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PHYSIOLOGICAL STUDIES ON SALT TOLERANCE OF TWO BANANA CULTIVARS

1- EFFECT OF SALT CONCENTRATION, SODIUM ADSORPTION RATIO (SAR) AND CHLORIDE LEVEL IN IRRIGATION WATER ON GROWTH AND CHEMICAL CONSTITUENTS

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ABSTRACT

The present study was conducted during 2006 and 2007 experimental seasons to investigate the salinity tolerance of banana plants through studying the response of some vegetative growth and chemical constituents to the specific and interaction effects of four evaluated factors i.e., a) banana cv. (Williams & Grand Nain); b) salinity concentration (2000 & 3000 ppm), c) SAR (3 & 6) and d) Cl:SO_4 ratio (low & high).

Data obtained revealed that all evaluated growth measurements (pseudostem height & circumference); (number of leaves & area); fresh and dry weights of differential above and underground plant organs, as well as leaves senescent rate responded significantly as they exhibiting a negative relationship to level of salinity, SAR and Cl:SO_4 ratio except senescent rate which followed a conflicted trend.

Nevertheless, all chemical constituents under study i.e., foliar photosynthetic pigments (chlo. A & B and carotines); proline and mineral nutrients (N, P, K, Ca, Mg, Fe, Mn and Zn) were significantly influenced. Whereas photosynthetic pigments and some nutrients (N, P, K, Mg, Fe, Mn and Zn) followed the same trend previously detected with growth measurements, however proline and both (Ca & Na) followed an opposite direction (similar to that found with senescent rate of leaves) regarding their response to level of salinity conc., SAR and Cl:SO_4 ratio. Besides, in most cases Grand Nain plants showed significantly higher values of both vegetative growth and chemical composition except senescent rate and leaf (Ca & Na) content, where the reverse was true with Williams cv.

INTRODUCTION

Banana (*Musa spp.*) is a tropical plant and considered as a one of the most popular fruit in Egypt for its high nutritive value and palatability for the Egyptian consumer. Also from the economical point of view, banana growers get relatively higher and fast net return from their orchard due to the rapid life cycle of banana plant. The over all average of banana in Egypt progressively developed through the former decade which reached about 28750 and 58607 Fed. in 1986 and 1999, respectively (Ministry of Agriculture, A.R.E., 1999). This average mainly concentrated in the delta and the Nile valley 32841 Fed. as there is an ample water supply, which is need to have good production.

The efficient use and preservation of water resources in Egypt i.e., River Nile, underground (well water) reuse of agriculture drainage are the critical challenge that certainly determine the future of agriculture development. So, the shortage in available fresh water supply needed to meet the extensions especially plantation of such crops having higher water requirements like as banana leads to consideration of reuse other resources like as waste water and well or sea water after mixing with fresh water that can be reutilized in irrigation purpose for the newly established banana orchards in reclaimed lands which reached 20752 Fe (1999).

Guide lines of interpretation of water quality for irrigation water indicated that there was no problem when the EC of the irrigation water was < 0.75 mmhos/cm and severe problems took place when EC was > 3.0 mmhos/cm (Ayers, 1977; Gupta, 1979 and Russell, 1982). Many authors were interested in exploring the mechanism of salt injury in different plants. Bernstein (1975) and Miller *et al.* (1990) they explained the adverse effects of salinity on plants growth in the following two topics:

1- The increase in the osmotic potential of the soil, which certainly result in reduction in the availability of water to the plant.
2- The specific toxic effect of some ions, such as Cl^-, Na^+ and especially in the certain sensitive crops, consequently caused a disturbance in the normal metabolism of plants.

Several authors pointed out that most of salt injuries are due to the three salinity aspects i.e. concentration and specific cations/anions particularly Na^+/Cl^-, respectively. Ivonova and Ivanova (1977) on peach found that NaCl inhibited tree growth more than salt Na_2SO_4. Moreover, most fruit crops are sensitive, chloride and sodium ion injuries may be the dominant factors in reducing fruit crops growth (Leon, 1980). Hartz (1984) found that salinity can prevent water uptake even when the soil is at field capacity. Fenn *et al.* (1968) showed that chlorides were more toxic than sulphates in the mechanism of plant injury, in case of specific ion toxicities, may involve an injury to plant regulatory system accumulation of Cl^- or Na^+ ions in the plant causing excessive water loss and leaf injury symptoms similar to those of drought. In addition, Gomes *et al.* (2001); Mohamed (2001), Abo El-Ez (2003), Carmo *et al.* (2003) and Gomez *et al.* (2004) on some banana cultivars demonstrated the effect of salinity on both vegetative and chemical properties.

Thus the present study was devoted to study the specific and interaction effects of banana cv., salinity concentration, SAR, $Cl:SO_4$ ratio and their combinations on growth and chemical compositions of two banana cultivars (Williams & Grand Nain).

MATERIAL AND METHODS

The present investigation was carried out during two successive seasons of 2006 and 2007 in greenhouse belonging to the Horticulture Research Station, El-Kanater, Qalyoubia, Governorate, Egypt. Three months old, uniform and healthy suckers (plants) of two banana cultivars (Williams and Grand Nain) were used as plant materials for this study.

On March 15th for both seasons suckers of two banana cultivars were transplanted individually i.e. each was planted in 35 cm in diameter pots (plastic bags) filled with 10 kg clay and sand mixture at 2:1 ratio (by volume). Irrigation was carried out twice weekly by adding one litter of tap water for each pot until investigated treatments of this study were started in both experimental seasons. Each pot (plant) was supplied with $(NH_4)_2SO_4$, K_2SO_4 and P_2O_5 applied every other two weeks at the rate of (1.7,1.2 and 0.6 gm/pot for 1st, 2nd and 3rd fertilizers, respectively, from April 1st until mid-September. However, irrigation with different saline solution was started two weeks later i.e., on April 1st and continued until October 1st..

Effect of different saline solutions on two banana cultivars.

In this regard eight solutions represented the different possible combinations between the following four investigated factors i.e., a) two banana cultivars (Williams and Garnd Nain), b) two saline concentrations (2000 and 3000 ppm), c) two SAR (3 & 6) and d) two $Cl:SO_4$ ratios (low & high), were prepared as shown in Table (1), besides tap water irrigation as control were investigated.

Thus; nine investigated treatments were as follows:

1- Tap water "control".
2- 2000 ppm saline solution with SAR 3 and low $Cl:SO_4$ ratio.
3- 2000 ppm saline solution with SAR 3 and high $Cl:SO_4$ ratio.
4- 2000 ppm saline solution with SAR 6 and low $Cl:SO_4$ ratio.
5- 2000 ppm saline solution with SAR 6 and high $Cl:SO_4$ ratio.
6- 3000 ppm saline solution with SAR 3 and low $Cl:SO_4$ ratio.
7- 3000 ppm saline solution with SAR 3 and high $Cl:SO_4$ ratio.
8- 3000 ppm saline solution with SAR 6 and low $Cl:SO_4$ ratio.
9- 3000 ppm saline solution with SAR 6 and high $Cl:SO_4$ ratio.

The complete randomized block design with five replications was devoted for arranging the above mentioned investigated treatments, whereas each replicate was represented by two plants.

1. Growth measurements:

On October 1st during both experimental seasons whereas the experiment was terminated the following morphological measurements were recorded:

1. Pseudostem length and circumference (cm).
2. Leaves measurements [total number, senescent rate of leaves (yellowish: total) and average area].
3. Fresh and dry weight of plant organs (leaves, pseudostem, corms and roots)

In each season the aforesaid growth measurements (except leaf area) were determined for every individual plant, then an average of two plants represented the same replicate was estimated. However, leaf area was determined in collected adequate samples from each plant. These samples were washed several times with distilled water, then, oven dried at 70°C till a constant weight for the dry matter estimation. Meanwhile, dried leaves were finally ground with stainless steel knife mill and stored in small light bags for N; P; K; Ca; Mg; Fe; Zn; and Mn determination.

Table (1): Preparation of the differential investigated eight saline solutions.

Saline solution	Salt* added per litter												SAR**	Cl meq/l	SO_4 meq/l	Cl/SO_4 ratio
	$CaCl_2$		$MgSO_4$		KCl		$CaCl_2$		Na_2SO_4		NaCl					
	g	meq	g	meq	g	meq	g	meq	g	meq	g	meq				
2000 ppm SAR 3 low Cl	0.45	8.11	0.50	8.33	0.08	1.07	0.42	4.83	0.25	3.52	0.35	5.13	3	14.30	16.68	0.86
2000 ppm SAR 3 high Cl	0.80	14.41	0.18	3.30	0.40	5.37	0.10	1.15	0.02	0.28	0.50	8.55	3	28.33	4.43	6.40
2000 ppm SAR 6 low Cl	0.35	6.31	0.25	4.17	0.15	2.01	0.35	4.02	0.55	7.75	0.35	5.98	3	14.30	15.94	0.90
2000 ppm SAR 6 high Cl	0.54	9.70	0.10	1.67	0.42	5.64	0.08	0.92	0.10	1.408	0.76	12.99	3	28.35	3.99	7.10
3000 ppm SAR 3 low Cl	0.66	11.89	1.20	20.00	0.03	0.68	0.33	4.69	0.42	5.87	0.36	6.13	6	17.70	29.82	0.59
3000 ppm SAR 3 high Cl	1.12	20.10	0.63	10.50	0.04	0.68	0.45	5.17	0.37	5.18	0.39	6.74	6	27.12	20.54	1.32
3000 ppm SAR 6 low Cl	0.42	7.50	0.75	12.50	0.14	0.68	0.45	5.17	0.70	9.86	0.54	9.23	6	17.41	27.53	0.63
3000 ppm SAR 6 high Cl	0..95	17.12	0.50	8.33	0.05	0.68	0.14	3.45	0.57	8.04	0.79	13.43	6	31.48	18.82	1.67

* Refers that salts used were estimated as unhydrous from.

** Refers that SAR = $\sqrt{meq \frac{Na}{(Ca + Mg)/2}}$

2. Chemical analysis:

In this regard leaf photosynthetic pigments (chlorophyll A, B and carotenoids) and leaf (proline), as well as leaf mineral composition in response to various investigated treatments were concerned.

2.1. Photosynthetic pigments (foliar pigments)

Leaf photosynthetic pigments (chlorophyll A & B and carotenoids compounds) were extracted by pure acetone and determined colorimetrically in each sampled leaves levels, at the optical densities of (662, 644 and 440 mm for chlorophyll A, B and carotenoides compounds, respectively, according to Nornal (1982) using the following equations:

Chl. A = (9.784 × E 664) – (0.99 × E 644) = mg/L.

Chl. B =(21.426 × E 644) – (4.650 × E 663) = mg/L.

Carotenoides = (4.685 × E 440) – 0.268 (chl. A + chl. B) = mg/L.

2.2. Estimation of proline content:

The proline was determined in fresh leaves according to the methods described by (Batels *et al.*, 1973) and confirmed by Draz, (1986).

2.3. Leaf mineral determination:

From each dried leaf sample 0.2 g was digested using perchloric acid and sulphoric acid mixture (1:1) (Piper, 1950) for the following mineral analysis:

1. Total nitrogen by semi micro-Kiel Dahl method as out lined by (Pregl, 1945).
2. Phosphorus using spekol spectrophotometer at 88.2 U.V. according to method described by (Murphy and Riely, 1962).
3. Potassium and Sodium were estimated photometrically using the methods recommended by (Brown and Lilleland, 1964).
4. Calcium, magnesium, iron, zinc and manganese were determined using atomic absorption spectrophotometer "Perkin Elmer 3300" after (Chapman and Pratt, 1961).

3. Statistical analysis:

All data of the present investigation were subjected to analysis of variance and significant difference among means were determined according to (Snedecor and Cochran, 1972). In addition significant difference among means were distinguished according to the Duncans, multiple test range (Duncan, 1955) whereas, capital and small letters were used for differentiating the values of specific and interaction effects of investigated factors, respectively.

RESULTS AND DISCUSSION

Data obtained concerning .the response of vegetative growth and chemical composition of banana suckers to specific and interaction effects of the investigated four factors i.e., banana cultivars; salinity concentration; SAR and $Cl:SO_4$ ratio of saline solutions used for irrigation are presented in Tables (2, 3, 4, 5, 6, 7, 8 and 9).

1. Vegetative growth measurements:

1.1. Pseudostem length and circumference:

A- Specific effect:

Concerning the specific effect of cultivar, Table (2) displays that both pseudostem measurements followed to great extent the same trend, where Grand Nain cv. exceeded significantly Williams cv. during both seasons.

As for the specific effect of salinity concentration, it was quite evident as shown from Table (2) that both investigated levels (2000 & 3000 ppm) reduced statistically both pseudostem parameters as compared to control (tap water irrigation). Herein, the severest reduction was always in concomitant to the 3000 ppm irrigated plants, descendingly followed by those subjected to 2000 ppm and tap water from statistical point of view. Nevertheless, the specific effect of two other investigated factors i.e. SAR (3 & 6) and $Cl:SC_4$ ratio (low & high) reflected also an obvious variance. Hence, a significant negative relationship between either SAR or $Cl:SO_4$ levels from one hand and values of both pseudostem parameters from the other was obviously detected during both seasons.

B- Interaction effect:

Data obtained revealed that each investigated factor reflected directly its own specific effect on interaction effect of their combinations. He rein, the most depressive effect was exhibited by the 300 ppm saline solution of SAR 6 and higher $Cl:SO_4$ ratio, regardless of banana cultivar, where the least values of both pseudostem parameters were detected during two seasons. On the contrary, the lightest reduction below control (tap water irrigation) was statistically in closed relationship to the Grand Nain suckers irrigated with 2000 ppm saline solution of SAR 3 and lower $Cl:SO_4$ ratio, for two pseudostem parameters which in most cases did not statistically vary than control during both seasons. In addition other investigated combinations were in between the aforesaid two extremes.

1.2. Leaves measurements (total number/plant; senescent rate yellowish: total" and average leaf area):

A- Specific effect:

Referring the specific effect of cultivar, Table (3) displays that the response of 3 leaves measurements did not follow the same trend. Anyhow, two banana cultivars had approximately the same number of total leaves per plant. However, for two other leaves parameters, two conflicted trends were detected. Whereas Wilhams cv. showed significantly higher rate of senescent leaves (yellowish: total number), but the reverse was true with average leaf area since Grand Nain surpassed statistically Williams cv. during both seasons.

As for the specific effect of three other investigated factors (salinity concentration, SAR and $Cl:SO_4$ ratios) Table (3) declares that both total number of leaves/plant and average leaf area followed the same trend, whereas a negative linear relationship between values of three investigated factors (concentration, SAR and $Cl:SO_4$) from one hand and both concerned leaves measurements (number & area) from the other were detected during two seasons. On the contrary with the senescent rate of leaves the trend of response took the other way around (positive relationship).

Table (2): Pseudostem length and circumference (cm) of banana suckers as affected by specific and interaction effects of cultivars salt concentration, SAR, $Cl:SO_4$ ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Treatments \ Cultivars			Pseudostem length (cm)			Pseudostem circumference (cm)		
Conc. X SAR		$Cl:SO_4$	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season								
Control (tap water)			57.2ab	58.8a	**58.0A**	12.8a	12.4a	**12.6A**
2000 ppm	SAR 3	Low	57.2ab	57.8ab	**52.3B**	11.1b	12.4b	**10.4B**
		High	57.2ab	55.4b		10.1c-e	10.8bc	
	SAR 6	Low	52.2c	53.4de		9.9c-e	10.2cd	
		High	49.8cd	51.8d-f		9.6de	9.2e	
3000 ppm	SAR 3	Low	48.4de	49.6fg	**45.0C**	7.4f	7.4f	**6.4C**
		High	45.6e-g	48.0g		6.4gh	7.0fg	
	SAR 6	Low	45.2fg	45.0h		6.1hi	5.9h	
		High	44.2fg	39.0i		5.2i	5.6hi	
Mean**			**48.7B**	**51.8A**		**9.1B**	**9.3A**	
Mean of SAR (3 & 6)			**51.8A**	**48.9B**		**9.8A**	**8.7B**	
Mean of low & high $Cl:SO_4$ ratio			**51.1A**	**49.3B**		**9.5A**	**8.9B**	
2007 season								
Control (tap water)			**56.8b**	**58.6a**	**57.7A**	**12.6ab**	**14.2a**	**13.4A**
2000 ppm	SAR 3	Low	51.4d	58.0ab	**52.3B**	10.7c	12.2b	**10.3B**
		High	47.8e	57.8ab		10.2c	10.4c	
	SAR 6	Low	47.2ef	54.6c		9.9c	10.1c	
		High	46.6fg	54.6c		9.3c-e	9.4cd	
3000 ppm	SAR 3	Low	45.6gh	5o.6d	**45.0C**	7.8ef	8.0d-f	**6.8C**
		High	44.2hi	48.6e		6.7fg	7.2fg	
	SAR 6	Low	42.8ij	45.2gh		6.1g	6.6fg	
		High	41.2k	41.4jk		5.8g	6.0g	
Mean**			**48.7B**	**51.8A**		**9.2B**	**9.8A**	
Mean of SAR (3 & 6)			**51.8A**	**48.9B**		**10.0A**	**8.2B**	
Mean of low & high $Cl:SO_4$ ratio			**51.1A**	**49.3B**		**9.8A**	**9.2B**	

Mean followed by the same letter/s are not significantly different at 5% level.
*, ** Refer to specific effect of saline concentrations and banana cultivars, respectively

B- Interaction effect:

Table (3) shows a considerable variances in three leaves measurements, whereas specific effect of each investigated factor was directly reflected on their interaction effect.

Herein, the severest reduction in both average leaf area and total number of leaves/plant associated with the greatest rate of senescent leaves was significantly in closed relationship with such combinations representative of the irrigated Williams and Grand Nain banana plants (especially former cultivar) irrigated with 3000 ppm saline solution of SAR (6) and higher $Cl:SO_4$ ratio during two seasons of study. On the contrary, the lightest influence than control was markedly coupled with the irrigated Williams and Grand Nain banana plants (especially later cultivar) with 2000 ppm solution of SAR 3 and lower $Cl:SO_4$ ratio. In addition, other combinations were in between.

1.3. Fresh and dry weight of aboveground (aerial) and underground organs:

1.3.1. Aboveground organs (pseudostem & leaves):

A- Specific effect:

In this respect fresh and dry weights of both pseudostem and leaves in response to four investigated factors were the two aboveground organs concerned as shown in Table (4). Two organs followed the same trend, whereas Grand Nain cv. showed heavier weight than Williams cv. Moreover, with increasing level of salinity concentration of the saline solution and/or any of its SAR/$Cl:SO_4$ ratio weight values (fresh & dry) of both leaves and pseudostem were significantly decreased.

B- Interaction effect:

Table (4) shows that the specific effect of the four investigated factors (banana cv., saline concentration, SAR and $Cl:SO_4$ ratio) were reflected on interaction effect of their combinations. Anyhow, the severest depressive effect on fresh and dry weights of the aboveground plant organs (leaves & pseudostem) was significantly exhibited by the 3000 ppm of either lower or higher SAR and $Cl:SO_4$ ratio, regardless of banana cultivar during two seasons (2006 & 2007). However, in most cases irrigated Williams plants with 3000 ppm saline solutions of SAR 6 and higher $Cl:SO_4$ ratio tended to have the lightest (fresh and dry) weights of two aerial plant organs), but differences is significantly absent as compared to three other combinations of 3000 ppm of SAR. Such trend was true during both 2006 & 2007 seasons except with leaves fresh weight. On the contrary, the least reduction in fresh and dry weights of leaves and pseudostem exhibited by irrigation with saline solutions as compared to control (tap water irrigation) was always in significant concomitant to Grand Nain plants irrigated with 2000 ppm saline solution of SAR 3 and lower $Cl:SO_4$. In addition, other combinations were in between.

1.3.2. Underground organs:

In this regard true stem (corm) and roots were the two underground organs investigated regarding the response of their fresh and dry weights to specific and interaction effects of four factors as shown from tabulated data in Table (5).

A- Specific effect:

Both underground organs (corm & roots) followed the same trend previously detected with the aboveground organs regarding the response to specific effect of four investigated factors (banana cultivar, salinity concentration, SAR and $Cl:SO_4$ ratio).

B- Interaction effect:

It is quite evident that the trend of response was so firm and to great extent and coincident with the above mentioned one for the aerial plant organs.

Table (3): Some leaves measurements (total number, senescent rate and average leaf area) of banana suckers as affected by specific and interaction effects of cultivars salt concentration, SAR, Cl:SO_4 ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Treatments \ Cultivars			Total number of leaves/plant			Senescent rate (yellowish: total)			Average leaf area (cm^2)		
Conc. X SAR		Cl:SO_4	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season											
Control (tap water)			13.80a	14.00a	**13.90A**	0.144f	0.141f	**0.144C**	999.0b	1150.0a	**1075.0A**
2000 ppm	SAR 3	Low	12.20b	12.40bc	**11.90B**	0.228c-e	0.159ef.	**0.229B**	776.0d	987.0b	**805.0B**
		High	12.00bc	12.20b		0.245cd	0.193 d-f		667.0ef	972.0b	
	SAR 6	Low	11.60b-d	11.80b-d		0.228c-e	0.245c		662.0ef	915.0c	
		High	11.20	11.25b-d		0.300c	0.236cd		660.0ef	800.0d	
3000 ppm	SAR 3	Low	10.80c-e	10.80c-e	**9.93C**	0.377b	0.240cd	**0.418A**	624.0fg	684.0e	**595.0C**
		High	10.40de	10.75c-e		0.390 b	0.253cd		598.0g	651.0e-g	
	SAR 6	Low	9.40ef	9.60ef		0.509 a	0.502a		524.0h	631.0e-g	
		High	8.60f	9.00f		0.536a	0.536 a		423.0i	623.0fg	
Mean**			**11.48A**	**11.54A**		**0.261B**	**0.314A**		**693.0B**	**856.0A**	
Mean of SAR (3 & 6)			**11.98A**	**11.04B**		**0.240B**	**0.334A**		**811.0A**	**739.0B**	
Mean of low & high Cl:SO_4 ratio			**11.64A**	**11.38B**		**0.274B**	**0.301A**		**795.0A**	**754.0B**	
2007 season											
Control (tap water)			13.0ab	13.80a	**13.60A**	0.131ij	0.101j	**0.116C**	975.0c	1719.0a	**1351A**
2000 ppm	SAR 3	Low	12.20b-d	12.80a-c	**11.70B**	0.209f-h	0.171hi	**0.229B**	720.0d	1127.0b	**812.0B**
		High	11.60c-f	11.80c-e		0.239e-g	0.186g-i		692.0d	946.0c	
	SAR 6	Low	11.20d-g	11.60c-f		0.258d-f	0.231e-h		656.0d	871.0cc	
		High	11.00d-h	11.40d-g		0.275de	0.261d-f		639.0d	846.0cc	
3000 ppm	SAR 3	Low	10.60e-h	11.00d-h	**9.90C**	0.393c	0.264d-f	**0.432A**	409.0ef	692.0d	**433.0C**
		High	10.20g-i	10.40h		0.399c	0.311d		375.0e-g	623.0d	
	SAR 6	Low	9.20ij	9.80h-j		0.522b	0.449c		364.0e-g	447.0e	
		High	8.80j	9.20ij		0.592a	0.522b		268.0g	282.0fg	
Mean**			**11.34A**	**11.38A**		**0.314A**	**0.261B**		**607.0B**	**927.0A**	
Mean of SAR (3 & 6)			**11.78A**	**10.94B**		**0.240B**	**0.334A**		**818.0A**	**717.0B**	
Mean of low & high Cl:SO_4 ratio			**11.56A**	**11.16B**		**0.274B**	**0.301A**		**806.0A**	**729.0B**	

Mean followed by the same letter/s are not significantly different at 5% level.

*, ** Refer to specific effect of saline concentrations and banana cultivars, respectively

Table (4): Fresh and dry weights (g) of aerial/aboveground organs (leaves & pseudostem) of banana plants as affected by specific and interaction effects of cultivar; salt concentration; SAR; Cl:SO_4 ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Treatments \ Cultivars			Leaves fresh weight			Leaves dry weight			Pseudostem fresh weight			Pseudostem dry weight		
Conc. X SAR		Cl: SO_4	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season														
Control (tap water)			179.4b	229.1a	**204.3A**	26.59a	20.62b	**23.60A**	298.5a	298.5a	**272.4A**	15.55b	19.87a	**17.71A**
2000 ppm	SAR 3	Low	123.3d	160.9bc	**127.6B**	18.08bd	19.18bc	**15.37B**	220.0bc	225.4bc	**204.1B**	11.83d	16.92b	**12.11B**
		High	97.2ef	147.3c		14.09ef	17.25cd		196.4cd	214.7bc		11.69d	14.22bc	
	SAR 6	Low	91.2e-g	156.8bc		11.83fg	17.00cd		192.8cd	213.7bc		10.70d	11.23d	
		High	89.6e-g	154.2c		9.39g-i	16.10de		179.1c-e	190.7cd		9.73de	10.55d	
3000 ppm	SAR 3	Low	85.5e-g	107.9de	**78.4C**	7.51i-k	10.25gh	**7.81C**	164.7de	182.7c-e	**141.4C**	7.75ef	7.77ef	**6.35C**
		High	74.9f-h	96.2ef		7.38i-k	9.50g-i		159.1de	164.6de		6.70fg	7.10eg	
	SAR 6	Low	76.3f-h	59.2h		6.45jk	8.48h-j		115.3f	137.5ef		5.20fg	6.50fg	
		High	68.6gh	58.7h		5.74k	7.14i-k		112.3f	100.0f		4.85g	4.95fg	
Mean**			**106.5B**	**139.9A**		**13.37B**	**14.61A**		**192.2B**	**193.7A**		**9.97B**	**11.89A**	
Mean of SAR (3 & 6)			**130.2A**	**116.3B**		**15.05A**	**12.93B**		**208.0A**	**177.2B**		**12.09A**	**9.76B**	
Mean of low & high Cl:SO_4 ratio			**127.0A**	**119.5B**		**14.60A**	**13.38B**		**199.6A**	**186.2B**		**11.38A**	**10.48B**	
2007 season														
Control (tap water)			184.7b	241.6a	**213.1A**	14.87c	24.50a	**19.69A**	288.2a	296.3a	**292.3A**	15.93b	20.83a	**18.83A**
2000 ppm	SAR 3	Low	116.4c-e	163.9b	**123.3B**	13.13cd	17.37c	**12.86B**	174.5a	212.6b	**169.2B**	12.75c	13.13bc	**11.91B**
		High	114.6c-f	135.5c		12.45c-e	14.68c		170.5bc	182.8bc		11.90c	12.52c	
	SAR 6	Low	102.5d-j	130.8c		11.88de	11.47d-f		145.5bc	164.8cd		11.25c	11.91c	
		High	95.0g	127.9cd		11.70d-f	10.23e-g		127.2c-e	175.4bc		10.65c	11.20c	
3000 ppm	SAR 3	Low	91.6g	88.1fg	**74.7C**	9.05f-h	8.18g-i	**7.13C**	110.0d-f	118.5e-g	**94.5C**	5.29d-f	7.58d	**5.27C**
		High	86.0g	80.1g		7.63g-i	7.26g-i		98.5e-g	110.1e-g		4.49ef	6.60de	
	SAR 6	Low	78.0g	51.0h		7.03hi	6.05i		81.2gh	91.0f-h		4.05ef	6.73de	
		High	76.6g	37.9h		5.65i	5.85i		69.0h	87.6f-h		3.11f	4.33ef	
Mean**			**95.5B**	**137.5A**		**10.41B**	**13.41A**		**158.1B**	**170.7A**		**10.37B**	**10.74A**	
Mean of SAR (3 & 6)			**130.2A**	**112.6B**		**12.92A**	**10.92B**		**176.2A**	**152.6B**		**11.10A**	**10.00B**	
Mean of low & high Cl:SO_4 ratio			**124.9A**	**112.9B**		**12.35A**	**11.48B**		**168.3A**	**160.6B**		**10.95A**	**10.16B**	

Mean followed by the same letter/s are not significantly different at 5% level.

* ** Refer to specific effect of saline concentrations and

Table (5): Fresh and dry weights (g) of underground organs (corms & roots) of banana plants as affected by specific and interaction effects of cultivar, salt concentration; SAR; Cl:SO_4 ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Cultivars / Treatments			Corms fresh weight			Corms dry weight			Root fresh weight			Root dry weight		
Conc. X SAR		Cl: SO_4	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season														
Control (tap water)			122.20b	146.9a	**134.6A**	11.33b	21.48a	**16.14A**	150.3a	154.1a	**152.2A**	17.45a	19.38a	**18.42A**
2000 ppm	SAR 3	Low	110.60c	105.60cd	**97.8B**	10.02bc	10.96b	**8.54B**	104.4d-f	124.4b	**107.1B**	11.83c	14.21b	**10.09B**
		High	96.91d-f	103.60c-e		8.68cd	8.69cd		94.3e-h	121.7bc		9.33d-f	10.71cd	
	SAR 6	Low	92.82fg	96.70d-f		6.55d-f	9.00bc		89.8f-h	118.4b-d		8.13e-g	10.36c-e	
		High	81.60hi	94.70e-g		6.32ef	8.10c-e		85.3g-i	118.3b-d		6.56g-i	9.61c-f	
3000 ppm	SAR 3	Low	75.80ij	86.30gh	**67.7C**	4.10gh	6.50d-f	**3.91C**	84.0g-i	107.7c-e	**75.4C**	5.72hi	7.84f-h	**5.43C**
		High	70.61j	81.00hi		3.77gh	5.58fg		70.4i	99.5f-g		4.62ij	7.80f-h	
	SAR 6	Low	58.40k	61.30k		2.91h	3.56gh		47.2j	78.9hi		3.10j	6.32g-i	
		High	53.01k	55.40k		2.22h	2.67h		45.1j	70.1i		3.01j	5.03ij	
Mean**			**92.90B**	**93.40A**		**7.63B**	**8.89A**		**97.8B**	**109.1A**		**9. 11B**	**10.68A**	
Mean of SAR (3 & 6)			**99.90A**	**86.30B**		**9.11A**	**7.41B**		**111.1A**	**95.8B**		**10.89A**	**8.90B**	
Mean of low & high Cl:SO_4 ratio			**95.71A**	**90.60B**		**8.64A**	**7.88B**		**105.9A**	**100.9B**		**10.43A**	**9.35B**	
2007 season														
Control (tap water)			201.3a	123.3c	**162.3A**	10.98b	14.12a	**12.55A**	144.5ab	166.0a	**155.2A**	8.46d	21.08a	**14.77A**
2000 ppm	SAR 3	Low	142.0b	111.1d	**102.7B**	9.44b-d	10.33bc	**7.56B**	102.2cd	124.0bc	**106.1B**	7.57de	14.30b	**9.16B**
		High	105.2de	97.8f		6.92e-g	8.45c-e		100.0de	107.3c-e		6.95de	12.12c	
	SAR 6	Low	91.5fg	94.3fg		6.05f-h	7.79d-f		98.6de	100.3de		5.96ef	10.99c	
		High	86.5g	93.1fg		5.08g-i	6.45e-h		100.0de	100.1de		4.70f-h	10.65c	
3000 ppm	SAR 3	Low	65.7i	78.4h	**56.6C**	4.58hi	3.98ij	**2.92C**	74.0fg	84.8ef	**68.4C**	3.34h-j	7.31de	**4.23C**
		High	55.7j	70.7hi		3.20i-k	3.84i-k		72.5fg	75.2fg		2.80ij	6.82de	
	SAR 6	Low	49.8j	52.6j		1.88k	2.30jk		57.9fg	75.0fg		2.56ij	5.08fg	
		High	38.9k	41.00k		1.76k	1.78k		40.4gh	67.4fg		1.81j	4.08g-i	
Mean**			**88.6B**	**103.8A**		**6.20B**	**7.21A**		**95.2B**	**106.5A**		**5.26B**	**11.35A**	
Mean of SAR (3 & 6)			**105.1A**	**87.2B**		**7.58A**	**5.82B**		**106.7A**	**95.0B**		**9.08A**	**7.54B**	
Mean of low & high Cl:SO_4 ratio			**101.A**	**91.4B**		**7.15A**	**6.26B**		**104.1A**	**97.6B**		**8.67A**	**7.95B**	

Mean followed by the same letter/s are not significantly different at 5% level.

*, ** Refer to specific effect of saline concentrations and banana cultivars, respectively

The present results regarding the reduction in investigated vegetative growth (leaves, pseudostem, corms and roots) exhibited by saline solutions may be due to the absorption of particular ions to toxic accumulation level, that decrease the essential nutrients and consequently induced a drastic changes in the ion relationship of plants (Wadleigh and Gaash, 1963). Moreover, the application of saline solution may lead to the suggestion that salinity induced earliness of plant senescense as a result of the accumulation of some ions (Na and/or Cl) to reach toxic levels that may adoptive mechanism of banana to retranslocate excess amount of Na and/or Cl out of younger leaves to the older ones to put them away from the physiologically active tissues (Winter, 1982). Besides, the reduction in growth caused by water stress composed mainly of tension or osmotic components (Hayward and Bernsteen, 1958), who suggested also that salinity like drought may reduce water potential and pressure potential (turgar pressure).

In addition, the depressive effect of increasing salt concentration, SAR and/or $Cl:SO_4$ ratio on plant height, fresh and dry weights of plants may be due to the disturbance in metabolic pathway of plants as a result of salts on enzymatic activities (Strogonov, 1964) or to the adverse effect of Na and Cl ions on metabolism or disturbed water relations (Delane *el al.*, 1982).

The present results are in general agreement with the findings of Gomes *et al.* (2001), Mohamed (2001), Abo El-Ez (2003), Carmo *et al.* (2003) and Gomes *et al.* (2004), on some banana cvs. demonstrated the effect of salinity on vegetative growth.

II- Chemical constituents:

In this respect leaf photosynthetic pigments (chlorophyll A, B and carotein), proline and some mineral elements (N, P, K, Ca, Mg, Na, Fe, Mn and Zn) were the investigated chemical constituents regarding their response to specific and interaction effects of four studied factors:

II.1. Leaf photosynthetic pigments and proline contents:

Data of both 2006 and 2007 seasons are presented in Table (6).

A. Specific effect:

It is quite clear as shown from data in Table (6) that all 3 photosynthetic pigments and proline responded specifically to four investigated factors from one hand, however, they followed two conflicted trends from the other, Herein, Grand Nain plants leaves were significantly richer in there chlorophyll a, b and carotenoids contents, but the reverse was true for leaf proline content whereas its leaves were the poorest as compared to control.

In addition, 3 pigments (chlorophyll a, b and carotenoids compounds) reduced significantly by increasing level of either salt concentration, SAR or $Cl:SO_4$ ratios of saline solutions. However, the trend took the other way around with proline content.

B. Interaction effect

Table (6) reveals obviously that each investigated factor reflected directly its own effect on their different combinations. Herein, the least values of there photosynthetic pigments associated with the greatest proline value were significantly in

closed relationship to the 3000 ppm of SAR 6 and either lower or higher $Cl:SO_4$ ratio irrigated plants, regardless of banana cultivar. Such trend was generally true during both seasons with few exceptions pointed out that two cultivars exchanged their situation. In other words irrigated Williams suckers with 3000 ppm saline solution of SAR 6 and higher $Cl:SO_4$ ratio were relatively the most sensitive to saline stress as their leaf 3 photosynthetic pigments and proline contents were concerned during both seasons except chlorophyll A & B content during 2nd season, where those of Grand Nain were relatively the inferior. On the contrary, both Williams and Grand Nain plants subjected to the 2000 ppm saline solution of SAR 3 and lower $Cl:SO_4$ ratio showed not only the least variance i.e. reduction in their leaf chlorophyll (A & B) and carotenoids compound associated with the least increase in proline content but also they were not significantly vary from statistically point of view. In addition other combinations were in between.

These results are in general agreement with the earlier findings of Poljakoff and Gali (1975), Patel *et al.* (1984), Kabeel (1985), Omar (1996) and Ali (2005) regarding the reduction on chlorophyll content. Moreover, findings of Nieves *et al.* (1991) and Gaser (1992) gave support to the detected trend of proline response to salinity.

II.2. Leaf mineral composition:

The response of leaf N, P, K, Mg, Ca, Na, Fe, Mn and Zn contents to the specific and interaction effects of investigated four factors (banana cv.; salinity concentration; SAR and $Cl:SO_4$ ratio and their combinations were concerned.

II.2:1. Macro nutrient elements:

Data obtained regarding the macro nutrient elements (N, P, K, Ca, and Mg) besides Na buring both 2006 & 2007 seasons are presented in table (7) and (8).

A. Specific effect:

As for the specific effect of cultivar, table (7) and (8) display a considerable variations varied from one nutrient element to another. Anyhow, Grand Nain leaves were significantly richer in their P, K, and Mg content, while the reverse was true with both Ca and Na content. On the other hand two banana cultivars were equally similar in their leaves N content from statistical point of view.

Nevertheless, the trend of response to specific effect of salt concentration was firmer and showed two conflicted patterns. Herein, N, P, K, and Mg were significantly in negative relationship to salt concentration. However, both Ca and Na followed an opposite trend.

Referring the specific effect of SAR and $Cl:SO_4$ ratio, it is quite evident that both followed typically the same trend which was to great extend coincident with that previously detected with salinity concentration. Anyhow, the higher SAR or $Cl:SO_4$ ratio was the least leaf N, P, K, and Mg content associated with the highest Ca and Na leaf content.

cultivars salt concentration, SAR, Cl:SO_4 ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Treatments \ Cultivars			Leaf chlorophyll (A) mg/g.F.Wt.			Leaf chlorophyll (B) mg/g.F.Wt.			Leaf carotein (mg/g. F.Wt.)			Leaf proline (mg/g. F.Wt.)		
Conc. X SAR		Cl: SO_4	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season														
Control (tap water)			2.60ab	2.69a	**2.65A**	0.930a	0.890ab	**0.910A**	1.95ab	2.20a	**2.08A4**	1.39hi	1.00i	**1.20C**
2000 ppm	SAR 3	Low	2.42bc	2.45ab	**1.95B**	0.817a-c	0.780a-c	**0.658B**	1.85ab	2.10ab	**1.62B**	1.64gh	1.43hi	**2.16B**
		High	2.09cd	2.45ab		0.760bc	0.590de		1.79bc	1.80bc		2.32ef	1.79gh	
	SAR 6	Low	1.96d	2.31bc		0.720cd	0.500ef		1.47cd	1.60bc		2.72c-e	2.11fg	
		High	1.73d	2.03cd		0.670cd	0.433fg		1.05e	1.22d		2.80c-e	2.44d-f	
3000 ppm	SAR 3	Low	1.26e	1.52d	**1.15C**	0.380g-i	0.423f-h	**0.312C**	0.873ef	0.790e-h	**0.694C**	3.09bc	2.89cd	**3.18A**
		High	1.05e	1.15e		0.250hi	0.330f-i		0.740e-g	0.740e-g		3.10bc	3.09c	
	SAR 6	Low	1.01e	1.13e		0.240hi	0.330f-i		0.520gh	0.630e-h		3.57ab	3.25bc	
		High	0.880e	1.063e		0.223i	0.320f-i		0.460h	0.500f-h		4.20a	3.52ab	
Mean**			**1.77B**	**1.97A**		**0.549B**	**0.600A**		**1.188B**	**1.22A**		**2.56A**	**2.30B**	
Mean of SAR (3 & 6)			**1.99A**	**1.74B**		**0.615A**	**0.526B**		**1.40A**	**1.25B**		**2.17B**	**2.69A**	
Mean of low & high Cl:SO_4 ratio			**1.96A**	**1.69B**		**0.601A**	**0.540B**		**1.40A**	**1.25B**		**2.31B**	**2.55A**	
2007 season														
Control (tap water)			2.57c	3.85a	**3.12A**	0.863c	1.62a	**1.24A**	1.76b	2.24a	**2.00A**	1.23hi	1.17i	**1.20C**
2000 ppm	SAR 3	Low	1.82de	3.14b	**2.13B**	0.760cd	1.12b	**0.768B**	1.39c	2.07a	**1.44B**	1.47hi	1.30hi	**2.16B**
		High	1.79de	2.40c		0.670de	0.870c		1.38c	1.77b		1.98fg	1.67gh	
	SAR 6	Low	1.78de	2.37c		0.637e	0.860c		1.17cd	1.70b		2.39d-f	2.23ef	
		High	1.56e	2.17cd		0.617e	0.610e		1.09de	0.990d-f		2.58c-e	2.57c-e	
3000 ppm	SAR 3	Low	1.13f	1.08f	**0.902C**	0.397fg	0.440f	**0.331C**	0.770fg	0.920d-g	**0.674C**	2.92bc	2.70b-d	**3.18A**
		High	0.907fg	1.08f		0.373fg	0.340f-h		0.710gh	0.860e-g		3.11ab	2.87b c	
	SAR 6	Low	0.863fg	0.810fg		0.317f-h	0.270gh		0.460i	0.827fg		3.37a	2.83b-d	
		High	0.720fg	0.620g		0.297gh	0.213h		0.343i	0.503hi		3.43a	3.08ab	
Mean**			1.59B	2.12A		0.580B	0.797A		1.04B	1.46A		2.35A	2.18B	
Mean of SAR (3 & 6)			**2.61A**	**1.73B**		**0.746A**	**0.631B**		**1.39A**	**1.11B**		**2.04B**	**2.50A**	
Mean of low & high Cl:SO_4 ratio			**1.94A**	**1.77B**		**0.729A**	**0.647B**		**1.33A**	**1.16B**		**2.17B**	**2.36A**	

Mean followed by the same letter/s are not significantly different at 5% level.

*, ** Refer to specific effect of saline concentrations and banana cultivars, respectively

Table (7): Leaf nitrogen, phosphorus and potassium contents as affected by salt concentration, SAR, Cl:SO_4 ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Treatments \ Cultivars			Leaf N (%)			Leaf P (%)			Leaf K (%)		
Conc. X SAR	Cl:SO_4		Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season											
Control (tap water)			2.700a	2.90a	**2.8A**	0.365a	0.367a	**0.266A**	3.50a	3.50a	**3.50A**
2000 ppm	SAR 3	Low	2.400b	2.60b	**2.25B**	0. 360a	0.365a	**0.245B**	2.20c	3.03b	**2.15B**
		High	2.200b	2.20b		0.242b	0.252b		2.00c	2.200c	
	SAR 6	Low	2.200b	2.20b		0.240b	0.2427b		2.00c	2.200c	
		High	2.100b	2.10b		0.227b	0.22320c		1.600d	2.00c	
3000 ppm	SAR 3	Low	2.100b	2.10b	**1.81C**	0.215c	0.2150c	**0.199C**	1.400de	1.30ef	**1.13C**
		High	2.00bc	2.00b		0.202c	0.200d		1.13ef	1.20ef	
	SAR 6	Low	1.80cd	1.70cd		0.200c	0.195d		1.03fg	1.13ef	
		High	1.40d	1.40d		0.175d	0.1900d		0.800g	1.00fg	
Mean**			**2.12A**	2.16A		**0.205B**	**0.233A**		**1.92B**	**2.11A**	
Mean of SAR (3 & 6)			**2.32A**	**2.05B**		**0.237A**	**0.223B**		**2.13A**	**1.89B**	
Mean of low & high Cl:SO_4 ratio			**2.27A**	**2.10B**		**0.237A**	**0.225B**		**2.11A**	**1.92B**	
2007 season											
Control (tap water)			2.90ab	3.00a	**2.95A**	0.270a-c	0.282a	**0.276A**	3.64ab	3.83a	**3.74A**
2000 ppm	SAR 3	Low	2.40c-e	2.60bc	**2.36B**	0.270a-c	0.282a	**0.255B**	3.48a-c	3.48a-c	**3.39B**
		High	2.30c-e	2.50cd		0.252cd	0.265a-c		3.45a-c	3.39bc	
	SAR 6	Low	2.30c-e	2.40cd		0.245d	0.262bc		3.41a-c	3.38bc	
		High	2.20d-f	2.20d-f		0.227ef	0.242de		3.333bc	3.20c	
3000 ppm	SAR 3	Low	2.30c-e	2.067e	**1.85C**	0.212fg	0.205g	**0.195C**	2.60d	2.020e	**1.72C**
		High	1.90f-h	1.90f-h		0.197g	0.200g		1.77ef	1.75ef	
	SAR 6	Low	1.70hi	1.80gh		0.195g	0.195g		1.54f-h	1.60fg	
		High	1.40 i	1.70hi		0.160h	0.195g		1.30gh	1.16h	
Mean**			**2.23A**	**2.33A**		**0.229B**	**0.242A**		**2.76B**	**2.81A**	
Mean of SAR (3 & 6)			**2.39A**	**2.16B**		**0.244A**	**0.227B**		**2.94A**	**2.64B**	
Mean of low & high Cl:SO_4 ratio			**2.35A**	**2.21B**		**0.241A**	**0.229B**		**2.90A**	**2.69B**	

Mean followed by the same letter/s are not significantly different at 5% level.

*, ** Refer to specific effect of saline concentrations and banana cultivars, respectively

Table (8): Leaf sodium, calcium and magnesium contents of banana suckers as affected by specific and interaction effects of cultivars salt concentration, SAR, Cl:SO_4 ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Treatments \ Cultivars			Leaf Na (%)			Leaf Ca (%)			Leaf Mg (%)		
Conc. X SAR		Cl:SO_4	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season											
Control (tap water)			0.180gh	0.140h	**0.160C**	1.45fg	1.41g	**1.43C**	0.500b	0.66	**0.580A**
2000 ppm	SAR 3	Low	0.240e-g	0.200f-h	**0.245B**	1.49e-g	1.47fg	**1.57B**	0.440b-d	0.520b	**0.408B**
		High	0.250ef	0.220e-g		1.56c-g	1.52d-g		0.407cd	0.460bc	
	SAR 6	Low	0.250ef	0.240e-g		1.63c- e	1.59c-f		0.400cd	0.380cd	
		High	0.280e	0.280e		1.66cd	1.63c-e		0.360de	0.300ef	
3000 ppm	SAR 3	Low	0.360d	0.280e	**0.433A**	1.67cd	1.63c-e	**1.77A**	0.220gh	0.247fg	**0.178C**
		High	0.423c	0.360d		1.84ab	1.66cd		0.200gh	0.220gh	
	SAR 6	Low	0.500b	0.430c		1.880a	1.72bc		0.160hi	0.140hi	
		High	0.530ab	0.580a		1.91a	1.89a		0.100 i	0.140hi	
Mean**			**0.311A**	**0.282B**		**1.65A**	**1.59B**		**0.329B**	**0.372A**	
Mean of SAR (3 & 6)			**0.265B**	**0.341A**		**1.57B**	**1.68A**		**0.387A**	**0.314B**	
Mean of low & high Cl:SO_4 ratio			**0.282B**	**0.324A**		**1.59B**	**1.65A**		**0.367A**	**0.335B**	
2007 season											
Control (tap water)			0.170h	0.163h	**0.167C**	1.42d-g	1.37g	**1.40C**	0.513bc	0.645a	**0.579A**
2000 ppm	SAR 3	Low	0.240g	0.230g	**0.303B**	1.44c-f	1.40fg	**1.46B**	0.470c-e	0.543b	**0.442B**
		High	0.290f	0.287f		1.48cd	1.41f-g		0.430ef	0.490b-c	
	SAR 6	Low	0.343e	0.290f		1.49c	1.46c-f		0.400fg	0.447d-f	
		High	0.400d	0.343e		1.49c	1.47c-e		0.352gh	0.400fg	
3000 ppm	SAR 3	Low	0.463c	0.413d	**0.476A**	1.56b	1.56b	**1.58A**	0.320hi	0.365gh	**0.286C**
		High	0.460c	0.460c		1.59b	1.56b		0.290ij	0.320hi	
	SAR 6	Low	0.633a	0.580b		1.60ab	1.58b		0.252jk	0.275 i-k	
		High	0.633a	0.580b		1.74a	1.59b		0.220k	0.245jk	
Mean**			**0.380A**	**0.351B**		**1.52A**	**1.48B**		**0.361B**	**0.438A**	
Mean of SAR (3 & 6)			**0.317B**	**0.413A**		**1.47B**	**1.52A**		**0.439A**	**0.375B**	
Mean of low & high Cl:SO_4 ratio			**0.352B**	**0.378A**		**1.49B**	**1.51A**		**0.423A**	**0.390B**	

Mean followed by the same letter/s are not significantly different at 5% level.

*, ** Refer to specific effect of saline concentrations and banana cultivars, respectively

B. Interaction effect:

Each investigated factor reflected its own specific effect on the differential investigated combinations. Hence, the greatest interaction effect on leaf macro nutrient elements contents i.e. the least N, P, K, and Mg% associated with the highest Ca and Na content was allows in significant concentration to the four combinations representative of plants with 3000 ppm of SAR and lower or higher $Cl:SO_4$ ratio, regardless of banana cultivar. However, such trend in most cases was true during two seasons, but those irrigated with 3000 ppm of SAR 6 and higher $Cl:SO_4$ ratio tended to be relatively more depressed, especially Williams suckers.

On the contrary the least influence was detected by those combinations representative of 2000 ppm saline solution of lower SAR and $Cl:SO_4$ ratio which didn't significantly differ than control (tap water irrigation) in most cases during two seasons, with a relative tendency showed that Grand Nain plants were more tolerant.

In addition, other combinations were in between the aforesaid two extremes.

II.2.2. micro nutrient elements:

Leaf Fe, Mn, and Zn contents as influenced by the investigated four factors and their combinations were the investigated four factors and their combinations were the micro nutrient elements studied.

A. Specific effect:

Table (9) display obviously that three microelements represented specifically to the four investigated factors from one hand and followed the same trend from the other. Herien, Grand Nain leaves were significantly richer in their Fe, Mn and Zn content than the other cultivar (Williams). Moreover, Fe, Mn and Zn content were significantly reduced with increasing level of any of the three investigated factors i.e. salinity concentration, SAR and $Cl:SO_4$ ratios.

B. Interaction effect:

It was so clear that the irrigated Williams suckers with 3000 ppm saline solution of SAR 6 and either lower or higher $Cl:SO_4$ ratio had satistically the poorest leaves Fe, Mn and Zn contents. Such trend was true during both seasons, especially with that combination of higher $Cl:SO_4$ ratio, however differences were more pronounced with both Fe and Mn than Zn content.

On the contrary, the highest leaf Fe, Mn and Zn content was significantly coupled with tap water irrigated Grand Nain plants descendingly followed by the 2000 ppm, SAR 3 and lower $Cl:SO_4$ ratio irrigated plants of the same cultivar which showed the least rate of reduction in their leaf Fe, Mn and Zn content.

In addition other combinations were in between with a relative tendency of variance differed from one micronutrient element to another.

These results are in general agreement with the findings of Patil and Patil (1982) on pomegramate; Sharaf *et al.* (1985) on (Guava and Olive) and some grape species); Gaser (1986) on avocado; Omar (1996) on apricot and mango seedlings and Hasan (2005) on some olive cultivars.

Table (9): Leaf iron, manganese and Zinc contents of banana suckers as affected by specific and interaction effects of cultivars salt concentration, SAR, Cl:SO_4 ratio in saline irrigation water and their combinations during 2006 and 2007 seasons.

Treatments / Cultivars			Leaf Fa (ppm)			Leaf Mn (ppm)			Leaf Zn (ppm)		
Conc. X SAR	Cl:SO_4		Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season											
Control (tap water)			267.3d	339.5a	**303.4A**	60.00ab	61.08a	**60.54A**	35.60a	40.50a	**38.05A**
2000 ppm	SAR 3	Low	249.8d	331.5a	**268.5B**	53.13c	57.50b	**47.78B**	33.40c	36.60b	**32.65B**
		High	249.5e	300.3b		43.65e	53.75c		30.70d	36.13b	
	SAR 6	Low	228.0ef	298.7b		40.63f	48 .75d		30.23d	33.00c	
		High	217.0e-g	293.3b		39.38f	45.42e		28.90e	32.20c	
3000 ppm	SAR 3	Low	181.0h	216.5f-g	**189.2C**	27.63g	35. 50k	**37.98C**	23.50g-i	25.40f	**23.50C**
		High	175.5hi	213.0fg		25.00j	34.50g		22.73hi	24.70fg	
	SAR 6	Low	161.3ij	208.0g		20.63k	33.83g		23.17li	23.80gh	
		High	152.0j	206.0g		14.58l	30.00h		22.30i	22.37hi	
Mean**			**212 .94B**	**274.58A**		**38.42B**	**45.94A**		**28.62B**	**31.52A**	
Mean of SAR (3 & 6)			**246.07A**	**237.31B**		**45.18A**	**39.43B**		**30.92A**	**29.21B**	
Mean of low & high Cl:SO_4 ratio			**248.16A**	**239.34B**		**43.87A**	**40.74B**		**30.51A**	**29.61B**	
2007 season											
Control (tap water)			302.8ab	307.3a	**305.1A**	60.35c	,68. 35a	**64.35A**	42.53b	53.10a	**47.81A**
2000 ppm	SAR 3	Low	287.2b	300.0ab	**269.1B**	52.73e	62.30a	**50.14B**	39.13bc	49.20a	**40.93B**
		High	267.0c	291.5ab		44.45h	60.25b		38.00b-d	50.60a	
	SAR 6	Low	257.5cd	267.3c		37.80j	58.05d		34.70cd	42.07b	
		High	231.5fg	251.0c-e		32.45k	53.08e		33.27d	40.50d	
3000 ppm	SAR 3	Low	200.7h	246.5d-f	**197.3C**	29.00l	50.60f	**33.84C**	20.40e	33.27d	**20.28C**
		High	183.0i	236.7e-g		23.15m	48.13g		19.43e	21.43e	
	SAR 6	Low	165.0j	226.8g		19.10n	43.90h		17.43ef	19.83e	
		High	146.5k	173.2ij		17.55o	39.30i		13.77f	16.37ef	
Mean**			**239.98B**	**255.16A**		**37.69B**	**55.23A**		**30.12B**	**37.98A**	
Mean of SAR (3 & 6)			**262.27A**	**232.87B**		**49.93A**	**42.99B**		**36.73A**	**31.36B**	
Mean of low & high Cl:SO_4 ratio			**256.15A**	**239.11B**		**48.22A**	**44.71B**		**35.20A**	**32.89B**	

Mean followed by the same letter/s are not significantly different at 5% level.

*, ** Refer to specific effect of saline concentrations and banana cultivars, respectively.

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دراسات فسيولوجية على تحمل نباتات صنفين من الموز للملوحة
١- تأثير التركيز ونسبة كل من الصوديوم المدمص والكلوريد على النمو الخضرى والمحتوى الكيماوى

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أجريت هذه الدراسة خلال موسمى ٢٠٠٦، ٢٠٠٧ لدراسة مدى تحمل نباتات الموز الحديثة للملوحة من خلال تقييم استجابة بعض من قياساتها الخضرية والمحتوى الكيميائى للتأثير النوعى لأربعة عوامل مختبرة هى:

أ- صنف الموز (جراند نان، ويليامز)،

ب- تركيز ملوحة ماء الرى (٢٠٠٠، ٣٠٠٠ جزء فى المليون)،

ج- مستوى الصوديوم المدمص (٣، ٦).

د- نسبة الكلوريدات إلى الكبريتات (منخفضة، عالى) والتفاعل بينهما.

وقد أظهرت النتائج المتحصل عليها أن القياسات الخضرية (ارتفاع ومحيط الساق الكاذب)، (عدد الأوراق ومساحة الورقة)، الوزن الطازج والجاف لأجزاء النبات المختلفة (فوق أو تحت الأرض) وكذلك معدل شيخوخة الأوراق تأثرت معنويا بالعوامل المختبرة حيث كان هناك علاقة عكسية (سلبية، بين مستوى تركيز الأملاح ونسبة كل من الصوديوم المدمص والكلوريدات إلى الكبريتات ماعدا نسبة شيخوخة الأوراق التى سلكت اتجاها مضادا (علاقة طردية).

أما عن المحتوى الكيماوى والذى شمل صبغات التمثيل الضوئى بالورقة (كلوروفيل أ، ب، الكاروتين) الحمض الأمينى برولين والمحتوى المعدنى لبعض العناصر الغذائية (N, P, K, Ca, Mg, Na, Fe, Mn, Zn) فقد استجابت أيضا معنويا لأى من العوامل المختبرة وسلكت اتجاهين متضادين الأول تمثل فى أن جميع صبغات التمثيل الضوئى وبعض العناصر المعدنية (N, P, K, Mg, Fe, Mn, Zn) قد سلكت نفس الاتجاه الذى أظهرته قياسات النمو الخضرى (علاقة عكسية بين محتوى كل عنصر ومستوى كل من تركيز الملوحة والصوديوم المدمص ونسبة الكلوريدات إلى الكبريتات أما الاتجاه الآخر وهو مضاد للأول ويمثل محتوى الأوراق من كل من الحمض الأمينى برولين والكالسيوم والصوديوم فقد أظهر علاقة طردية مثل الذى أظهرته نسبة شيخوخة الأوراق (من حيث تأثير مستوى كل من تركيز الملوحة، الصوديوم المدمص ونسبة الكلوريدات إلى الكبريتات، وعلى الجانب الآخر فإن نباتات الجراند نان تميزت بارتفاع قيم قياساتها الخضرية والمحتوى الكيماوى عن نظراتها للصنف ويليمز ما عدا نسبة شيخوخة الأوراق ومحتواها من البرولين والكالسيوم والصوديوم فكان العكسى صحيحا.