cultivar had the highest free water (FW) and LWD. Minufiya 6/96 had the highest BW, BW/FW, RWC and recorded the lowest FW and LWD followed by Minufiya 171/96 then Minufiya 2/96.

Regarding the effect of interaction, results in **Table (2)** showed that, the values of interaction for TWC was not significant in both seasons, the highest value of BW was recorded by Minufiya 2/96 at the level of 10%. Meanwhile, the lowest value of this character was obtained with 50% salinity ratio of Mabrouka cultivar. The obtained results are in accordance with those obtained by **Selim and El-Gamal (2004).**

3. Some chemical contents of potato leaves

Photosynthetic pigments and total carbohydrates

Low and moderate salinity levels (10 and 30%) increased chlorophyll (a + b), carotenoids and total carbohydrates in sweet potato leaves **(Table 3).** On the other hand, the highest level of salinity (50%) led to a significant decrease in these components compared with control plants. The stimulating effect of low and moderate salinity on chl. (a + b) and total carbohydrates may be attributed to

the enhancing effect of low salinity level on auxins, gibberellin and cytokinin contents **(Ghallab and Nesiem, 1999).** It is known that, cytokinins stimulate chlorophyll synthesis and delay chlorophyll destruction thus delay senescence **(Bradford, 1983). Khafagy and Sakr (1989)** added that, low salinity level stimulates nitrogen uptake, which may enhance chlorophyll biosynthesis. The decrease in chlorophyll content under high salinity level may be due to the salinity increased abscisic acid (ABA) content **(He and Cramer, 1996).** Abscisic acid is known to accelerate leaf senescence through inhibiting chlorophyll synthesis **(Fouda, 1999).** This may be connected to the root absorption of NaCl solution at high concentration, which causes yellowings and necroses on the leaves **(Devecchi and Remotti, 2004).** Concerning the effect of cultivars, data presented in the same table showed that, the Mabrouka cultivar recorded the highest concentrations of chl. (a + b), carotenoids and total carbohydrates followed by Minufiya 6/96 and Minufiya 2/96, meanwhile Minufiya 171/96 recorded the lowest. In the second season the obtained results confirmed those of the first one. These results are in agreement with those findings found by **Selim and El-Gamal (2004)** on barley. Concerning the interaction effect, chl. (a + b), carotenoide, total carbohydrates were increased in Minufiya 6/96 cultivar at salinity levels up to 50%, on the other hand, Mabrouka cultivar showed a significant decrease in these characters under all saline water ratios compared with the control.

Proline concentration

Data for proline concentration in leaves of sweet potato plant grown under different salinity levels are given in **Table (3).** It was observed that its concentration was increased under 10 and 30% levels, then slightly decreased at the highest ratio (50%). In this connection, **Begum and Karmoker (1999)** suggested that, proline produced in leaves is transported to the storage roots of the stressed plant, thereby helping the plant to regulate the osmotic potential of tuber root cells under salinity. Concerning the cultivars effect, results in **Table (3)** showed that, Minufiya 6/96 had the highest proline concentration followed by Minufiya 2/96 and 171/96. Meanwhile, Mabrouka cultivar recorded the lowest concentration. Under salt stress, new cultivars accumulated greater amounts of proline significantly reduced the level of free radicals and improved tolerance to NaCl **(Hong *et al* 2000).**

The interaction between sweet potato cultivars and salinity was significant. The proline concentration was significantly increased in the leaves of Minufiya 6/96 at all saline water ratios, whereas increased in the leaves of both Minufiya 2/96 and 171/96 up to level of 30% then decreased. Mabrouka cultivar showed lost values in this character with all water salinity levels compared with other treatments. This means that under the stress salinity, the new cultivars produced a high concentration of proline that prevented the adversely effect of salinity and tolerated it. In this concern, **Hare and Cress (1997) and Namich (2008)** showed that proline plays a clear role as an osmolytes for osmotic adjustment, buffering cellular redox potential (under stress conditions). It also may cause cytoplasmic acidosis and maintaining appropriate $NADP^+$ / NADPH ratios compatible with metabolism.

Mineral contents

It can be clearly seen from the data reported in **Table (4)** that, Na^+ concentration in the leaves was increased with increasing salinity ratio (50%) in the irrigation water. On the other hand, N, P, K^+ and Ca^{++} concentrations were increased at low and moderate water salinity levels then decreased. Similar findings have been reported by **He and Cramer (1996)** on *Brassica species* and **Nesiem and Ghallab (1999)** on wheat. The increase in leaves-N under moderate salinity conditions might be attributed to that salinity enhances protein synthesis in cereals (**Langdale *et al* 1973).**

The increase in Ca^{++} concentration at the low and moderate salinity levels may indicating that Ca^{++} may play a role in the response of sweet potato plants to salinity conditions. Calcium is widely recognized to play an important role in regulating the passive entry of Na and the K / Na selectivity **(Greenway and Munns, 1980).** Moreover, Ca^{++} was found to reduce permeability of Na through the plasma membrane and to prevent loss of K / Na selectivity **(He and Cramer, 1992).** Also, Ca^{++} increases the rigidity of plant cell walls by completing with polysaccharides **(Cleland *et al* 1990).** In this concern, nutrient absorption by plants can be disrupted by excessive ions in solution either via direct ionic competition between ions such as (Na^+ and K^+), (Ca^{2+} and Mg^{2+}) and (NO_3^- and Cl^-) or by the decrease in osmotic potential of solution reducing the mass flow of mineral nutrients to the root surface **(El-Deeb *et al* 2004).**

As for the effect of cultivars, data indicated that, the Minufiya 6/96 recorded the highest values of N, P, K and Ca followed by Minufiya 2/96 and Minufiya 171/96. Meanwhile, Mabrouka cultivar recorded the lowest. At the highest salinity ratio, Minufiya 6/96, Minufiya 2/96 and Minufiya 171/96 accumulated the lowest Na^{+} meanwhile Mabrouka cultivar showed the highest amount. These results indicated that three new cultivars were more tolerant to salinity compared with Mabrouka cultivar. A significant interaction between cultivar and salinity was noticed. The content of N, P, K and Ca were increased in new cultivars at the salinity level up to 30% then decrease. Whereas decreased at all salinity levels in Mabrouka cultivar.

4. Yield and its components

Data in **Table (5)** revealed that, average root length, root diameter, total root yield, express as gram per plant and dry matter (%) were increased significantly at (10%) saline water level. On the other hand, the moderate and high salinity levels (30 and 50%) significantly decreased these parameters. These results were previously observed by **(Fouda, 1999)** on mungbean. The reduction in yield due to high salinity levels may be attributed to the decreasing number of branches and photosynthetic pigment contents **(Tables 1 and 3).** In this connection, **He and Cramer (1993)** attributed the reduction in wheat seed yield to the reduction in net assimilation rate and leaf area as well as inhibition of carbohydrate translocation **(Nesiem and Ghallab, 1999).**

Data presented in the same table indicated also that, the new and local cultivars of sweet potato under study varied significantly in most yield characters. The highest values of the tuber roots length, diameter, total tuber root yield and dry matter content (%) were obtained from the Minufiya 6/96 followed by Minufiya 2/96 then Minufiya 171/96. Meanwhile, the tuber root yield of Mabrouka cultivar was completely depressed at 30 and 50% salinity levels. The results are in agreement with those obtained by **Selim and El-Gamal (2004)** on barley genotypes.

Data given in **Table (5)** indicated that, the interaction between sweet potato cultivars and salinity was significantly affected yield observed. Minufiya 6/96, 2/96 and 171/96 gave the highest significant tuber root yield and dry matter under saline water level up to 30% and thereafter decreased.

5. Some chemical constituents of tuber roots

Total carbohydrates, soluble sugars and starch content

Data presented in **Table (6)** indicated that total carbohydrates, soluble sugars and starch content were significantly increased at 10% salinity solution. On the other hand, the moderate and high salinity levels (30 and 50%) significantly decreased these parameters.

The reduction effect of salinity on carbohydrates, starch and soluble sugars accumulation may be attributed to reduction of photosynthetic area, probably due to an inhibition of leaf expansion, photosynthetic pigments formation and consequently reduced assimilation rate **(He and Cramer, 1993)** as well as accumulation of carbohydrates and soluble sugars **(Bruns and Caesar, 1990).** This accumulation may be due to reduction in phloem translocation **(Nesiem and Ghallab, 1999).** Moreover, many plants which are stressed by salinity accumulate starch and soluble carbohydrate in the leaves **(Rathert, 1984)** or sugar phosphates **(Nieman and Clark, 1976).** This accumulation has been attributed to impaired carbohydrate utilization **(Munns and Termaat, 1986).**

Also, data in the same table showed that, Minufiya 6/96 had the highest values of these characters followed by Minufiya 2/96 then Minufiya 171/96. Meanwhile, Mabrouka cultivar recorded the lowest one. A significant interaction between sweet potato cultivars and salinity was observed. So, the highest concentration of total carbohydrate, starch content and soluble sugar being obtained due to Minufiya 6/96 with low salinity level (10%). On the other hand, low salinity level decreased significantly these parameters of Mabrouka cultivar.

Total carotene and vitamin C concentrations

It is evident from the data in **Table (6)** that, generally, total carotene and vitamin C concentrations of storage roots were increased at 10% level water salinity and thereafter decreased. On the other hand, the moderate and high levels of salinity (30 and 50%) led to a significantly decrease in these characters. As for the effect of four cultivars on carotene and vitamin C concentrations, data in the same table, showed that the Minufiya 2/96 recorded the highest values followed by Minufiya 6/96 then Minufiya 171/96, meanwhile Mabrouka cultivar recorded the lowest one. Concerning the interaction effect, the highest values of these

characters were obtained from Minufiya 2/96 at the moderate level of salinity (30%). Meanwhile, the lowest values of these characters were obtained with the salinity level (10%) with Mabrouka cultivar. Finally, a contemplative look at the obtained results, it could be concluded that, the three new sweet potato cultivars had the best growth, more stable in most of physiological and chemical components, the highest yield and nutrient value under the low and moderate salinity levels (10 and 30%). Therefore, the three new sweet potato cultivars which can be cultivated great success in the desert area under different irrigation water salinity levels.

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