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PHYSIOLOGICAL STUDIES ON SALT TOLERANCE OF SOME BANANA CULTIVARS

2- EFFECT OF CHLORIDE LEVEL IN IRRIGATION WATER AND FOLIAR SPRAY WITH SOME MINERALS ON GROWTH AND CHEMICAL CONSTITUENTS OF SALT STRESSED PLANTS.

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ABSTRACT

This study was conducted in 2006 and 2007 experimental seasons to throw some lights on possibility of minimizing the injuries resulted by saline irrigation water through investigating the effect of foliar spray with some nutrient elements in order to alleviate such disorders observed on growth and nutritional status of two banana cultivars suckers.

So, a factorial experiment was designed to study the specific and interaction effects of three factors (banana cultivar, $Cl:SO_4$ ratio of saline solutions used for irrigation and sprayed nutrient elements P, K, Zn).

Data obtained displayed that all evaluated growth measurements considerably responded to specific effects of 3 investigated factors. Since, saline stressed banana plants achieved some positive effects by P, K and Zn sprays, where an increase in most measurements of either growth (pseudostem height and circumference; leaves number & area and fresh & dry weights of plant organs) or chemical composition (leaf photosynthetic pigments, N, P, K, Mg, Fe, Mn and Zn contents) associated with a noticeable reduction in both leaves senescent rate and some chemical constituents content (leaf proline, Ca and Na) were detected. Moreover, raising $Cl:SO_4$ of saline solution used for irrigation exhibited an opposite trend to that found with P, K, Zn sprays. Meanwhile, the specific effect of cultivar pointed and that Grand Nain cv. had greater values of most vegetative growth and chemical constituents than Williams cv. except (leaves senescent rate, leaf proline, Ca and Na content). Consequently, the saline stressed banana plants (especially those of Grand Nain cv. irrigated with saline solution of lower $Cl:SO_4$ ratio) when sprayed with K or Zn exhibited the greatest values of most measurements for both vegetative growth and chemical constituents associated with the least values of (leaves senescent rate, leaf proline, Ca and Na contents). Accordingly, it could be concluded that saline solution of 3000 ppm, SAR 6 and lower $Cl:SO_4$ could be safely and when combined with K and/or Zn sprays.

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. Nowadays,

there is a great plantation of banana in new reclaimed lands especially Noubaria as the acreage reached 20752 fed. in 1999.

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 reducetion 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.

Fenn *et al.* (1968) showed that chlorides were more toxic than sulphates in the mechanism of plant injury. 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. Recently, mutualistic association of foliar sprayed salt stressed plants with nutrient elements as (P, K and Zn), have attracted the attention of agricultural researchers due to understanding the importance of spray elements, Sharaf *et al.* (1984), Khamis *et al.* (1985) and Ali (2005).

The present study was devoted to minimize the injuries resulted by using saline irrigation water through foliar spray with some nutrient elements in order to alleviate such disorders observed on growth and nutritional status of two banana cvs. (Williams and Grand Nain).

MATERIAL AND METHODS

This study was conducted during two consecutive 2006 and 2007 experimental seasons in the greenhouse of the Horticulture Research Station at El-Khanater, Qalyoubia Governorate on 3 months old banana plants of "Williams and Grand Nain cvs".

In mid-March during both seasons banana suckers were transplanted individually in plastic bags (30 cm. in diameter), each field with 10 kg clay and sand mixture (2:1 by volume), then regularly supplied with tap water twice weekly (1 liter/each) until the investigated treatments had been started two weeks later (April 1st). Taking into consideration that all banana plants devoted for the present work were also subjected to the same N, P or K fertilization program adopted in 1st paper.

The main objective was hopped to alleviate the harmful salinity influence exhibitted on both vegetative growth and nutritional status of the salinity stressed Williams and Grand Nain banana suckers (irrigated with 3000 ppm saline solution of SAR 6 and lower /higher $Cl:SO_4$ ratio) through investigating their response to foliar spray with P, K or Zn. Thus, a factorial experiment was devoted to investigate the specific effect of banana cultivar (Williams & Grand Nain); $Cl:SO_4$ ratio of saline solution (low & high) and foliar sprayed nutrient element (P, K, Zn at 250, 250, 100 ppm, respectively; besides tap water spray as control), as well as the interaction

effect of their combinations. The complete randomized block design with five replications (each represented by two plants) was used for arranging the investigated treatments i.e., sixteen combinations (2 banana cvs. x 2 $Cl:SO_4$ ratios x 4 spray treatments), whereas plants of each banana cultivar were subjected to the following eight treatments [(saline solutions of 3000 ppm and SAR 6 with either low or high $Cl:SO_4$ ratios) and four spray treatments (tap water, P, K and Zn)].

1- Saline stressed plants* of lower $Cl:SO_4$ ratio + water spray.
2- Saline stressed plants* of higher $Cl:SO_4$ ratio + water spray.
3- Saline stressed plants* of lower $Cl:SO_4$ ratio + P spray (250 ppm).
4- Saline stressed plants* of higher $Cl:SO_4$ ratio + P spray (250 ppm).
5- Saline stressed plants* of lower $Cl:SO_4$ ratio + K spray (250 ppm).
6- Saline stressed plants* of higher $Cl:SO_4$ ratio + K spray (250 ppm).
7- Saline stressed plants* of lower $Cl:SO_4$ ratio + Zn spray (100 ppm).
8- Saline stressed plants* of higher $Cl:SO_4$ ratio + Zn spray (100 ppm).

Two saline solutions used for irrigation (3000 ppm and SAR 6 of either lower or higher $Cl:SO_4$ ratio) were prepared as shown in Table (1) for being applied at the rate of 1 litter/pot every three other days from April 1st till October 1st. To prevent salts accumulation rewatering with fresh water was done fortnightly till October 1st. However, foliar spray with either tap water, P, K or Zn solutions were applied monthly from April 15th to mid September, where tween-20 at the rate of 0.1% was used as surfactant agents.

1. Vegetative growth:

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.

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 levels, at the optical densities of (662, 644 and 440 mm for chlorophyll A, B and carotenoides compounds, respectively, according to Saric *et al.* (1967) 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:

* Irrigated with 3000 ppm saline solution of SAR 6.

Table (1): Preparation of 300 ppm saline solution of SAR6 and lower/higher Cl:SO_4 ratio.

Saline solution	Salt* added per litter															Cl/SO_4 ratio
	$CaCl_2$		$MgSO_4$		KCl		K_2SO_4		Na_2SO_4		NaCl		SAR**	Cl	SO_4	
	g	meq	g	meq	g	meq	g	meq	g	meq	g	meq		meq/l	meq/l	
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 all salts used were estimated as unhydrous from.

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

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 differrence among mean 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 investtigated factors respectively.

RESULTS AND DISCUSSION

1. Vegetative growth:

Data obtained regarding the response of vegetative growth measurements to the specific and interaction effects of three investigated factors, i.e. banana cultivar (Williams and Grand Nain); $Cl:SO_4$ ratio of saline solution used for irrigation (low and high rates of 3000 ppm and SAR6) and spray treatments (tap water, P, K and Zn sprays) during 2006 and 2007 seasons are presented in Tables (2, 3, 4 and 5).

1.1. Pseudostem length and circumference:

A- Specific effect:

Regarding the specific effect of banana cultivar, Table (2) shows obviously that both pseudostem parameters followed the same trend, where Grand Nain cv. had significantly taller and thicker pseudostem during two seasons of study. As for the specific effect of $Cl:SO_4$ ratio of saline solution, it was quite clear that raising it resulted significantly in reducing both pseudostem height and cirecumference during two seasons. Nervertheless, Table (2) displays also that both pseudostem parameters were increased significantly as a result of spraying any of P, K or Zn nutrient elements in comparision with those of control (water sprayed saline stressed plants) during two seasons. However, Zn spray was the most effective as compared to either P or K spray. Superiority of Zn spray over P and K was significant with pseudostem height only, while with pseudostem circumferences did not reach level of significance. These results are in general agreement with that reported by Rajupt *et al.* (1976) on mango trees who found that spraying $ZnSO_4$ at 0.2-0.8% increased length of the terminal shoots. In this respect zn stimulated cell elongation by encouraging cell walls to strech Nason (1950). In addition, Behairy *et al.* (1985) on guava and olive, Omar (1996) on apricot and almond seedlings, Abd-El-Magied (1998) on almond seedlings and Ali (2005) on some apple rootstocks.

B- Interaction effect:

It was quite evident as shown from Table (2) that specific effect of each investtigated factor reflected directly on its own combinations. Anyhow, the tallest and thickest pseudostems were significantly in closed relationship to the saline stressed banana plants (especially at lower $Cl:SO_4$ ratio) of Grand Nain cv., when sprayed with either Zn or K solutions. However, in most cases slaine stressed plants sprayed with Zn solution tended to have taller and thicker pseudostem than the analogous ones K sprayed plants. On the contrary, water sprayed saline stressed plants (control) were statistically the most stunted ones, regardless of banana cultivar. However, in most cases those irrigated with 3000 ppm and SAR6 of the higher $Cl:SO_4$ showed the greatest rate of reduction for both pseudostem parameters. In addition, other 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:

With regard to the specific effect of banana cultivar, it was quite evident the each studied leaf measurement followed its own

trend. Herein, two banana cvs. had statistically the same number of total leaves per plant. Meanwhile, two other leaves parameters followed two conflicted trends. Whereas Wilhams cv. showed significantly higher rate of senescent leaves, but the reverse was true with average leaf area since Grand Nain cv. was significantly the superior during both seasons.

Table (2): Pseudostem length and circumference (cm) of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, Cl:SO_4, ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Pseudostem length (cm)			Pseudostem circumference (cm)		
Foliar spray	Cl:SO_4 ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season							
Water spray (control)	Low	41.2c-e	43.0e	39.53C	5.1fg	7.0ef	6.1B
	High	40.6de	42.1e		4.8fg	5.6g	
P spray	Low	44.0b-e	47.7bc	45.5B	8.2b-d	9.2b-d	8.8A
	High	43.0ce	46.8c-e		6.9de	7.4cd	
K spray	Low	44.2b-d	50.8ab	46.6B	8.5bc	10.4bc	9.3A
	High	43.4c-e	46.4c-e		7.5cd	8.8b-d	
Zn spray	Low	474b-d	51.8a	48.1A	9.0ab	11.0a	9.4A
	High	46.6-e	48.0bc		8.0b-d	8.9b-d	
Mean**		43.9B	47.1A		7.5B	8.5A	
Mean of low and high Cl:SO_4 ratio		46.3A	46.5B		8.4A	7.4B	
2007 season							
Water spray (control)	Low	42.8f42.8f	45.2e	42.7C	6.1fg	6.5e	5.9B
	High	41.2f	41.4f		5.2g	5.8f	
P spray	Low	47.2c-e	53.0b	49.4B	8.0cd	9.1ab	8.4A
	High	45.6de	51.4b		7.1cd	8.8ab	
K spray	Low	48.2c	53.8b	50.88B	8.0cd	9.4ab	8.5A
	High	46.0c-e	52.2b		7.5d	8.9ab	
Zn spray	Low	48.0cd	56.4a	59.9A	8.2c	9.5a	8.7A
	High	46.7c-e	52.4b		7.6cd	9.2ab	
Mean**		45.7B	50.7A		7.3B	8.4A	
Mean of low and high Cl:SO_4 ratio		49.28A	47.11B		8.11A	7.6B	

Means followed by the same letter/s are not significantly different at 5% level.
*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

Referring the specific effect of sprayed nutrient elements (Table 3) displays that three leaves measurements responded significantly, however two opposite trends were detected. Anyhow, both total leaves number/plant and average leaf area significantly increased in P, K or Zn sprayed plants from one hand and Zn spray was the superior from the other especially with later measurement whereas variances were significant. The trend took the other way around with senescent rate, whereas three sprayed ele-ments decreased it significantly and resulted approximately in the same value. These results go line with the findings of Sari El-Deen *et al.* (1979) who mentioned that vegetative area and total leaves number/olive transplant grown under salinity stress were greatly affected by mineral foliar spray. Meanwhile, Behairy *et al.* (1985) on salt stressed guava and olive seedlings, reported that spraying with Zn improved their vegetative growth.

Table (3): Some leaves measurements (total number, senescent rate and average leaf area) of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, $Cl:SO_4$, ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Total number leaves/plant			Senescent rate (yellowish:total)			Average leaf area (cm^2)		
Foliar spray	$Cl:SO_4$ ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season										
Water spray (control)	Low	9.6d	9.4de	9.2B	0.509a	0.479a	0.590A	524d	447e	419C
	High	9.0de	8.6e		0.536a	0.536a		423e	282f	
P spray	Low	11.8c-e	12.0ab	11.5A	0.200b	0.183b	0.236B	662bc	722ab	685B
	High	10.8c	11.4a-c		0.229b	0.240b		636c	718ab	
K spray	Low	12.2ab	11.8a-c	11.6A	0.231b	0.229b	0.228B	663bc	735ab	685B
	High	11.2bc	11.2bc		0.252b	0.232b		636c	706a-c	
Zn spray	Low	12.4a	12.4a	11.9A	0.226b	0.195b	0.213B	714ab	754a	722A
	High	11.4a-c	11.4a-c		0.246b	0.245b		700a-c	719ab	
Mean**		11.1A	11.0A		0.304A	0.293B		620B	735A	
Mean of low and high $Cl:SO_4$ ratio		11.5A	10.6B		0.281B	0.315A		653A	603B	
2007 season										
Water spray (control)	Low	9.8ef	9.2f	9.3B	0.522b	0.449c	0.521A	463f	631d	422C
	High	9.2f	8.8f		0.592a	0.522b		368g	623d	
P spray	Low	11.4a-d	12.2ab	11.4A	0.212i-f	0.246de00	0.236B	628e	747a	664B
	High	10.8de	11.2b-d		0.249d	0.238 d-f		572e	708a-c	
K spray	Low	11.6a-d	12.0a-e	11.4A	0.180ef	0.210.d-f	0.206B	651cd	778a	666B
	High	11.0cd	10.8de		0.246de	0.232d-f		533e	722ab	
Zn spray	Low	11.4a-d	12.4a	11.5A	0.176f	0.210d-f	0.214B	654b-d	775a	677A
	High	10.8de	11.4a-d		0.226d-f	0.217d-f		534e	743a	
Mean**		10.8A	11.0A		0.300A	0.289B		526.5B	666.5 A	
Mean of low and high $Cl:SO_4$ ratio		11.3A	10.5B		0.275B	0.313A		653.75A	560.25 B	

Means followed by the same letter/s are not significantly different at 5% level.
*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

B-Interaction effect:

Table (3) displays obviously that all combinations of saline stressed plants sprayed with P, K and Zn solutions varied significantly than those of water sprayed ones during two seasons. However, spray with either K or Zn solution for Grand Nain and Williams plants irrigated with 3000 ppm, SAR6 saline solution of lower $Cl:SO_4$ ratio especially with former banana cultivar were generally the most effective. Herrin, the highest values of both total number of leaves per plant and average leaf area associated with the least senescent leaves rate were observed during both seasons. The reverse was true for the water spray saline stressed plants especially those irrigated with saline solution of higher $Cl:SO_4$ where the least values of both total number and average area coupled with the highest senescent rate were generally found, regardless of banana cultivars. In addition, other combinations were in between, however significant differences were less pronounce with senescent rate especially as those combinations of P, K and Zn sprays were compared each other during two seasons.

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

1.3.1. Aboveground organs (pseudostem and leaves):

In this regard fresh and dry weights of both pseudostem and leaves were the two aboveground organs investigated.

A. Specific effect:

With regard to the specific effect of banana cultivar (Table 4) clears that two organs followed the same trend, whereas Grand Nain cv. had significantly heavier organs than Williams. However, the variance was more pronounced with leaves than pseudostem during both seasons. As for the specific effect of $Cl:SO_4$ ratio of saline solution, Table (4) shows that raising it decreased both organs weights. However, both aboveground organs responded specifically to the 3 sprayed elements, whereas 3 elements solutions exhibited significant increase over control. Zn in most cases was significantly the superior descendingly followed by K and P solutions.

B. Interaction effect:

Table (4) displays obviously that specific effect of each investigated factor (cultivar, $Cl:SO_4$ of saline solution and foliar spray of saline stressed banana plants with P, K and Zn solutions) was directly reflected on interaction effect of their combinations. Herin, the heaviest fresh and dry weights of both pseudostem and leaves were significantly in closed relationship to the Zn and K sprayed Grand Nain saline stressed plants especially those irrigated with lower $Cl:SO_4$ solution during both seasons. On the contrary, the lightest weights of both organs was markedly linked to water spray saline stressed plants especially of higher $Cl:SO_4$ irrespective of cultivar. In addition, other combinations were in between.

1.3.2. Underground organs (corms and roots):

A. Specific effect:

Referring the specific effect of cultivar (Table, 5) reveals that fresh and dry weights of both corms and roots (underground plant organs) followed the same trend previously found with two aboveground organs, whereas Grand Nain was statistically the superior during two seasons. Moreover, the response to specific effect of three nutrient elements sprays was significantly cleared. Hence, foliar spray with any of P, K or Zn solution resulted significantly in an obvious increase in fresh and dry weights of true underground organs as compared to control (unsprayed saline stressed banana plants). However, Zn sprayed saline stressed plants was the most effective. Differences were significant except as compared to the K sprayed plants whereas the increase did not reach level of significance during both seasons.

B- Interaction effect:

It was quit evident that the same trend of response previously found with two aboveground plant organs was also detected with both underground organs, whereas saline stressed Gran Nain banana plants irrigated with 3000 ppm of SAR6 and lower $Cl:SO_4$ ratio) sprayed with rather Zn or K solution exhibited the highest weights of two organs. However, the increase was not significant

either compared to the combination of Grand Nain plants sprayed with P solution subjected to the same saline solution ($Cl:SO_4$ ratio) or to the Zn sprayed Williams plants irrigated with 3000 ppm solution of SAR6 and lower $Cl:SO_4$ ratio during both seeds.

The present results regarding the depressive effect of raising $Cl:SO_4$ in saline solution on vegetative growth measurements are in accordance with the findings of Ivanov and Iranova (1977) and Leon (1980) who demonstrated that NaCl inhibited trees growth more than Na_2SO_4. Moreover, the beneficial effect of P, K and Z spray on improving saline stressed banana plants is in congeniality with findings of Sharaf *et al.* (1985) on (olive and guava seedlings) and Khamis *et al.* (1985) on two grape species (American and European grape rooted cuttings). The same findings were obtained by Khdr *et al.* (1981) on guava and Cleopatra mandarin and Khamis *et al.* (1985) on Thompson seedless, they reported that both P and K foliar spray gave a significantly increase of leaves, stem, roots and total dry weights. In addition Rajput *et al.* (1976) on mango and Behairy *et al.* (1985) on guava and olive, and Ali (2005) on apple rootstocks, found that $ZnSO_4$ spray increased both fresh and dry weights of different plants organs.

II. Chemical compositions:

II.1. Leaf photosynthetic pigments and proline contents:

A. Specific effect:

Table (6) reveals that both photosynthetic pigments (chlorophyll A and B and carotenoids compounds) and proline in banana leaves responded significantly to specific effect of three investigated factors (banana cultivar, $Cl:SO_4$ ratio of saline solution and nutrient elements spray). However, two conflicted trends were detected for the response of three photosynthetic pigments from one hand and proline from the other to specific effect of each investigated factor. Herein, Grand Nain was significantly richer than Williams cv. in their leaves photosynthetic pigments, but the reverse was true with leaf proline content. Moreover, foliar spray with any of P, K or Zn solution increased leaf chlorophyll A, B and carotein, but decreased proline, whereas differences were more pronounced with Zn and K especially former element. Rasing $Cl:SO_4$ ratio resulted in decreasing leaf photosynthetic pigments but increased proline content.

B- Interaction:

It was quite evident as shown from Table (6) that specific effects of three investigated factors reflected on their combinations. Anyhow, the highest leaf chlorophyll A, B and carotein contents associated with the least proline level were significantly coupled to the saline stressed Grand Nain plants (irrigated with saline solution of lower $Cl:SO_4$ ratio) when sprayed with Z and/or K solutions during two seasons. However, the reverse was true with unsprayed saline stressed banana plants irrigated with saline solution of higher $Cl:SO_4$ ratio, regardless of cultivars, whereas the least photosynthetic pigments and highest proline levels were detected. In addition, other combinations were in between.

This result is in partial agreement with the finding of Ali (2005) on some apple rootstocks, who found that foliar spray with Zn, P and K increased leaves photosynthetic pigments and reduced leaf proline content.

II.2. Leaf mineral composition:

II.2.1. Macro-nutrient elements:

In this regard leaf N, P, K, Ca and Mg, besides Na in response to three investigated factors (banana cultivar, $Cl:SO_4$ ratio of saline solution and sprayed nutrient elements) and their combinations were concerned.

A. Specific effect:

Referring the specific of banana cultivar (Tables 7 and 8) declear that however each element followed its own trend but two conflicted trends were detected. Hence, Grand Nain was richer in its leaf P, K and Mg than Williams, while the reverse was true with both Ca and Na. Differences were significant during both 2006 and 2007 experimental seasons except with both N and Ca which were too little to be significant. Moreover, leaf macronutrient elements content responded specially to $Cl:SO_4$ in saline solution, where leaf N, P, K and Mg levels were significantly

in negative relationship but the opposite was found with Ca & Na contents during two seasons of study. In addition, specific effect offoliar sprayed nutrient elements was quite clear, where all three elements (P, K or Zn) affected significantly leaf contents of 6 macro-elements compared to the unsprayed saline stressed plants (water spray/control). However, K and/or Zn was more effective except with leaf P content whereas P foliar spray was the superior. Anyhow, two conflicted trends were detected whereas a significant increase was observed in leaf N, P, K and Mg content, while with Ca and Na content the reverse was found.

B- Interaction effect:

Data in Tables (7 and 8) show that the specific effect of each investigated factor was directly reflected on its own combination. Herein, the greatest leaf N, P, K and Mg values associated with the least leaf Ca and Na contents were in closed relationship to the saline stressed banana plants sprayed with either K or Zn solution (especially those of Grand Nain cv. irrigated with saline solution of lower $Cl:SO_4$ ratio, in most cases). Such trend was true during both seasons, except with leaf P%, whereas the saline stressed plants under saline solution of lower $Cl:SO_4$ ratio were significantly the richest.

II.2.2. Leaf micronutrient elements:

A- Specific effect:

In this regard leaf Fe, Mn and Zn contents were the three microelements investigated, data obtained during both 2006 and 2007 seasons are presented in Table (9). It was quite clear that variances due to specific effect of three investigated factors were significant. Anyhow, Grand Nain cv. had significantly richer leaf Fe, Mn and Zn contents as compared to Williams cv. Meanwhile, specific effect of each of three sprayed P, K or Zn solution was significant, however, Zn was statistically the superior with both Mn and Zn level but with leaf Fe content P solution spray was significantly the most effective. In addition, raising $Cl:SO_4$ ratio of irrigation saline solution resulted significantly in decreasing leaf Fe, Mn and Zn contents.

B. Interaction effect:

Data obtained revealed obviously that the highest leaf Fe content was significantly in closed relationship with the P sprayed saline stressed banana plants especially of Grand Nain cv. subjected to saline solution of lower $Cl:SO_4$ ratio. However, Zn sprayed Grand Nain saline stressed plants (under lower $Cl:SO_4$ ratio) showed significantly the highest leaf Mn and Zn contents during two seasons of study. On the contrary, the least leaf Fe, Mn and Zn contents were markedly coupled with the water sprayed saline stressed plants (especially Williams under higher $Cl:SO_4$ ratio) during two seasons. In addition, other combinations were in between the aforesaid two extremes.

The present results regarding the response of leaf mineral composition of saline stressed banana plants as influence by P, K and Z spray are in general agreement with the findings of Sharaf *et al.* (1984) on olive and guava seedlings, Behairy *et al.* (1985) on guava and olive seedlings, Khamis *et al.* (1985) on two grapes species (American and European grape rooted cullings) and Ali (2005) on some apple transplants.

Table (4): Fresh and dray weight (g) of aerial/aboveground organs (leaves & pseudostem) of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, $Cl:SO_4$, ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Leaves fresh weight (g)			Leaves dry weight (g)			Pseudostem fresh weight (g)			Pseudostem dry weight (g)		
Foliar spray	$Cl:SO_4$ ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season													
Water spray (control)	Low	71.53bc	72.78bc	70.25C	6.45fg	8.21d-f	6.99C	115.3e	137.5d	118.8C	5.05e	6.50de	5.33C
	High	68.63c	68.06c		5.74g	7.56c-g		109.9e	112.3e		4.82e	4.94e	
P spray	Low	91.13bc	118.50a	99.60B	8.87c-e	13.70a	10.54B	184.2bc	190.0a-c	182.1B	8.87bc	10.06ab	8.63B
	High	87.50bc	100.70a		8.16d-f	11.30b		165.7c	184.7bc		7.81cd	7.79cd	
K spray	Low	93.38b	124.90a	105.60A	9.85b-d	14.76a	11.41B	195.2ab	190.5a-c	184.2B	9.07a-c	10.39ab	9.21A
	High	83.15bc	121.00a		8.70c-e	11.42b		166.6c	188.6a-c		8.57bc	8.82bc	
Zn spray	Low	95.36b	129.10a	108.90A	10.72bc	15.37a	13.701A	210.3a	196.5ab	193.7A	9.97ab	11.04a	9.32A
	High	89.48bc	121.80a		8.74c-e	11.69b		180.2bc	187.8a-c		7.83cd	8.73b-d	
Mean**		85.08B	106.28A		8.41B	11.75A		166.2B	173.2A		7.96 B	8.29 A	
Mean of low and high $Cl:SO_4$ ratio		99.70A	92.58B		10.99A	9.16B		177.0A	162.4B		8.86A	7.39B	
2007 season													
Water spray (control)	Low	78.76f	51.15f	61.74C	6.05h	9.03g	7.999C	111.2f	121.0f	114.64C	4.94c	5.05cd	4.44C
	High	76.75e	40.30g		5.85hi	7.02i		108.9f	117.5f		3.74d	3.11d	
P spray	Low	93.48d	111.20b	97.76B	9.19d-f	11.35c-f	11.01B	168.3bc	153.7cd	155.7B	8.62a	8.76a	8.14B
	High	91.63d	92.69d		8.90ef	10.57f		155.5cd	144.8de		7.24b	7.50ab	
K spray	Low	93.48d	120.40a	99.82A	9.21d-f	11.61c-e	11.98B	168.6bc	175.5bc	156.6B	8.80a	8.95a	8.42A
	High	91.82d	94.06d		8.92ef	10.64ab		155.4cd	137.1e		7.84ab	8.16ab	
Zn spray	Low	94.35c	121.30a	111.10A	10.22a-c	13.12a	12.57A	194.3a	178.6b	193.3A	8.90a	9.06a	8.47A
	High	91.82d	98.88 c		8.93ef	12.02b-d		163.8c	156.4cd		8.42ab	8.79a	
Mean**		88.95B	91.25A		8.60B	10.67A		153.3B	148.1A		7.27B	7.35A	
Mean of low and high $Cl:SO_4$ ratio		95.51A	84.69B		9.80A	8.73B		157.7A	142.4B		7.72A	6.90B	

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

*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

Table (5): Fresh and dray weight (g) of aerial/aboveground organs (corms & roots) of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, Cl:SO_4, ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Corms fresh weight (g)			Corms dry weight (g)			Roots fresh weight (g)			Roots dry weight (g)		
Foliar spray	Cl:SO_4 ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season													
Water spray (control)	Low	54.4ef	61.3e	53.0C	2.91ef	2.56ef	2.33C	78.9bc	46.8d	60.6C	3.1e	6.32cd	4.37C
	High	49.0f	55.4ef		2.67ef	1.18f		71.8c	45.0d		3.01e	5.04d	
P spray	Low	88.9c-e	93.5a-c	86.2B	5.80cd	6.53a	5.66B	82.3b	111.9a	96.4B	7.54a-c	8.76a	7.49B
	High	80.1d	90.5a- d		4.38d	5.78ab		81.0b	109.4a		5.26d	8.23ab	
K spray	Low	91.2ab	95.6ab	88.3AB	5.79cd	7.32a	5.92A	88.0b	113.1a	98.5A	7.82a-c	8.92a	7.89A
	High	82.4cd	91.2a-d		4.53d	5.71b		82.1b	111.97a		6.43cd	8.29a	
Zn spray	Low	91.6ab	98.4a	89.0A	6.16c	7.73a	6.04A	87.4b	114.5a	99.6A	7.85a-c	9.08a	7.91A
	High	83.4b-d	91.4a-d		4.57cd	6.2ab		85.1b	111.7a		6.50b-d	8.44a	
Mean**		77.7B	84.6A		4.60A	5.38B		82.1B	95.5A		5.93B	7.89A	
Mean of low and high Cl:SO_4 ratio		85.1A	78.6B		5.60A	4.38B		90.4A	87.3B		6.40B	7.43B	
2007 season													
Water spray (control)	Low	49.8f	52.6f	45.6C	1.88f	2.3f	1.93C	57.9f	70.0de	60.2C	3.72ef	5.08c	3.37C
	High	38.9g	41.0g		1.76f	1.78f		40.5g	67.4e		2.73f	4.08cd	
P spray	Low	81.3c-e	93.5ab	85.2B	6.39b	5.48cd	5.39B	92.0ab	88.8a-c	86.8B	6.09cd	8.88ab	6.15B
	High	78.0e	83.7c-e		4.49e	5.13de		81.2cd	85.4bc		5.39de	8.05b	
K spray	Low	86.8b-e	94.8ab	86.3AB	7.54a	6.20bc	5.87A	96.4ab	92.7ab	90.9A	6.78cd	9.16ab	6.63A
	High	78.2e	85.8b-e		4.58de	5.26de		89.0bc	85.8bc		5.46de	8.10b	
Zn spray	Low	89.7a- c	96.9a	88.6A	6.99ab	6.68ab	6.02A	97.6a	98.6a-c	91.5A	7.05cd	10.03a	6.73A
	High	79.6de	88.3a-d		4.91de	5.49cd		90.6a-c	88.1bc		5.58c-e	8.49b	
Mean**		72.8B	79.6A		4.82A	4.79A		81.15B	84.1A		5.36B	7.73A	
Mean of low and high Cl:SO_4 ratio		80.7A	71.7B		5.43A	4.17B		86.3A	78.4B		9.18A	5.19B	

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

*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

Table (6): Leaf chlorophyll (A & B mg/g F.Wt.), carotein (mg/g F.Wt.) and Proline (mg/100 g F.Wt.) content of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, $Cl:SO_4$, ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Leaf chlorophyll A (mg/g F.Wt.)			Leaf chlorophyll B (mg/g F.Wt.)			Leaf carotein (mg/g F.Wt.)			Leaf proline (mg/100 g F.Wt.)		
Foliar spray	$Cl:SO_4$ ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season													
Water spray (control)	Low	1.010g	1.130c-g	0.975 C	0.220e-g	0.240 g	0.271B	0.827ef	0.730fg	0.665C	3.157 b	2.450c-f	3.265 A
	High	0.670h	1.090fg		0.287fg	0.237g		0.503 h	0.600d-f		4.267 a	3.187 b	
P spray	Low	1.550ab	1.550ab	1.382 B	0.400cd	0.540ab	0.437A	1.160bc	1.290ab	1.067B	2.133d-f	2.143 d-f	2.434 B
	High	1.200c-g	1.227d-f		0.350d-f	0.417c-e		0.870d-f	0.880d-f		2.927 bc	2.553 b-f	
K spray	Low	1.590ab	1.557ab	1.464AB	0.430cd	0.560a	0.465A	1.230ab	1.320ab	1.109B	2.040 ef	1.997 f	2.424 B
	High	1.300c-e	1.410b-d		0.390c-e	0.410c-e		0.940de	1.017cd		2.900 bc	2.733 b-c	
Zn spray	Low	1.610ab	1.640a	1.543A	0.460bc	0.590a	0.455A	1.223ab	1.350a	1.200A	2.093 ef	1.963 f	2.284 C
	High	1.430a-d	1.490a-c		0.390c-e	0.450b-d		1.007cd	1.220ab		2.813b-d	2.267c-f	
Mean**		1.299B	1.383A		1.227B	1.455A		0.970B	1.051A		2.792 A	2.412 B	
Mean of low and high $Cl:SO_4$ ratio		1.455 A	1.227B		0.378B	0.430A		1.141A	0.880B		2.247 B	2.957 A	
2007 season													
Water spray (control)	Low	0.880 h	0.720 i	0.730C	0.270g	0.403ef	0.344B	0.460hi	0.520g-i	0.438C	2.827cd	2.960bc	3.184 A
	High	0.703 i	0.620 j		0.180g	0.297fg		0.310 i	0.460hi		3.950 a	3.361 ab	
P spray	Low	1.490de	1.820a-c	1.461B	0.620ab	0.603a-c	0.533A	0.943c	1.180bc	0.874B	2.103e-g	2.247ef	2.300 B
	High	1.190 g	1.153 g		0.480c-e	0.450de		0.663f-h	0.710e-g		2.410c-f	2.540c-e	
K spray	Low	1.513de	1.840ab	1.533B	0.650b-e	0.630ab	0.564A	1.183bc	1.417ab	1.105B	2.033e-g	2.163e-g	2.280 B
	High	1.227fg	1.590d		0.520b-e	0.460de		0.833d-f	0.940 i		2.383d-f	2.440c-f	
Zn spray	Low	1.657cd	1.960a	1.656A	0.637ab	0.680a	0.557A	1.397ab	1.490a	1.224A	1.887 fg	1.653 g	1.993 C
	High	1.380ef	1.780bc		0.543b-c	0.570a-d		1.020cd	1.053cd		2.290d-f	2.143e-g	
Mean**		1.255B	1.435A		1.205B	1.485A		0.851B	0.971A		2.440 A	2.348 B	
Mean of low and high $Cl:SO_4$ ratio		1.485A	1.205B		0.506A	0.493B		0.941A	0.749B		2.234 B	2.645 A	

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

*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

Table (7): Leaf nitrogen, phosphorus and potassium content of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, $Cl:SO_4$, ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Leaf N%			Leaf P%			Leaf K%		
Foliar spray	$Cl:SO_4$ ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season										
Water spray (control)	Low	1.700cd	1.700cd	1.650C	0.195g	0.300de	0.241B	1.133ef	1.100ef	1.332C
	High	1.600d	1.600d		0.194g	0.275a-c		0.900f	1.000f	
P spray	Low	2.00ab	2.10ab	1.975B	0.342a	0.327a-c	0.336A	1.600b-d	1.800a-c	1.425B
	High	1.900a-c	1.900a-c		0.315b-d	0.321bc		1.200d-f	1.250d-f	
K spray	Low	2.133a	2.100ab	2.025AB	0.317b-d	0.320bc	0.311B	2.100a	2.200a	1.875A
	High	1.867a-c	2.00ab		0.295e	0.310c-e		1.600b-d	1.600b-d	
Zn spray	Low	2.167ab	2.233a	2.100A	0.332ab	0.325a-c	0.318AB	1.867ab	1.900ab	1.600B
	High	2.00ab	2.100ab		0.293e	0.318b-d		1.300de	1.333de	
Mean**		1.908A	1.967A		0.285B	0.312A		1.450B	1.592A	
Mean of low and high $Cl:SO_4$ ratio		2.004A	1.871B		0.307A	0.290B		1.700A	1.242B	
2007 season										
Water spray (control)	Low	1.700cd	1.700cd	1.650C	0.195g	0.300de	0.241C	1.600e	1.533ef	1.39C
	High	1.600d	1.600d		0.194g	0.275a-c		1.133f	1.300ef	
P spray	Low	2.00ab	2.10ab	1.975B	0.342a	0.327a-c	0.326A	2.900cd	3.380ab	2.875B
	High	1.900a-c	1.900a-c		0.315b-d	0.318b-d		2.610d	2.610d	
K spray	Low	2.133a	2.100ab	2.025AB	0.230a	0.227ab	0.224B	3.480a	3.500a	3.150A
	High	1.867a-c	2.00ab		0.220ab	0.219ab		2.700d	3.200a-c	
Zn spray	Low	2.200a	2.200a	2.150A	0.317b-d	0.320bc	0.311AB	2.970b-d	3.200a-c	2.963AB
	High	2.100ab	2.100ab		0.295e	0.310c-e		2.610d	2.790cd	
Mean**		1.942A	1.996A		0.259B	0.278A		2.465B	2.724A	
Mean of low and high $Cl:SO_4$ ratio		2.033A	1.904B		0.222A	0.204B		2.820A	2.369B	

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

*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

Table (8): Leaf sodium, calcium and magnesium content of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, $Cl:SO_4$ ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Leaf Na%			Leaf Ca%			Leaf Mg%		
Foliar spray	$Cl:SO_4$ ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season										
Water spray (control)	Low	0.330c	0.400b	0.410A	1.95a	1.92a	1.95A	0.153fg	0.160f	0.142C
	High	0.480a	0.430b		1.98a	1.94a		0.140g	0.113h	
P spray	Low	0.260dc	0.190fg	0.257B	1.74bc	1.67b-d	1.76B	0.253d	0.373a	0.268B
	High	0.320c	0.257dc		1.88a	1.74bc		0.220e	0.227e	
K spray	Low	0.180fg	0.180fg	0.216C	1.66cd	1. 66cd	1.71B	0.260d	0.347b	0.268B
	High	0.290cd	0.213ef		1. 77b	1.75bc		0.220e	0.247d	
Zn spray	Low	0.180fg	0.150g	0.193D	1.67b- d	1.63d	1.69B	0.293c	0.387a	0.302A
	High	0.260dc	0.180fg		1.73b-d	1.72b-d		0.227e	0.300c	
Mean**		0.288A	0.250B		1.80A	1.76A		0.221B	0.269A	
Mean of low and high $Cl:SO_4$ ratio		0.253B	0.304A		1.74B	1.81A		0.278A	0. 212B	
2007 season										
Water spray (control)	Low	0.460c	0.460c	0.533A	1.61b	1.57cd	1.60A	0.160e	0.120f	0.138C
	High	0.633a	0.580b		1.64a	1.58c		0.156e	0.113f	
P spray	Low	0.227g	0.290f	0.330B	1.54f	1.50g	1.53B	0.240d	0.280c	0.216B
	High	0.400d	0.403d		1.56de	1.51g		0.163e	0.170e	
K spray	Low	0.230g	0.170h	0.270C	1.50g	1.46h	1.51B	0.250d	0.300b	0.227B
	High	0.343e	0.333e		1.55ef	1.51g		0.166e	0.1950d	
Zn spray	Low	0.230g	0.173h	0.245D	1.50g	1.48h	1.51B	0.273c	0.330a	0.250A
	High	0.303f	0.272fg		1.55ef	1.52g		0.167e	0.250d	
Mean**		0.353A	0.332B		1.56A	1.52B		0.198B	0.220A	
Mean of low and high $Cl:SO_4$ ratio		0.280B	0.449A		1.52B	1.55A		0.244A	0.173B	

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

*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

Table (9): Leaf iron, magnesium and zinc content of saline stressed banana plants as influenced by specific and interaction effects of banana cultivar, $Cl:SO_4$, ratio of saline solution (3000 ppm & SAR 6) used for irrigation; foliar sprayed nutrient elements and their combinations during 2006 and 2007 seasons.

Treatment of saline stressed plants (3000 ppm x SAR6)		Leaf Fe ppm			Leaf Mn ppm			Leaf Zn ppm		
Foliar spray	$Cl:SO_4$ ratio	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*	Williams	Grand Nain	Mean*
2006 season										
Water spray (control)	Low	161.30 f	208.00e	181.80C	20.58f	34.18d	25.19B	21.00fg	23. 73e-g	22.06C
	High	152.00f	206.00e		17.27g	28.75e		18.83g	20.67g	
P spray	Low	283.30ab	299.50a	266.50A	36.13cd	37.25cd	35.00A	25.23b-d	27.67a-d	25.47B
	High	213.50de	280.30ab		30.50e	35.00d		21.63e-g	23.33e-g	
K spray	Low	211.00e	295.80a	255.50A	36.60d	41.25b	35.78A	25.43b-d	28.47a-c	26.71B
	High	234.00c	269.70b		30.67e	35.67d		22.63d-f	26.30c-f	
Zn spray	Low	210.70e	238.30ab	240.00B	37.67c	43.26a	36.92A	28.43ab	30.90a	28.67A
	High	206.00e	230.70cd		30.75e	36.07cd		24.63c-e	26.73c-e	
Mean**		203.30B	259.20A		29.69B	36.18A		23.48B	25.98A	
Mean of low and high $Cl:SO_4$ ratio		241.3 A	221.1 B		35.54A	30.33B		26.36A	23.09B	
2007 season										
Water spray (control)	Low	165.0f	226.80e	178.70D	17.15hi	43.35bc	29.19C	20.67gh	23.73fg	18.94C
	High	149.8f	173.20f		15.65i	40.60cd		13.97i	17.40h	
P spray	Low	293.70b	335.5a	282.90A	20.40g	43.43bc	30.8BC	27.10e	36.73a-c	30.90B
	High	258.2cd	281.7bc		19.70gh	39.67d		24.70gh	34.80bc	
K spray	Low	300.2b	291.7b	275.90B	21.13g	43.48bc	32.00B	27.44e	37.10ab	31.02AB
	High	216.2e	258.4cd		20.80g	42.60bc		25.97ef	35.10a-c	
Zn spray	Low	277.2bc	282.3bc	253.10C	29.94e	48.95a	36.85A	30.77d	38.53a	32.82A
	High	216.2e	236.7de		24.57f	43.95b		27.43e	35.53c	
Mean**		239.8B	255.5A		21.17B	43.25A		24.76B	32.24A	
Mean of low and high $Cl:SO_4$ ratio		271.50A	223.80B		33.69A	30.73B		30.26A	26.74B	

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

*, ** refer to specific effect of foliar spray treatment and banana cultivar, respectively.

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دراسات فسيولوجية على تحمل نباتات صنفين من الموز للملوحة
٢- تأثير نسبة الكلوريد والرش ببعض العناصر على النمو الخضرى والمحتوى الكيماوى للنباتات تحت الإجهاد الملحى.

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أجريت هذه الدراسة خلال موسمين تجريبين ٢٠٠٦، ٢٠٠٧ على شتلات موز صنفي ويليامز وجراندان بهدف تقليل الأثر الضار لاستخدام ماء ملحى للرى وذلك باختبار تأثير رش نباتات الموز التى تعانى الإجهاد الملحى بمحاليل بعض العناصر الغذائية (فوسفور – بوتاسيوم – زنك). وعليه فقد صممت تجربة عاملية لدراسة التأثير النوعى لثلاثة عوامل هى: (صنف الموز – نسبة الكلوريدات إلى الكبريتات بمحلول مياه الرى المالح – العنصر الغذائى الذى تم رشه) والتفاعل بينهما بحيث قيمت الاستجابة على بعض القياسات الخضرية (ارتفاع وسمك الساق الكاذبة عدد ومساحة الأوراق ونسبة الجفاف والشيخوخة للأوراق – الوزن الطازج والجاف لكل من أجزاء شتلة الموز فوق وتحت سطح الأرض). وعن أهم النتائج التى تحصل عليها خلال موسمى الدراسة وجد الآتى:

١- القياسات الخضرية:

أظهرت النتائج استجابة ملموسة لجميع القياسات الخضرية سواء للتأثير النوعى أو التفاعل للعوامل الثلاثة المختبرة. فقد حققت الشتلات تحت الأجهاد الملحى تأثيرا ايجابيا (زيادة ملموسة لكل النباتات الخضرية ماعدا نسبة الأوراق الجافة (الشيخوخة) التى قلت) نتيجة التأثير النوعى لأى من العناصر الثلاثة التى رشت بها تلك النباتات وإن كان الزنك ويلية البوتاسيوم هما الأكثر تفوقا أما عن التأثير النوعى لنسبة الكلوريدات إلى الكبريتات بمحلول ماء الرى الملحى فقد لوحظ علاقة عكسية. مع كل القياسات الخضرية باستثناء نسبة شيخوخة الأوراق (جفافها) فالعلاقة كانت طردية: كذلك لوحظ أن نباتات الصنف جراندان ذات قيم أعلى من الويليامز فى معظم النمو الخضرى باستثناء نسبة شيخوخة الأوراق.

٢- المحتوى الكيماوى:

لقد سلكت معظم القياسات الكيميائية (صبغة الكلوروفيل أ، ب والكاروتين والبرولين والمحتوى المعدنى (N, P, K, Mg, Ca, Na, Fe, Mn and Zn)) للأوراق نفس القياسات الخضرية حيث كان محتوى الأوراق من كل من: البرولين والكالسيوم والصوديوم مشابها لسلوك (شيخوخة الأوراق) بينما باقى قياسات المحتوى الكيماوى سلكت اتجاها مضادا سواء بالنسبة للتأثير النوعى أو التفاعل. وعموما فإن نباتات الموز تحت الإجهاد الملحى خاصة للصنف جراندان عند المستوى الأرقى من نسبة الكلوريدات إلى الكبريتات إذا تم رشها بأى من محلول الزنك أو البوتاسيوم قد حققت أعلى قياسات النمو الخضرى (ارتفاع وسمك الساق الكاذبة – العدد الكلى ومساحة الأوراق – أوزان أجزاء الشتلة) مصحوب بأعلى قيم المحتوى الكيماوى وذلك باستثناء نسبة شيخوخة الأوراق ومحتوى البرولين وكل من الكالسيوم والصوديوم (أدنى مستوى). هذا وقد لوحظ أن نباتات الموز جراندان هى الأكثر تفوقا عن الويليامز بالنسبة للقياسات الخضرية والمحتوى الكيماوى باستثناء نسبة شيخوخة الأوراق ومحتوى البرولين والكالسيوم والصوديوم .