PHYSIOLOGICAL STUDIES ON SALT TOLERANCE OF SOME BANANA CULTIVARS

2- Effect of sodium adsorption ratio (SAR), chloride level in irrigation water and foliar spray with some minerals on some chemical constituents.

By

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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 cold 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 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 chemical constituents of two banana cultivars (Williams & 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, Kalubia 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 exhibited 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; beside 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).

* **Irrigated with 3000 ppm saline solution of SAR 6.**

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 70ºC 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 carorenoides 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:

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 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 investigated 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 thinker 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 each level of significance.

B- Interaction effect:

It was quite evident as shown from table (2) that specific effect of each investigated 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 leaves 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.

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 elements decreased it significantly and resulted approximately in the same value.

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. Herring, 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 specially 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 farm 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 2000 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 2000 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 (1480) 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).

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

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 effect of cultivar Tables (7 and 8) that the response varied from an element to another. Herein, Grand Nain leaves were generally richer in their N, P, K and Mg contents, but the opposite was true with Ca and Na levels. Differences in most cases were relatively not so pronounced.

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 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 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 regared leaf Fe, Mn and Zn content were the three microelements investigated, data obtained during both 2006 and 2007 seasons are presented in Table (9). It was quite 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.

دراسات فسيولوجية على تحمل نباتات صنفين من الموز للملوحة

٢- تأثير التركيز ونسبة كل من الصوديوم المدمص والكلوريد على المحتوى الكيماوى

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أجريت هذه الدراسة خلال موسميين تجريبيين ٢٠٠٦، ٢٠٠٧ على شتلات موز صنفى 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 الموزن – نسبة الكلوريدات إلى الكبريتات بمحلول مياه الرى المالح – العنصر الغذائى الذى تم رشه) والتفاعل بينهما بحيث قيمت الاستجابة على بعض النباتات الخضرية (ارتفاع وسمك الساق الكاذبة عدد ومساحة الأوراق ونسبة الجفاف والشيخوخة للأوراق – الوزن الطازج والجاف لكل من أجزاء شتلة الموز فوق (تحت سطح الأرض). وعن أهم النتائج التى تحصل عليها خلال موسمى الدراسة وجد الآتى:

١- النباتات الخضرية:

أظهرت النتائج استجابة ملموسة لجميع النباتات 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 النباتات 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 المكونات الكيميائية {صبغة الكلورفيل أ، ب والكاروتين والبرولين والمحتوى المعدنى (N, P, K, Mg, Ca, Na, Fe, Mn and Zn)} للأوراق نفس النباتات 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 للنباتات الخضرية والمحتوى الكيماوى باستثناء نسبة شيخوخة الأوراق ومحتوى البرولين والكالسيوم والصوديوم .