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# EFFECT OF IRRIGATION FREQUENCY WITH DIFFERENT SALINE WATER LEVELS ON POTATO PLANTS. 2- CHEMICAL COMPOSITION

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***ABSTRACT:*** *The objective of the present investigation was to study the effect of different levels of salinity and irrigation water regime on mineral content of potato leaves.*

*Four levels of saline irrigation water E.C.0.4, 1.5, 3.0 and 4.5 dS $m^{-1}$ were used in the present study. Plants in each treatments were irrigated with one of the four mentioned salinity levels either once or twice a day every two days in pots containing sandy soil during fall 1998, 1999 and summer seasons of 1999, 2000. Diamant potato cultivar was used.*

*Twice irrigation significantly increased FW and Dw of foliage and produced a higher leaf content of chlorophyll, nitrogen, potassium and higher starch content. while it decreased the both sodium and proline content. The beneficial effect of irrigation frequency on reducing sodium content was more pronounced under the condition of using high levels of salinity i.e. E.C.3.0 and 4.5 dS $m^{-1}$. FW and DW of foliage decreased as salinity concentration increased .*

*High salinity level significantly increased the accumulation of free proline and sodium content in potato leaves. Leaf content of potassium took a reverse trend to that recorded for sodium content. Total chlorophyll was decreased gradually with the advance of plant age while free proline was increased in the same order. Leaf content of total chlorophyll and nitrogen decreased as saline irrigation water increased. The reduction of chlorophyll content may be due to the decrease in magnesium uptake as a result of increasing sodium level.. In potato leaves a positive relation was shown between total sugars concentration and level of saline water. The high salinity concentrations increased the reducing and non – reducing sugars till 75 DAP then decreased at 90 DAP. Also, total soluble sugars increased with irrigation once than twice.*

***Key words:*** *Salinity, Irrigation frequency, potato, Chlorophyll, Proline, FW., DW, reducing sugar, Starch.*

## INTRODUCTION.

Salinity is a major factor in limiting crop productivity in semi – arid areas of the world. Potatoes are moderately salt – sensitive (Pulivval and Yadav

1980) and very sensitive to water stress (Klein Kopf 1983). Also, salinity problems already exist especially in the reclaimed areas, which use ground water for crop irrigation.

In Egypt to face the increased consumption of food it is necessary to investigate both the vertical improvement of productive and semi – productive lands as well as the horizontal extension through the deserts. Both the vertical and horizontal extension for the cultivated area would be usually faced with salinity problems whether created from irrigation water or soil. There is a little information on the quality of tubers from plants irrigated with saline water.

Therefor, the purpose of the present study was to provide information on the effect of salinity and irrigation frequency on the growth and chemical constituent of potato plants.

## MATERIALS AND METHODS.

Two experiments of both fall and summer seasons were conducted at the experimental farm of Vegetable Research Department of the Horticulture Research Institute, Agriculture Research Center, Ministry of Agriculture at Dokki, Giza. The sand culture technique was used in this investigation. Diamant cultivar planted on October 25 and 20 for fall seasons of 1998 and 1999 respectively, and on February 17 and 15 for summer seasons of 1999 and 2000 respectively. Four levels of saline water E.C. 0.4 as a control, 1.5, 3.0 and 4.5 dS $m^{-1}$ were used. Plants in each treatment were irrigated with one of the four mentioned salinity levels either once or twice a day every two days.. Complete randomized blocks in factorial design were used with four replicates. each experimental unit contained 8 pots.

The saline water was prepared by dissolving Na Cl and CaCl salts in a ratio of 1: 1 Na: Ca. Feeding nutrient solution (Hoagland and Aron 1950) was prepared just before application to the pots by dilution with tap water Four plants from each treatment were taken at 75 days after planting (DAP) for determination the fresh and dry weight of foliage. Also, three samples each four plants from four different pots were randomly taken 60, 75 and 90 DAP for determinations the both total chlorophyll and free proline in fresh leaves. The leaf content of total chlorophyll in representative samples determined spectro photometrically as described by Arnon (1949). The free proline was determined according to Bates et al (1973). For measuring leaf content of reducing, non – reducing, total sugars and mineral composition of plant, i.e. sodium and potassium, leaves were dried at 60°c for 72 hours to a constant weight then they were ground to determine the reducing and total sugars content by using the method in A.O.A.C. (1975). Non – reducing sugar was calculated by subtracting reducing sugar from total sugar, Tuber content of starch was determined by using the method described in A.O.A.C. (1975), the sodium and potassium was also determined by using the flame photometer

method (Jackson 1973), total nitrogen by micro kjeldahl analysis (A.O.A.C.1975).

Data was statistically analyzed using the analysis of variance according to Snedicor and Cochran (1980). Least significant difference (L.S.D.) test at 5 % level was used to verify differences between treatments mean data.

## RESULTS AND DISCUSSION

### 1-Foliage fresh and dry weight.

Twice irrigation significantly increased fresh and dry weight of foliage as compared to once irrigation in both fall and summer seasons (Table 1).

Increasing salinity from E.C.0.4 dS $m^{-1}$ to E.C. 4.5 dS $m^{-1}$ decreased fresh weight of foliage significantly by 35.19 and 35.06% of fall 1998 and 1999 seasons and 33.87 and 36.32% of 1999 and 2000 summer seasons respectively. Similar results were obtained for dry weight of foliage. It decreased as salinity concentration increased by 35.61 and 31.15% for both fall seasons and 34.40 and 34.86% for 1999 and 2000 summer seasons respectively. Similar results were obtained by Morpurgo and Silva (1987), Bilski et al (1988), Abdallah and Ahmad (1990), EL-Kattib (1996), Jefferies (1996) and Karam et al (1997) who mentioned that increasing salinity caused a significant reduction in foliage fresh and dry weights, whereas Jorgensen (1982), Bilski et al (1988), Heuer and Nadler (1995) indicated that salinity increased the foliage fresh and dry weight.

The interaction effect between irrigation frequency and salinity concentration on foliage fresh weight was significant in the first fall season, while that of the second fall and both summer seasons was not significant. Similar results were obtained in foliage dry weight it was significant in both fall seasons, whereas it did not reach to a significant level in both summer seasons.

### 2-Chlorophyll content.

Results indicated that there was an increase in total chlorophyll in potato leaves as a result of using two irrigation frequencies comparing to one irrigation frequency during the different stages of growth under study i.e. 60, 75 and 90 DAP in the two fall and summer seasons (Fig .1).

With respect to the effect of saline water concentrations, it was obvious that total chlorophyll was decreased gradually with the advance of plant age as well as the increase in saline water concentrations during the two successive studied seasons. The lowest values were recorded after 90 DAP and when the highest level of saline water was used.

In summer seasons, similar results showed that chlorophyll content of potato leaf tended to increase under low salinity level then decreased with increasing salinity levels. The reduction of chlorophyll content may be due to the decrease in magnesium uptake as result of increasing sodium level.

**Table 1: Effect of irrigation frequency and concentration of saline water on foliage fresh and dry weight of potato plants at 75 days after planting during fall of 1998 and 1999 and summer seasons of 1999 and 2000.**

| | | Once irrigation | | | | Twice irrigation | | | | Average | | | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | E.C. dS m$^{-1}$ | | | | | | | | | | | | | |
| Seasons | years | 0.4 | 1.5 | 3.0 | 4.5 | 0.4 | 1.5 | 3.0 | 4.5 | 0.4 | 1.5 | 3.0 | 4.5 | once | twice |
| | | Fresh weight. | | | | | | | | | | | | | |
| Fall | 1998 | 94.19 | 97.16 | 72.92 | 58.57 | 95.70 | 100.07 | 78.37 | 64.49 | 94.94 | 98.62 | 75.65 | 61.53 | 80.71 | 84.66 |
| | 1999 | 88.49 | 95.17 | 70.87 | 55.18 | 95.27 | 97.90 | 76.10 | 62.20 | 90.38 | 96.54 | 73.49 | 58.69 | 77.43 | 82.12 |
| Summer | 1999 | 84.60 | 93.12 | 52.90 | 54.50 | 88.53 | 93.07 | 76.52 | 59.98 | 86.56 | 93.10 | 64.71 | 57.24 | 71.28 | 79.52 |
| | 2000 | 84.05 | 89.23 | 66.30 | 51.71 | 88.40 | 91.30 | 69.91 | 58.10 | 86.23 | 90.27 | 68.11 | 54.91 | 77.82 | 76.93 |
| | | Dry weight. | | | | | | | | | | | | | |
| Fall | 1998 | 13.49 | 14.07 | 10.62 | 8.47 | 14.03 | 14.43 | 11.39 | 9.24 | 13.76 | 14.25 | 11.01 | 8.86 | 11.66 | 12.27 |
| | 1999 | 12.84 | 13.79 | 10.33 | 8.13 | 13.41 | 14.18 | 11.08 | 9.95 | 13.13 | 13.99 | 10.71 | 9.04 | 11.27 | 12.16 |
| Summer | 1999 | 12.18 | 13.13 | 10.06 | 8.01 | 13.28 | 11.37 | 11.29 | 8.69 | 12.73 | 12.25 | 10.68 | 8.35 | 10.85 | 11.16 |
| | 2000 | 12.43 | 12.78 | 10.44 | 7.99 | 13.21 | 13.56 | 10.70 | 8.70 | 12.82 | 13.17 | 10.57 | 8.35 | 10.91 | 11.54 |

L.S.D. 5 %

| | Fresh weight | | | | Dry weight | | | |
|---|---|---|---|---|---|---|---|---|
| | Fall | | Summer | | Fall | | Summer | |
| | 1998 | 1999 | 1999 | 2000 | 1998 | 1999 | 1999 | 2000 |
| Irrigation frequency | 0.85 | 1.14 | 8.22 | 0.73 | 0.11 | 0.34 | N.S. | 0.18 |
| Salinity concentration | 1.20 | 1.61 | 11.63 | 1.69 | 0.16 | 0.48 | 3.25 | 0.26 |
| Irrigation x salinity | 1.70 | N.S. | N.S. | N.S. | 0.23 | 0.68 | N.S. | N.S. |

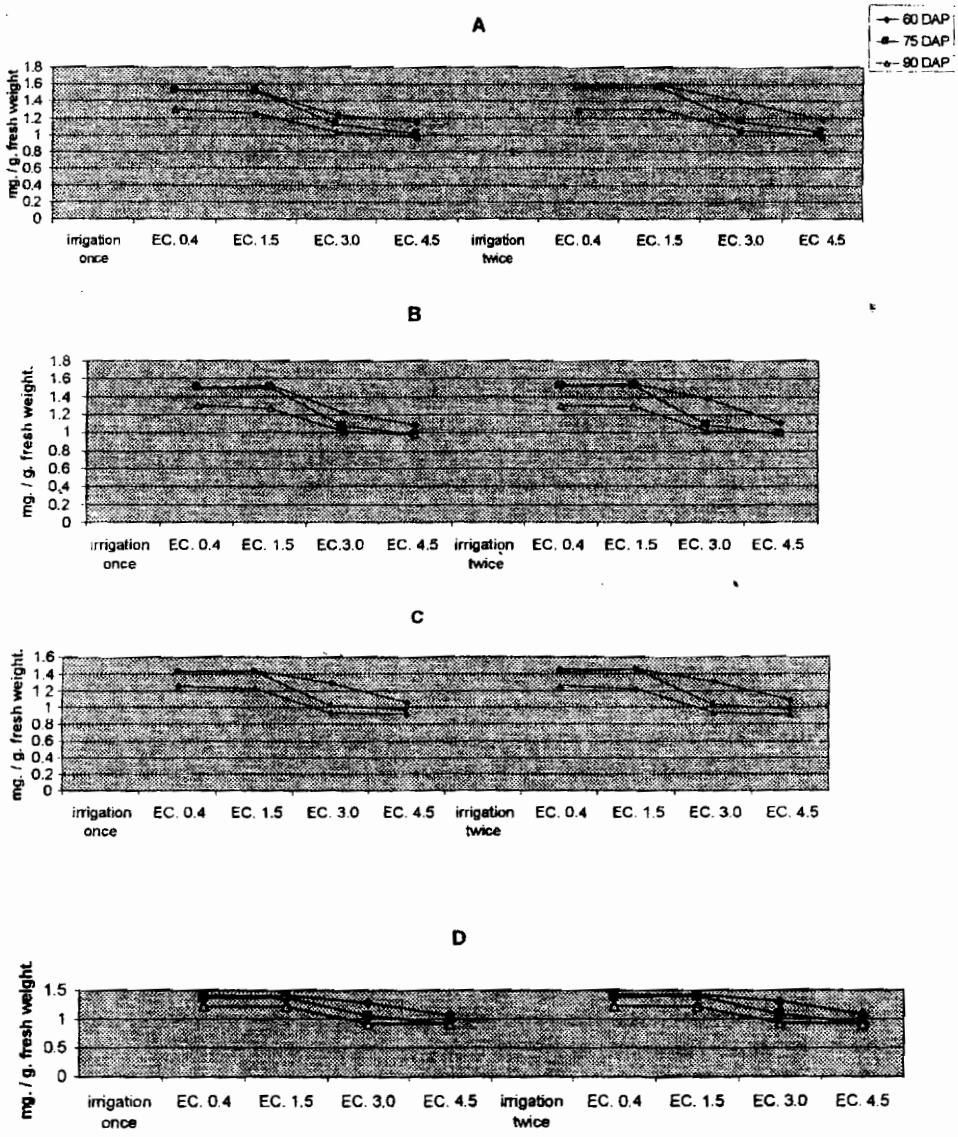


**Fig (1). Effect of once and twice irrigation frequencies with different concentrations of saline water. 0.4, 1.5, 3.0 and 4.5 dS $m^{-1}$ on total chlorophyll content (mg / g fresh weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), fall 1999 (B), summer 1999 (C) and summer 2000 (D) seasons.**

## 3-Free proline content.

Data showed that one irrigation frequency produced a figher level of proline as compared to two irrigation frequencies (Fig 2.).

High salinity level significantly increased accumulation of proline in potato leaves over the control (E.C. 0.4 dS $m^{-1}$). This was true at the three plant ages under study. Also, the accumulation was increased with the advance in the plant age. These results are in agreement with those of Levy et al (1988), Abdullah and Ahmad (1990) Perez et al (1993), Salsikala and Prasad (1994), Nadler and Heuer (1995), Heuer and Nadler (1998) and Evers et al (1999) who reported that proline content in leaves increased with increasing salinity. Salinity stress induces a characteristic change in the levels of free amino acids, especially a great increase in free proline which could be due to increase in proline synthesis or decreased proline degradation or both (Stewart and Lee 1974, and stewart et al 1980). Increasing proline accumulation with increasing salinity level was according to Potluri and Prasad (1993) due to new synthesis rather than breakdown of existing proteins. The large amount of accumulated free proline might also be a source of energy and nitrogen for the plant use when stress is relative (Barnett and Naylor 1966, Blum and Ebercon 1976).

## 4 – Starch content of tubers.

Twice irrigation frequency showed a significant increase in tuber starch content as compared to once irrigation frequency (Fig. 3). The highest concentration of saline water 4.5 dS $m^{-1}$ show a significant decrease for tuber starch content. Abdullah and Ahmad (1990), Bolarin et al (1995), and Barakat (1996) stated that increasing salinity reduced the tuber starch content.

In summer seasons, tuber content of starch was similarly affected by irrigation frequencies and salinity levels compared to fall seasons. However it was generally noticed that the starch tuber content in the fall seasons were higher than that recorded in the summer seasons.

## 5 – Reducing sugars.

Fig. (4) illustrate the effect of irrigation frequency, water salinity concentrations and their interaction on leaf content of reducing sugars in mg./g. dry weight of potato leaves at three plant ages i.e. 60, 75, and 90 DAP during fall and summer seasons of 1998, 1999, and 1999, 2000 respectively.

It is clear that reducing sugars contents in potato leaves significantly increased when irrigation was carried out once a day as compared to twice irrigation frequency. Data indicated that the reducing sugars content increased by increasing water saline concentration and plant age from 60 to 75 DAP. Thereafter, they were dropped down where the minimum value were obtained at plant age of 90 DAP. These results are in agreements with Abdullah and Ahmad (1990), Potluri and Prasad (1993), Bolarine et al (1995) and Nadler and Heuer (1995) who indicated that increasing salinity level led to increase the reducing sugars content.

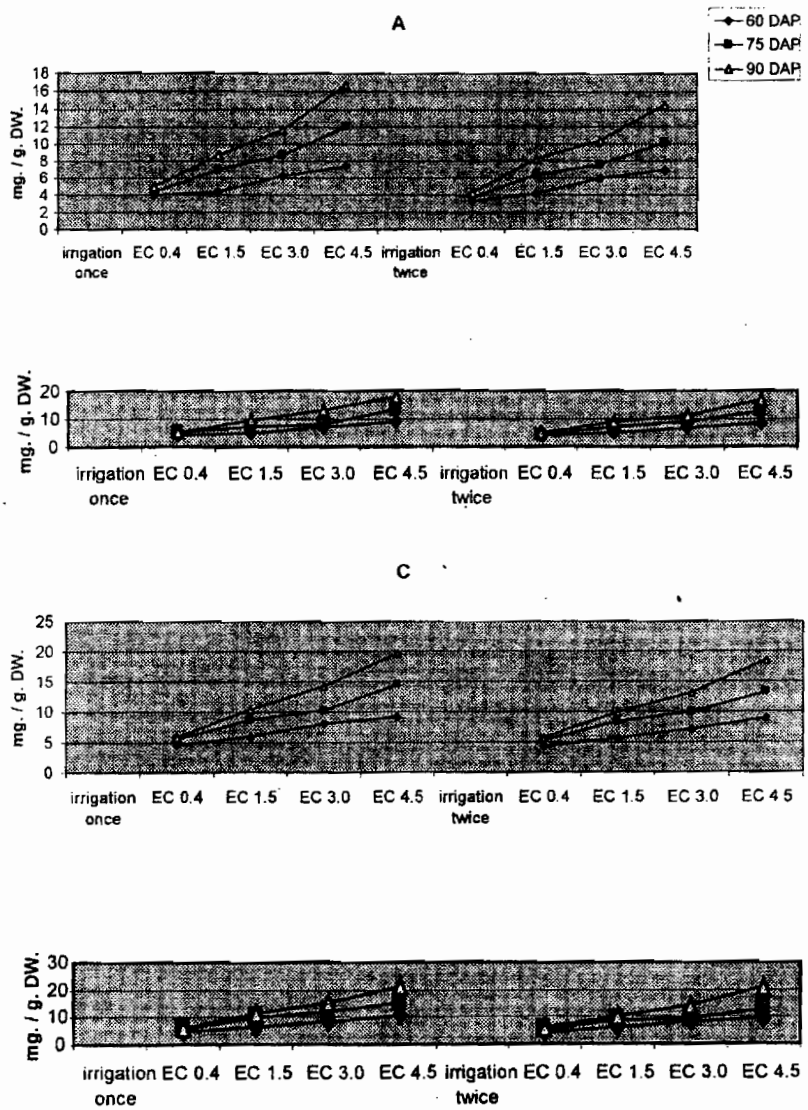


**Fig (2). Effect of once and twice irrigation frequencies with different concentrations of saline water 0.4, 1.5, 3.0 and 4.5 dS $m^{-1}$ on proline content (mg. / g. dry weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), fall 1999 (B), summer1999 (C) and summer 2000 (D) seasons**

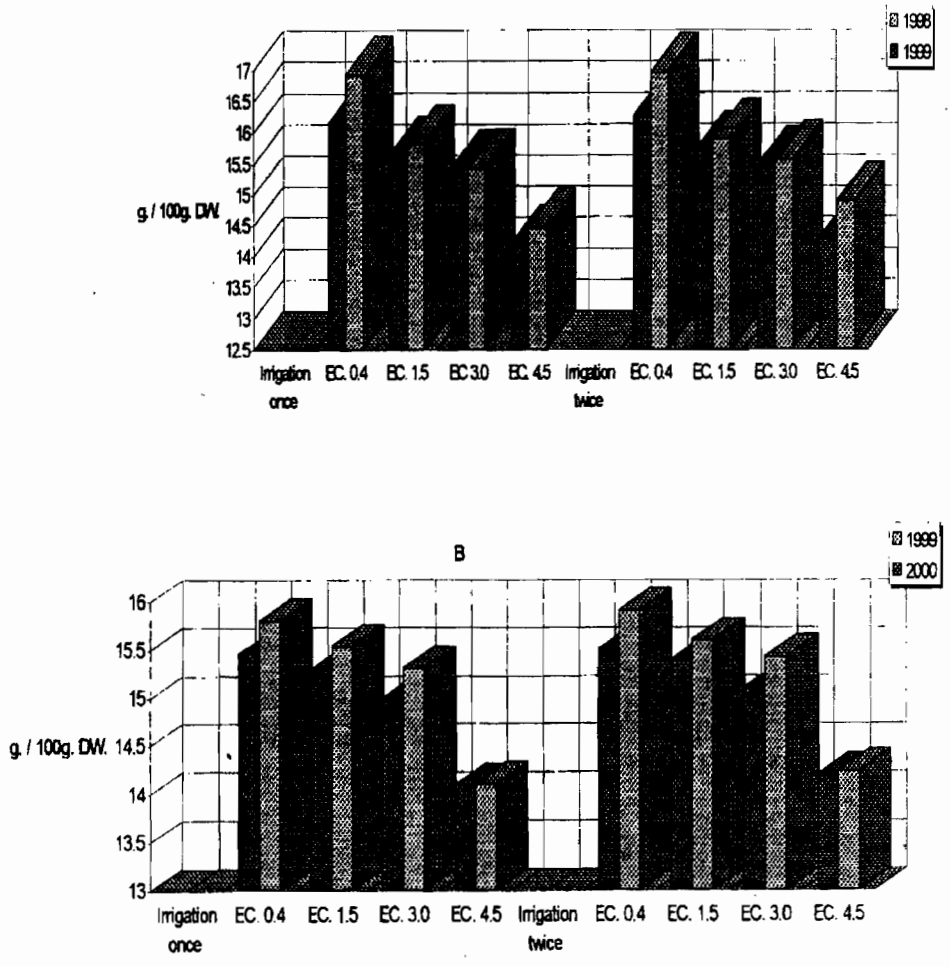


**Fig. (3). Effect of irrigation frequency with saline water on starch content (g. / 100 g. DW) during fall 1998 and 1999 (A) and summer 1999 and 2000 (B) seasons**

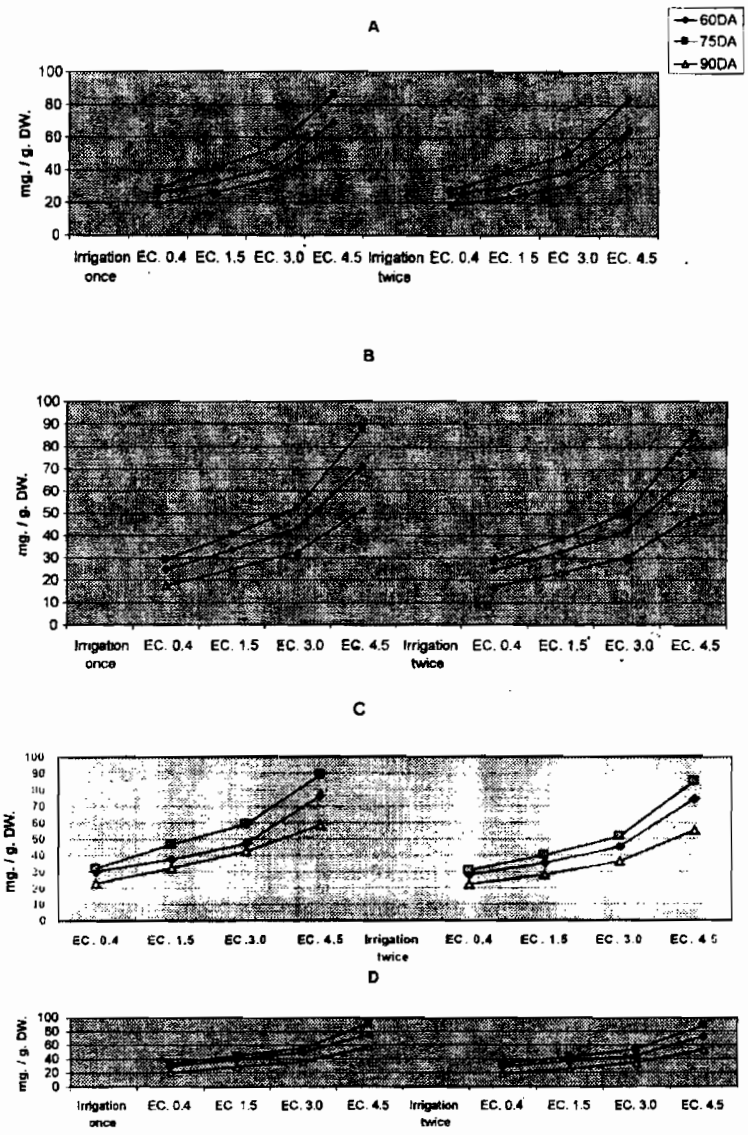


**Fig. (4). Effect of irrigation frequency with different concentrations of saline water on reducing sugars content (mg. /gm. Dry weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), fall 1999 (B), summer 1999 (C), and summer 2000 (D) seasons**

In summer seasons, the leaf content of reducing sugars was similarly affected with irrigation frequencies and salinity levels to that recorded in fall seasons.

## 6 – Non – reducing sugars.

Once irrigation frequency produced a higher content of non- reducing sugars as compared to twice irrigation frequency. (Fig.5).

Using water with high salt content in irrigation led to significant increase in the non–reducing sugars at the early and middle stages i.e. after 60 and 75 DAP, whereas it significantly decreased at 90 DAP. The effects of irrigation frequency, salinity concentrations and their interaction on leaf content of non–reducing sugars during summer season did not differ from that observed in fall seasons.

## 7 – Total soluble sugars.

In leaves, total soluble sugars concentration increased by irrigation once a day than twice a day at all stages of growth (Fig. 6).

The maximum value of total soluble sugars was obtained at age of 75 DAP by using water salinity. 4.5 dS $m^{-1}$ under once irrigation then it tended to decrease until it reached the lowest value at age of 90 DAP. In fall seasons, the interaction effect between irrigation frequency and salinity concentrations did not reach a significant level at all plant ages under study, whereas the interaction was significant at 90 DAP in the first summer season.

It could be also noticed from the present study that plants grown in summer season contained a higher amount of total soluble sugars than those grown in fall season did. This may be due to the evaporation rate, which was higher in summer than fall season and subsequently led to increase the total soluble sugar concentration in leaves.

## 8 -Leaf nitrogen content.

Data presented in (Fig.7) reveal that nitrogen concentration in potato leaves was significantly increased under the conditions of two irrigation a day as compared to one irrigation frequency in both fall and summer seasons. Regarding saline concentration of irrigation water, the results indicate a sharp decrease in nitrogen concentration at. 3.0 and 4.5 dS $m^{-1}$ while no significant differences were detected in nitrogen content between the control treatment 0.4 dS $m^{-1}$ and the treatment. Generally, the treatment of irrigation frequency during summer seasons showed similar effects. On the other hand, the interaction between irrigation frequency and salinity levels on nitrogen content was significant at the ages of 60 and 90 DAP in the first fall season and 60 DAP In the second season, while that it was significant only 60 DAP in the first one. These results are in harmony with those noticed by Nadler and Heuer (1995) and EL- Khattib (1996) who noticed that increasing salinity reduced the nitrogen content in plant leaves. The reduction in nitrogen uptake may be attributed to specific inhibitory effects of Na on the metabolic carriers responsible for anion absorption ($No_3$) as mentioned by EL – Nimr (1986).

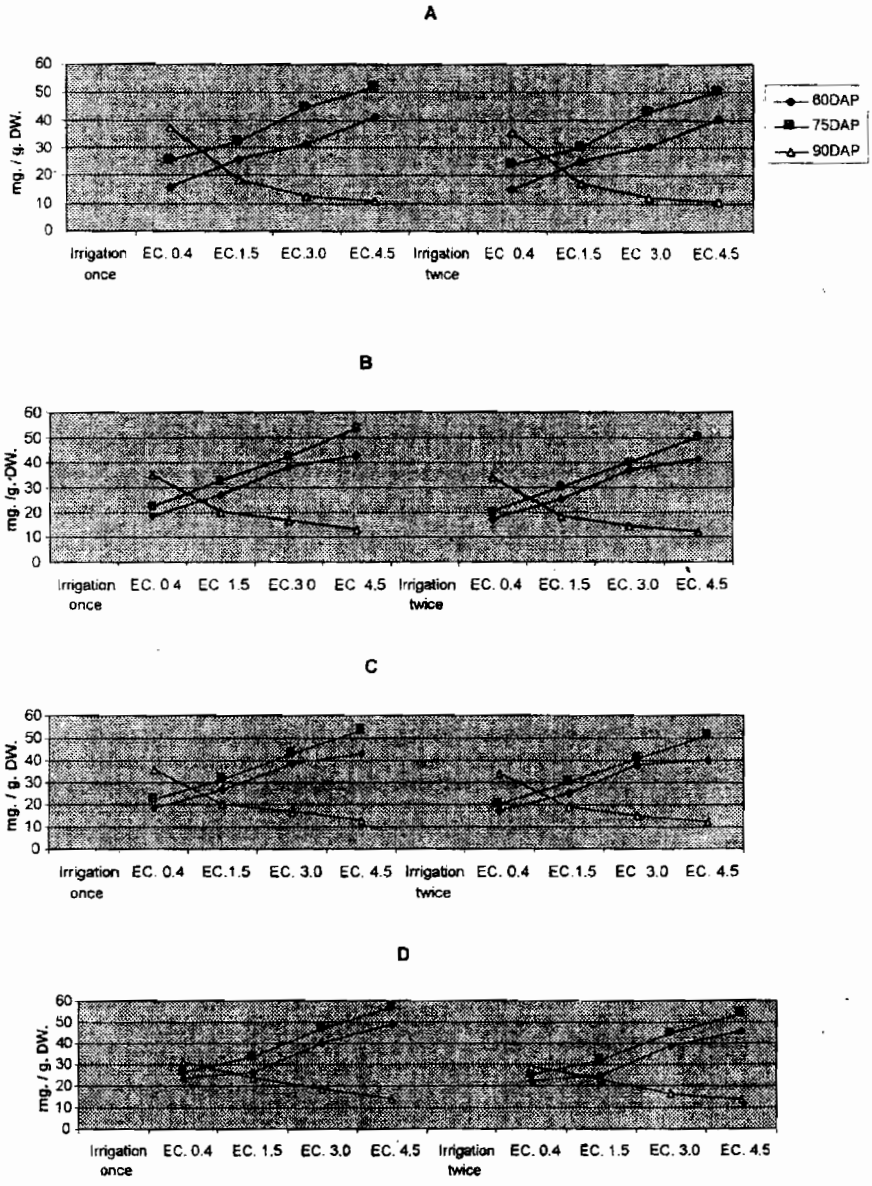


**Fig. (5). Effect of irrigation frequency with different concentrations of saline water on non reducing sugar (mg. / gm. Dry weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), 1999 (B), summer 1999 (C), and 2000 seasons .**

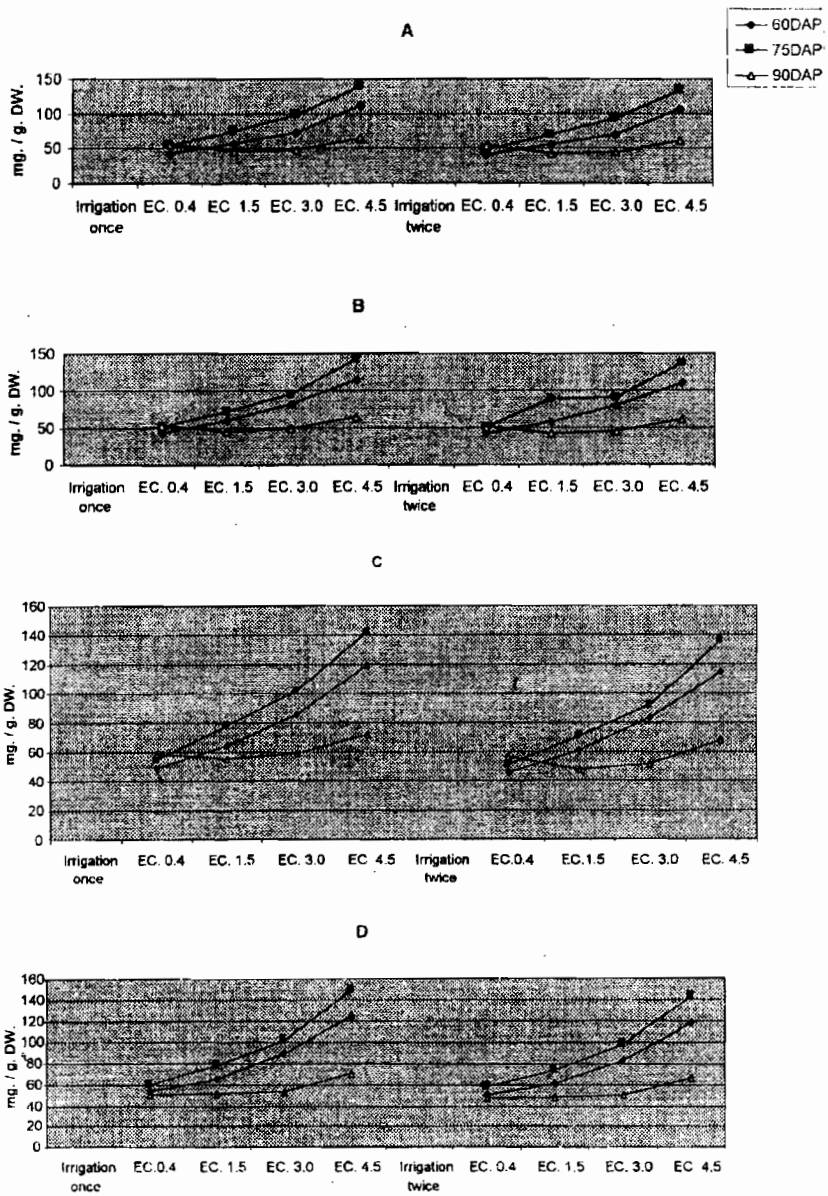


**Fig. (6). Effect of irrigation frequency with different concentrations of saline water on total sugars (mg./gm. Dry weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), 1999 (B), summer 1999 (C) and 2000 (D) seasons.**

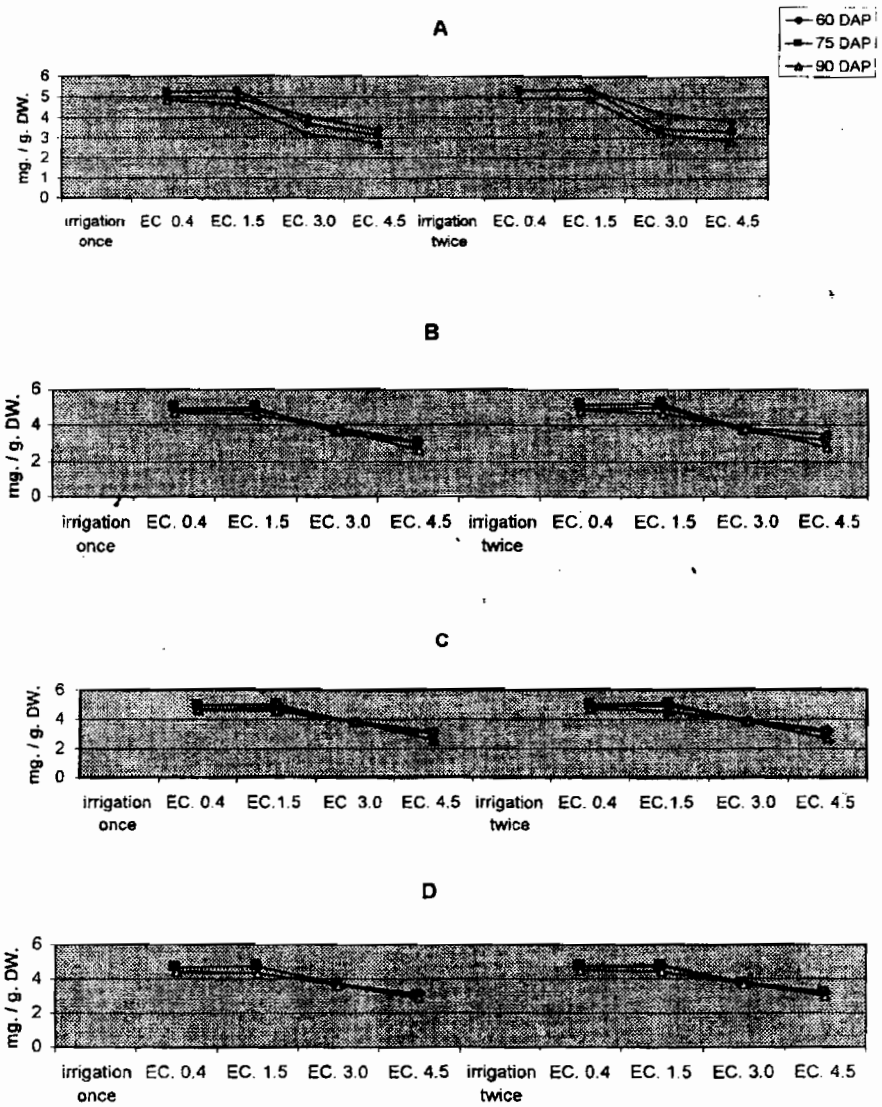


**Fig. (7). Effect of once and twice irrigation frequencies with different concentrations of saline water 0.4, 1.5, 3.0 and 4.5 Ds $m^{-1}$ on nitrogen content (mg./g. dry weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), fall 1999 (B), summer 1999 (C) and summer 2000 (D) seasons.**

## 9 - Leaf sodium content.

Increasing irrigation frequencies from once to twice a day decreased leaf sodium content in both fall and summer seasons, whereas increasing water salinity enhanced higher accumulation of sodium concentration in leaves. This increment may be due to the increase of this cation in root media, moreover this accumulation indicated the important role of this element in raising the osmotic pressure that led to facilitate the absorption of water which was needed for plants to tolerate the harmful effect of salinity on growth. Moreover, the beneficial effect of irrigation frequency on reducing sodium contents was more pronounced under the conditions of using high level of salinity i.e. at 3.0 and 4.5 dS $m^{-1}$ (Fig. 8).

These results are in agreement with those obtained by Jorgensen (1982), Potluri and Prasad (1993), Nadler and Heuer (1995), Barakat (1996), EL-Khattib (1996) and Alhagdow et al (1999) who indicated that increasing salinity led to increase sodium content in plant leaves.

## 10 -Leaf potassium content.

Data presented in Fig. 9 reveal that the effect of irrigation frequencies and salinity levels on leaf content of potassium took a reverse trend to that recorded for sodium content. In this respect irrigation two times a day significantly increased potassium content, whereas increasing salinity level in irrigation water reduced leaf potassium content. .

Generally, the interaction between irrigation frequencies and salinity levels on potassium content at different plant ages was significant in both fall and summer season. The highest value of potassium content was noticed in the plants irrigated twice a day with tap water. 0.4 dS $m^{-1}$, whereas the lowest value was recorded in plants irrigated once a day with water having 4.5 dS $m^{-1}$ salinity. These results were in agreement with those recorded by Cramer et al 1995, Nadler and Heuer 1995, Barakat (1996), EL- Khattib (1996) and Cano et al (1998) who reported that increasing salinity led to a decrease in potassium content.

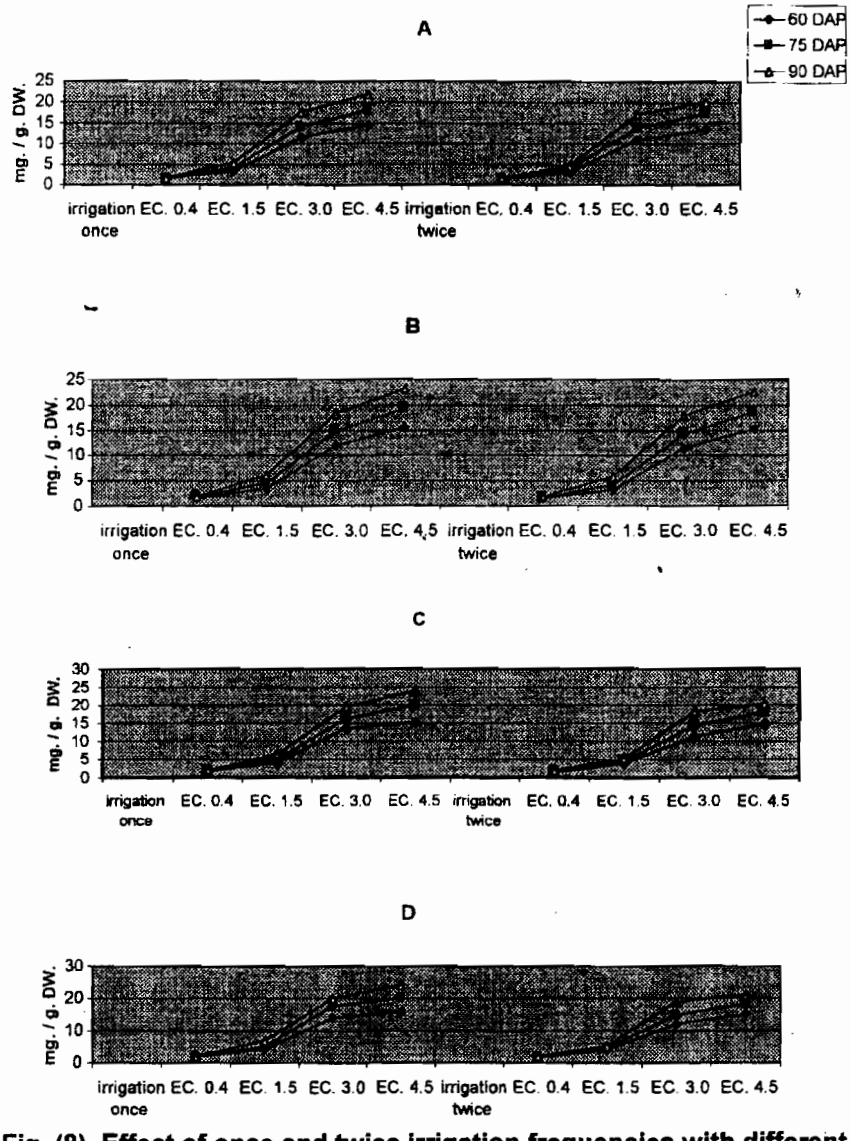


**Fig. (8). Effect of once and twice irrigation frequencies with different concentrations of saline water 0.4, 1.5, 3.0 and 4.5 $dSm^{-1}$ on sodium content (mg./ g. dry weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), fall 1999 (B), summer 1999 (C)and summer 2000 (D) seasons.**

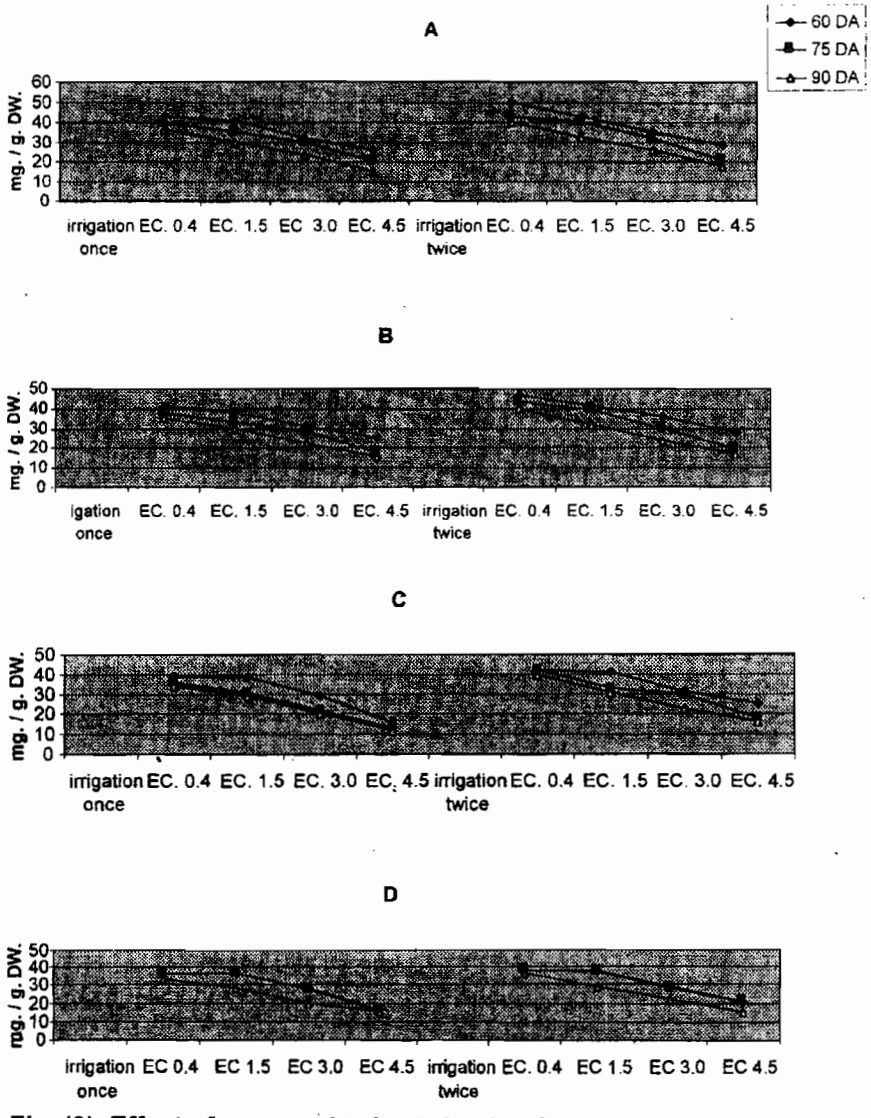


**Fig. (9). Effect of once and twice irrigation frequencies with different concentrations of saline water, 0.4, 1.5, 3.0 and 4.5 $dSm^{-1}$ on potassium content (mg. / g. dry weight) in potato leaves at 60, 75 and 90 days after planting (DAP) during fall 1998 (A), fall 1999 (B), summer 1999 (C) and summer 2000 (D) seasons.**

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# تأثير الري المتكرر بمستويات مختلفة من الماء المالح على نبات البطاطس.
# ٢- المكونات الكيميائية.

حسين محمد رمضان[١]، سيد فتحي السيد[٢]،احمد حسن خريبة[٢] واحمد محمد حامد[١].

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## الملخص العربي

الهدف من هذا البحث هو دراسة تأثير المستويات المختلفة من الملوحة ونظم الري على المحتويات المعدنية في أوراق نباتات البطاطس.

استخدمت أربع مستويات من الملوحة ٠,٤، ١,٥، ٣,٠، ٤,٥ ديسم في هذه الدراسة. وريت النباتات المنزرعة في أصص تحتوى على تربة رملية في كل معاملة من المعاملات السابقة مرة أو مرتين كل يومين خلال موسمي الخريف ١٩٩٨، ١٩٩٩ وموسمي الصيف ١٩٩٩، ٢٠٠٠ وكان الصنف المستخدم هو الديامونت

أدى الري مرتين إلى ازدياد الوزن الطازج والوزن الجاف للمجموع الخضري وكذلك محتوى الأوراق من الكلوروفيل والنيتروجين والبوتاسيوم بينما انخفض محتوى كل من الصوديوم والبرولين.

لوحظ أن التأثير المفيد لتكرار الري على انخفاض محتوى الصوديوم كان واضحا تحت ظروف استخدام التركيزات المرتفعة من الملوحة (٣,٠ أو ٤,٥ دسم)

انخفض كل من الوزن الطازج والجاف للمجموع الخضري للنبات بزيادة تركيز الملوحة. كما انخفض الكلوروفيل تدريجيا بتقدم عمر النبات بينما ازداد البرولين في نفس الوقت.

انخفض محتوى الأوراق من الكلوروفيل والنيتروجين بزيادة الملوحة في ماء الري.

أدت المستويات العالية من الملوحة إلى زيادة معنوية لتجمع البرولين وكذلك محتوى الصوديوم في أوراق البطاطس بينما أخذ البوتاسيوم الاتجاه العكسي لمحتوى الصوديوم في الأوراق.

تبين أن هناك علاقة إيجابية بين تركيز السكريات الكلية في الأوراق وتركيز الماء المالح المستخدم. لوحظ ازدياد السكريات المختزلة والغير مختزلة حتى ٧٥ يوم من الزراعة بزيادة تركيز ملوحة ماء الري ثم بدأت في الانخفاض حتى٩٠ يوم من الزراعة. كما ازدادت السكريات الذائبة الكلية بالري مرة واحدة مقارنة بالري مرتين.