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EFFECT OF DIFFERENT LEVELS OF IRON ON VEGETATIVE GROWTH AND MINERAL CONTENT OF "WILLIAMS" BANANA PLANTS GROWN IN SAND CULTURE

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ABSTRACT

This work was carried out for two seasons on young banana plants (*Musa* sp. "Williams Hybrid") grown in sand culture. The experiment included five levels of iron relative to iron in the standard nutrient solution (S.N.S.). These levels were 0%, 50%, 100 %, 200% and 400% Fe. Removing iron from the nutrient solution gave the lowest values of vegetative growth than those of other treatments but no symptoms of chlorosis were detected on leaves. However, all vegetative growth parameters were gradually increased by increasing iron level in the nutrient solution. The maximum increase was obtained by S.N.S. (100%Fe) and (200%Fe) treatments which in most cases gave similar values. More increase in iron level (400% Fe) led to reduce growth comparing with the other treatments. Removing iron from the nutrient solution decreased N and Fe content but led to increase Mn content in leaf blades. Iron content was in plant gradually increased by increasing iron in the nutrient solution. However, there was a gradual decrease in manganese content by increasing iron level in the nutrient solution. On the other hand, it seems that iron treatments had no clear effect on N, P, K and Zn contents. Depending upon the interaction between iron treatments and sampling dates, in the two seasons the different limits of iron content in leaf blades were 71.4-119ppm, 153-281 ppm, 213-308 ppm, 360-640 ppm and 447-853 ppm for plants grown under lack, low, optimum, high and very high level (excess) of iron, respectively.

Key words: *Musa* sp. "Williams Hybrid", iron, sand culture, banana plants, vegetative growth, mineral content

INTRODUCTION

This research was carried out to study the effect of different levels of iron on growth and mineral content of young banana plants (*Musa* sp "Williams Hybrid") grown in sand culture. No doubt, this study may be helpful to determine the low, optimum and high levels of iron which in turn will be important in arriving at a proper program for banana fertilization.

MATERIALS AND METHODS

The present study was conducted for two successive seasons (2005/2006 and 2007/2008) to study the effect of different levels of iron on growth and mineral content of young banana plants (*Musa* sp. "Williams Hybrid") grown in sand culture. Plants were growing in a plastic house, Faculty of Agriculture, Ain Shams Univ., Shoubra EL-Kheima, Egypt.

To start the experiment with similar plants of banana, plantlets were produced by *in vitro* culture technique and planted in small plastic pots (50 ml capacity) filled with peat moss and perlite under plastic house. After two months of acclimatization (at the end of May) in each season, plantlets were removed carefully from these pots then washed with deionized water to clean the roots from the root medium (peat moss and perlite). Plantlets were transferred to large plastic containers(one litre capacity) filled with sand which was previously treated with 10% commercial hydrochloric acid for 24 hours, then thoroughly washed with tap water then washed again several times with deionized water to free it from all solutes and any trace of acid. Banana plants were left to grow in these containers, irrigated with deionized water and sprayed three times weekly with a commercial fertilizer (Newlife) which contained N-P-Kat 19:19:19 +some micronutrients, until five-seven leaves had emerged per plant. In the last week of July plants were selected for uniformity and one plant was transplanted to a new plastic container. The dimensions of each container were 60, 40 and 35 cm for the upper, lower diameters and the height, respectively. These plastic containers (60- litre- capacity) were filled with treated sand as mentioned previously. All plants were fertilized with the Standard Nutrient Solution (S.N.S.) of Long Ashton for macronutrients and micronutrients according to **Hewitt (1966)** but with different concentrations of iron. Iron treatments relative to Fe in

the S.N.S. were 0%, 50%, 100 % (S.N.S.), 200% and 400% Fe. The analogous concentrations of Fe in ppm were 0, 1.4, 2.8(S.N.S), 5.6 and 11.2respectively. Thus, the experiment included five treatments and each treatment was replicated five times on one-plant-plots in a completely randomized design. Plants were supplied every other day with the different nutrient solutions at a rate of 2 liter / plant. It should be pointed out that leaching had been carried out every 2 weeks with deionized water by a rate of 2 liter / container.

Vegetative characteristics

The following measurements were determined monthly from the last week of August up to the last week of the next August in each season:-

a- Plant height was measured from the ground surface up to the top of the pseudostem in cm.

b- Pseudostem circumference was measured at 5 cm above ground surface in cm.

c- Total number of leaves developed per plant was counted monthly from the beginning of August up to the next August of each season.

d- Blade area (cm^2) was calculated by measuring the length and width of the blade of the third full expanded leaf from the top of the plant. The area was calculated by multiplying the product of length and width of the blade by the factor 0.8 **(Murray**, **1960).**

e- Total chlorophyll content was measured in the blade of the third full expanded leaf from plant top in early December, April and August in each season by using a SPAD – 502 MINOLTA chlorophyll meter. The SPAD – 502 meter determines the relative amount of chlorophyll present by measuring the transmittance of the leaf in two wave length regions (the red and near-infrared). Using these two transmittance, the meter calculates a numerical SPAD value which is proportional to the amount of chlorophyll present in the leaf.

In early December, April and August in both seasons, a sample from the middle part of the blade of the third leaf from the top of each plant was taken by cutting about 10 cm wide strips from both sides of the midrib as recommended by **Hewitt, 1955** for nutrient analysis. The samples were washed with tap water and rinsed with distilled water

then oven dried at 60-70°C and ground for mineral analysis as will be mentioned later.

Methods of nutrients determination

Dried samples were ground by means of stainless steel rotary knife mill then digested according to the method of **Jackson, 1967** and the digested solutions were used to determine each of N, P, K, Fe, Zn and Mn .Total nitrogen was determined by micro Kjeldahl method as described by **Pregl, 1945.** Phosphorus was determined by means of a spectrocolourimeter, using the method of **Truog and Meyer, 1929**. Potassium was estimated by a flame photometer according to **Brown and Lilleland, 1946.** Iron, zinc and manganese were determined with an atomic absorption spectrophotometer.

Each of nitrogen, phosphorus and potassium content were expressed as a percent of dry matter, whereas iron, zinc and manganese were calculated as parts per million (ppm) in dry matter.

Statistical analysis

As mentioned before, the experiment included five treatments and each treatment was replicated five times on one-plant-plots in a completely randomized design. The part concerned with the effect of different levels of iron and sampling dates on banana plants was statistically analyzed as a factorial experiment in a completely randomized design. All data obtained were statistically analyzed by using the analysis of variance **(Snedecor and Cochran, 1980).** Means were differentiated by Duncan's multiple range test at 5 % level **(Duncan, 1955).**

RESULTS AND DISCUSSION

Effect of different levels of iron on vegetative growth

A- Effect on circumference of pseudostem

In the two seasons, removing iron (0%Fe treatment) generally gave the least significant values in any given month in the two seasons (Table 1). However, the circumference was increased gradually by increasing iron concentration up to S.N.S. treatment which gave in most cases the highest values. More increase in iron level reduced the circumference and the lowest values in most cases were obtained by 400% Fe treatment. However, the difference between these treatments (100, 200 and 400 % Fe) in most cases lacked significance.

Table (1): Effect of different levels of iron on pseudostem circumference of "Williams" banana plants grown in sand culture during two seasons.

Treatments Fe%* in N.S.	Pseudostem circumference in (cm)											
	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
2005/2006 season													
0	8.2 b	11.3 c	13.4 c	15.8 b	16.0 b	16.4 b	17.2 b	19.9 c	22.0 c	24.0 b	25.0 b	26.6 b	26.8 c
50	8.0 b	11.5 c	13.0 c	16.2 b	16.2 b	17.2 b	18.4 b	22.1bc	24.0 bc	25.4 b	26.2 b	28.0 b	28.8 b
100(S.N.S.)	8.6 ab	14.0 ab	16.7 ab	20.3 a	20.6 a	20.8 a	22.1 a	24.2 ab	26.4 ab	29.0 a	31.8 a	33.4 a	33.6 a
200	8.9 a	14.6 a	17.1 a	20.0 a	20.4 a	20.67 a	22.0 a	25.6 a	27.8 a	29.4 a	31.2 a	32.2 a	32.4 a
400	8.4 ab	13.2 b	15.3 b	18.3 ab	18.6 ab	19.0 ab	20.1 ab	23.0 ab	25.4 ab	28.2 a	30.8 a	31.8 a	32.6 a
2007/2008 season													
0	8.7 ab	11.7 b	12.7 b	14.3 b	14.7 b	16.3 b	17.7 b	18.0 b	21.0 c	22.3 c	23.0 c	23.3 d	24.0 d
50	9.0 a	12.2 b	13.3 b	15.0 b	15.7 b	17.2 b	18.3 b	18.7 b	21.0 c	24.3 bc	25.3 b	25.3 c	26.3 c
100(S.N.S.)	8.0 ab	14.8 a	16.3 a	16.5 a	18.0 a	20.0 a	21.6 a	23.0 a	25.8 a	27.8 a	28.8 a	29.0 a	30.0 a
200	9.0 a	12.2 b	13.0 b	13.9 b	14.3 b	17.0 b	20.0 ab	20.7 ab	24.3 ab	26.0 ab	27.0 ab	27.3 b	28.0 b
400	7.3 b	12.5 b	12.9 b	14.0 b	14.3 b	16.3 b	18.3 b	19.0 b	22.3 bc	24.3 bc	25.3 b	26.3 bc	26.7 bc

* Fe% relative to iron in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan ´s multiple range test, 5% level.

B- Effect on height of pseudostem

In the two seasons, removing iron decreased in height of the pseudostem when compared with any other treatment except in January and February in the first season (Table 2). However, the height of pseudostem in the two seasons was increased gradually by increasing Fe concentration. The maximum values were obtained by (100% Fe) and (200%Fe) treatments. More increase in iron (400%Fe treatment) led to decrease the height of pseudostem.

Table (2): Effect of different levels of iron on pseudostem height of "Williams" banana plants grown in sand culture during two seasons.

Treatments Fe%* in N.S.	Pseudostem height in (cm)												
	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
2005/2006 season													
0	36.0c	47.8b	50.4c	63.4c	74.4a	80.8a	88.4a	90.6b	95.0b	97.6c	99.6c	105.4c	107.2c
50	39.2a-c	51.2b	58.4bc	70.0bc	75.6a	82.0a	88.8a	95.0ab	102.6a	109.4b	115.6b	117.8b	120.0b
100(S.N.S.)	43.0a	61.0a	67.8a	80.6a	85.2a	88.6a	92.2a	95.2ab	105.8a	114.8ab	122.0a	123.2a	125.6a
200	42.8ab	59.2a	70.4a	75.6ab	80.6a	82.2a	92.6a	96.8a	107.4a	116.2a	122.8a	124.0a	127.0a
400	38.8bc	53.2b	62.0ab	72.2b	76.8a	83.6a	89.0a	92.4ab	103.2a	110.6b	116.2b	118.2b	119.2b
2007/2008 season													
0	24.0b	41.7b	50.3a	54.7b	58.0c	63.7c	67.7b	69.3c	77.0b	85.3c	89.33c	93.33d	96.67c
50	25.3ab	49.0a	54.7a	57.7b	63.0b	72.7b	75.0b	78.0ab	83.0b	92.3b	98.00ab	102.0bc	108.3a
100(S.N.S.)	25.3ab	50.0a	54.7a	64.0a	73.7a	79.7a	82.7a	85.0a	91.3a	99.3a	100.0a	106.7ab	110.7a
200	28.7a	50.7a	55.0a	59.3ab	65.0b	70.7b	74.3b	77.0a-c	82.3b	91.0bc	101.0a	107.3a	111.7a
400	24.7ab	50.3a	54.7a	57.3b	60.7bc	64.0c	69.3b	72.0bc	82.0b	89.0bc	95.00b	101.0c	105.0b

* Fe% relative to iron in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan ´s multiple range test, 5% level.

C- Effect on total number of leaves

Generally, removing iron tended to reduce number of leaves especially in the later period of the first season and in most months in the second season when compared with other treatments (Table 3). Other treatments in all months gave more or less similar values from the statistical stand point. However, treatment 100% Fe gave the highest values especially in the second season.

Table (3): **Effect of different levels of iron on total number of leaves of "Williams" banana plants grown in sand culture during two seasons.**

Treatments Fe%* in N.S.	No. of leaves per plant												
	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
2005/2006 season													
0	10.2a	12.0a	13.8ab	15.8ab	16.6a	16.8ab	17.8ab	19.6ab	20.6b	21.4b	23.2c	25.2b	25.6b
50	10.6a	11.4a	13.6b	15.4b	16.2a	16.6b	17.2b	19.2b	21.2b	22.8a	24.6b	26.8a	27.4a
100(S.N.S.)	11.0a	12.6a	15.0a	17.0a	17.6a	17.8a	18.6a	20.4a	22.4a	23.6a	25.6ab	27.4a	27.8a
200	11.0a	11.6a	14.0ab	15.4b	16.2a	16.8ab	17.6ab	19.2b	21.2b	22.8a	25.2ab	27.2a	27.6a
400	10.4a	12.4a	14.6ab	16.0ab	17.0a	17.2ab	18.4a	20.2a	22.2a	23.6a	26.0a	27.8a	28.2a
2007/2008 season													
0	8.3 a	11.7b	13.3ab	14.3a	15.0c	16.0b	17.0c	17.7b	18.7c	21.0b	21.7 b	22.7 b	23.7 b
50	8.7 a	12.3ab	13.0b	14.3a	15.7 bc	17.3 ab	18.3a-c	18.7ab	20.3a-c	22.3b	23. 3 ab	24.0 ab	24.7 ab
100(S.N.S.)	9.0 a	13.0a	14.7a	16.0a	17.0a	18.0a	19.0ab	19.7a	21.3ab	25.0a	25.0 a	25.7 a	26.7 a
200	9.0 a	12.0b	13.7ab	15.7a	16.7ab	18.3a	19.3a	19.7a	21.7a	22.7b	24.0 a	24.3 ab	26.0 a
400	9.3 a	11.7b	13.7ab	14.7a	15.7bc	16.7ab	17.7bc	18.3ab	19.7bc	22.3b	23.3 ab	24.3 ab	25.3 ab

* Fe% relative to iron in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan ´s multiple range test, 5% level.

D-Effect on blade area

Removing iron (0%Fe treatment) gave the least significant values in any given month in the two seasons (Table 4). Blade area was increased gradually by increasing iron up to (100% Fe treatment). More increase in iron (treatments 200% and 400%Fe) tended to reduce the area of blade gradually and treatment 400% Fe gave significantly lower values than those of 100% or 200% Fe treatments. This was true in the two seasons of the experiment. In this respect, the size of the blade of the third leaf from the top of the plant of the zero iron treatment was about 60% and 70% that of S.N.S. treatment in the first and second seasons respectively.

Table (4): Effect of different levels of iron on blade area of "Williams" banana plants grown in sand culture during two seasons.

Treatments Fe%* in N.S.	Area of blade of the third leaf from the top of the plant in cm^2												
	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.
2005/2006 season													
0	610 b	965 c	1353 c	1510 c	1680 c	1680 c	1707 c	1914 c	2057 c	2462 d	2778 c	2857 d	2869 d
50	669 ab	1104 bc	1308 c	1588 c	1797 bc	1800 bc	1965 bc	2088 c	2370 b	2878 c	3191 b	3346 c	3368 c
100(S.N.S.)	777 a	1426 a	1989 a	2402 a	2280 a	2280 a	2399 a	2846 a	3007 a	3492 ab	3872 a	3999 ab	4016 ab
200	731 ab	1271 ab	1757 ab	2074 b	2127 a	2127 a	2365 a	2685 a	2921 a	3594 a	3945 a	4089 a	4135 a
400	654 ab	1284 ab	1490 bc	1945 b	2027 ab	2027 ab	2204 ab	2343 b	2801 a	3232 b	3528 b	3785 b	3831 b
2007/2008 season													
0	308 b	806 c	953 c	1078 b	1184 c	1288 c	1366 c	1423 c	1523 c	1714 d	1800 d	1880 d	1920 d
50	345 ab	992 b	1153 b	1350 a	1488 b	1669 b	1792 ab	1850 b	1996 b	2241 b	2343 b	2427 b	2530 b
100(S.N.S.	442 a	1321 a	1422 a	1522 a	1710 a	1861 a	1968 a	2061 a	2317 a	2626 a	2703 a	2800 a	2927a
200	391 ab	1005 b	1194 b	1389 a	1539 ab	1628 b	1759 b	1805 b	1925 b	2208 b	2344 b	2483 b	2652 b
400	399 ab	1072 b	1114 bc	1160 b	1211 c	1327 c	1394 c	1512 c	1676 c	1985 c	2085 c	2168 c	2252 c

* Fe% relative to iron in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan´s multiple range test, 5% level.

E- Effect on chlorophyll content

Removing iron from the nutrient solution gave the least significant values of chlorophyll in any given month in the two seasons (Table 5). Generally, in the two seasons, chlorophyll content in leaf blades of other treatments was more or less similar from the statistical standpoint. Although banana plants were subjected to different levels of iron in the nutrient solution from August until the next August (about 13 months). Plants of all iron treatments appeared healthy and no symptoms of chlorosis were detected on leaves (Fig. 1). Thus, it seems that preventing the supply of iron for about 13 months after planting had no effect on the appearance of the leaves which in turn, proves the low iron requirements of banana plants.

From the foregoing results, it could be concluded that in the two seasons all vegetative growth parameters were increased gradually by time except the period from December to January (winter period). Thereafter, the plant resumed its active growth to reach the maximum values in August. Regarding the iron treatments, the data proved that removing iron from the nutrient solution gave the lowest values of vegetative growth than those of other treatments. However, all vegetative growth parameters were gradually increased by increasing iron level in the nutrient solution. The maximum increase was

obtained by S.N.S. (100%Fe) and (200%Fe) treatments which in most cases gave similar values. On the other hand, more increase in iron level (400%Fe) tended to reduce vegetative growth of the plants than the above two treatments. Thus it seems that, iron in the Standard Nutrient Solution seems to be adequate for the vegetative growth of banana plants.

Fig. (1). Effect of removing iron from the nutrient solution on leaves of "Williams" banana plant at the end of the growing season.

Table (5):- Effect of different levels of iron on chlorophyll content in leaf blade of "Williams" banana plants grown in sand culture during two seasons.

Treatments (Fe%* in N.S.)	Chlorophyll content in the blade of the third leaf from the top of the plant (SPAD) value		
	December	April	August
	2005/2006 season		
0	31.3c	38.0b	34.0d
50	44.0b	57.0a	58.7bc
100(S.N.S)	54.7a	54.7a	57.7b
200	51.0a	56.3a	62.3a
400	53.7a	57.0a	56.7c
	2007/2008 season		
0	40.3b	43.3b	40.0c
50	53.3a	57.7a	59.0ab
100(S.N.S)	53.0a	59.3a	61.7a
200	53.3a	56.7a	58.7ab
400	54.0a	56.7a	55.7b

* Fe% relative to iron in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.
Values having the same letters in the same column in each season are not statistically different by Duncan ´s multiple range test, 5% level.

Effect of different levels of iron and sampling date on mineral content in leaf blades

A- Effect on nitrogen

Effect of iron level. In the two seasons removing iron (0%Fe treatment) gave the least values of N content. Nitrogen content was gradually increased by increasing iron up to 200% Fe treatment which gave the highest values comparing with any other treatment followed by a slight decrease by 400% Fe treatment (Table 6).

Effect of sampling date. Although samples were taken from leaves of similar age, the highest significant values of nitrogen were obtained by samples taken in August in the two seasons followed in decreasing order by April and December samples respectively.

The interaction between iron level and sampling date. Removing iron reduced the values of nitrogen significantly in any given month in both the two seasons. On the other hand, other treatments gave similar nitrogen values but treatments 200%Fe in August in the first season and 400%Fe in August in the second season gave the highest values in the two seasons.

Table (6):-Effect of different levels of iron and sampling date on N, P and K content in leaf blades of "Williams" banana plants grown in sand culture during two seasons.

Treatments Fe%* in N.S.	N % in dry matter				P % in dry matter				K % in dry matter			
	Dec.	April.	Aug.	Mean	Dec.	April.	Aug.	Mean	Dec.	April.	Aug.	Mean
2005/2006 season												
0	2.63e	2.67e	2.74de	**2.68C'**	0.407a-d	0.424a-d	0.337c-e	**0.389A'**	2.71cd	2.22e	3.21b	**2.71B'**
50	2.67e	2.98bc	2.88cd	**2.84B'**	0.388b-e	0.376b-e	0.320c-e	**0.361A'**	2.64d	1.93f	3.18b	**2.58C'**
100(S.N.S.)	2.87cd	2.99bc	2.89cd	**2.92B'**	0.446a-c	0.349c-e	0.313c-e	**0.369A'**	2.55d	1.92f	2.89c	**2.45D'**
200	2.94c	2.95c	3.19a	**3.03A'**	0.491ab	0.294de	0.310c-e	**0.365A'**	2.59d	1.96f	3.21b	**2.58C'**
400	2.59e	2.70de	3.15ab	**2.81B'**	0.527a	0.268e	0.310c-e	**0.369A'**	2.73cd	2.05ef	4.06 a	**2.94A'**
Mean	**2.74C**	**2.86B**	**2.97A**		**0.452A**	**0.342B**	**0.318B**		**2.64B**	**2.01C**	**3.31A**	
2007/2008 season												
0	2.61ef	2.73d-f	2.70d-f	**2.68B'**	0.404bc	0.370c-e	0.304ef	**0.359A'**	2.57cd	3.00ab	3.07ab	**2.88A'**
50	2.64d-f	2.60ef	2.97bc	**2.74B'**	0.403bc	0.271f	0.248f	**0.308B'**	2.32d	2.83bc	3.07ab	**2.74A'**
100(S.N.S.)	2.57f	2.71d-f	3.02b	**2.77B'**	0.359c-e	0.253f	0.319d-f	**0.310B'**	2.23d	3.03ab	3.40a	**2.89A'**
200	2.89b-d	3.02b	3.02b	**2.98A'**	0.496a	0.401bc	0.313d-f	**0.403A'**	2.46cd	3.27ab	3.07ab	**2.93A'**
400	2.76c-f	2.85b-e	3.25a	**2.95A'**	0.477ab	0.391cd	0.272f	**0.380A'**	2.22d	3.13ab	3.10ab	**2.82A'**
Mean	**2.69B**	**2.78B**	**2.99A**		**0.428A**	**0.337B**	**0.292C**		**2.36B**	**3.05A**	**3.14A**	

* Fe% relative to iron in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.

Means of each of treatments, months or their interactions in each season having the same letters are not statistically different by Duncan multiple range test, 5% level.

B- Effect on phosphorus

Effect of iron level. In the first season, there were no significant differences among iron treatments (Table 6). The highest values of phosphorus were obtained by treatments 200%Fe, 400%Fe and 0%Fe respectively. Since the results varied from season to season. So it could be safely concluded that iron level had no particular trend on phosphorus content.

Effect of sampling date. In both seasons, sampling in December gave the highest values followed in decreasing order by sampling in April and August, respectively. Thus, it seems that date of sampling had an important effect on phosphorus content.

The interaction between iron level and sampling date. The interaction was significant in the two seasons. The values of phosphorus in a given month were similar for all treatments except those of 200 and 400% Fe treatments which showed the highest values in December.

C- Effect on potassium

Effect of iron level. In the two seasons iron treatments had no clear effect on potassium content especially in the second season where all iron treatments gave more or less similar values (Table 6)**.**

Effect of sampling date. In the first season, sampling in August was the highest followed in decreasing order by those in December and April, respectively. In the second season, in sampling in April and August were similar but they were higher than that of December. Thus, it could be concluded that, the highest values of potassium content were obtained in August sample.

The interaction between iron level and sampling date. Most treatments in each sampling date in each season gave similar potassium values. However, treatment 400%Fe in August gave the highly significant value in the first season whereas 100% treatment in August gave the highest value in the second season.

D- Effect on iron

Effect of iron level. In the two seasons iron content was gradually and significantly increased by increasing iron level. (Table 7) The highest values were obtained by 400%Fe treatment.

Effect of sampling date. Although samples were taken from leaves of similar age, the highly significant values were obtained by sampling in

August in the two seasons. On the other hand, samples taken in December or April were similar from the statistical standpoint although sampling in April gave slight higher values than those of December.

The interaction between iron level and sampling date. Removing iron reduced values of iron significantly in any given month in both the two seasons. The highest values were obtained in August by treatment 400% Fe in the two seasons.

Depending upon the results of the interaction in the two seasons, the minimum and the maximum values of Fe (ppm) of different treatments are illustrated in (Fig.2). Therefore, it could be concluded that iron content in leaf blades ranged between 71.4-119ppm due to removing iron from the nutrient solution. This range means lack of iron but without any deficiency symptoms on the leaves. However, iron content was increased and ranged between 153-281 ppm in leaf blades when plants were supplied with 50%Fe. This means that iron is low. Iron content in leaf blades of plants supplied with the S.N.S. ranged between 213-308 ppm. This means that iron is optimum. Increasing iron supply up to 200%Fe increased iron content and the percentage of iron ranged between 360-640 ppm. This means that iron is high. More increase in iron supply increased iron content and ranged between 447-853 ppm .This could be considered that iron is very high (excess).

Table (7):-Effect of different levels of iron and sampling date on Fe, Zn and Mn content in leaf blades of "Williams" banana plants grown in sand culture during two seasons.

Treatments Fe%* in N.S.	Fe (ppm) in dry matter				Zn (ppm) in dry matter				Mn (ppm) in dry matter			
	Dec.	April.	Aug.	Mean	Dec.	April.	Aug.	Mean	Dec.	April.	Aug.	Mean
2005/2006 season												
0	107 gh	93 h	93 h	**97 D'**	71.3 de	62.7 e	76.9 c-e	**70.3 B'**	685 a	539 a-c	408 cd	**544 AB'**
50	153 f-h	207 e-h	233 e-h	**198 CD'**	73.3 de	66.7 e	80.7 c-e	**73.6 B'**	640 a	432 b-d	440 b-d	**504 AB'**
100(S.N.S.)	213 e-h	300 d-g	307 c-f	**273 C'**	77.3 c-e	82.0 c-e	85.3 b-e	**81. 6B'**	645 a	549 a-c	592 a-c	**595 A'**
200	360 c-e	493 b-d	640 b	**498 B'**	114 a-c	94.0 b-e	123 ab	**111 A'**	611 ab	507 a-d	421 b-d	**513 AB'**
400	447 cd	500 bc	853 a	**600 A'**	109 a-d	86.7 b-e	134 a	**110 A'**	600 a-c	501 a-d	336 d	**479 B'**
Mean	**256 B**	**318B**	**425A**		**89.2AB**	**78.4B**	**99.99A**		**636 A**	**505 B**	**439B**	
2007/2008 season												
0	119 g	100 g	71.4g	**96.8E'**	74.8 a-c	59.1 bc	96. 7a	**76.8A'**	618 a-c	722 ab	748 a	**696 A'**
50	200 f	231 ef	281 e	**237 D'**	67.6 bc	58.6 bc	73.8a-c	**66.7A'**	506 c-f	547 b-d	519 c-e	**524 B'**
100(S.N.S.)	291 df	308 de	297 de	**299 C"**	65.2 bc	75.7 a-c	85.7ab	**75.6A'**	493 c-g	530 c-e	550 b-d	**524 B'**
200	369 cd	409 bc	466 ab	**415 B'**	59.5 bc	54.3 c	83.8ab	**65.9A'**	322 fg	349 e-g	361 d-g	**344 C'**
400	470 ab	470 ab	510 a	**483 A'**	61.5 bc	54.8 c	83.8ab	**66.7A'**	322 fg	312 g	328 fg	**321 C'**
Mean	**290 B**	**304 AB**	**325 A**		**65.7 B**	**60.5 B**	**84.8A**		**452 A**	**492 A**	**501 A**	

* Fe% relative to iron in the Standard Nutrient Solution (S.N.S.). N.S. = Nutrient Solution.

Means of each of treatments , months or their interactions in each season having the same letters are not statistically different by Duncan ´s multiple range test, 5% level

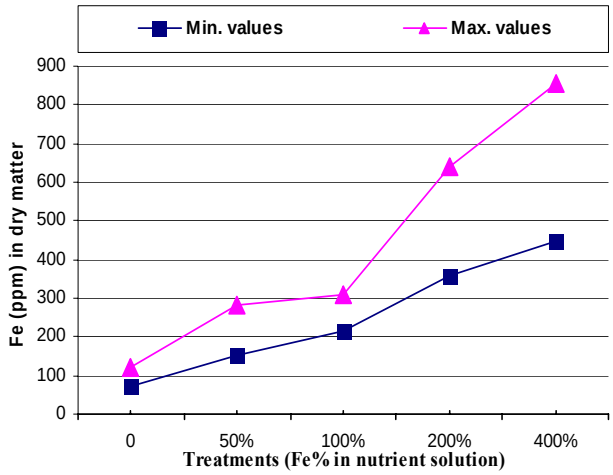

Fig. (2). The minimum and maximum values of iron in blades of "Williams" banana plant as affected by different levels of iron in the nutrient solution.

E- Effect on zinc

Effect of iron level. Results in (Table 7) showed that the effect of treatments varied with the season. In the first season, zinc content was gradually increased by increasing iron level and the highly significant values were obtained by 200 and 400% Fe treatments which gave similar values. In the second season, the different iron levels gave similar values. Thus, it seems that iron treatments had no clear effect on zinc content.

Effect of sampling date. Although samples were taken from leaves of similar age, the highly significant values of zinc were obtained by sampling in August in the two seasons. On the other hand, samples taken in December or April gave similar values without any significant difference between them but.

The interaction between iron level and sampling date. Most treatments gave similar zinc values on any given date in each season and treatments 200% ,400%Fe in August gave the significant highly values in the first season, whereas most iron treatments in August gave the highest values in the second season without any significant difference between them.

F- Effect on manganese

Effect of iron level. In the first season manganese content (Table 7**)** of most treatments was similar without any significant difference between

most treatments. In the second season, Mn content was gradually decreased by increasing the level of iron. However, in both the two seasons the least values were obtained by the highest level of iron (400%Fe).

Effect of sampling date. Although samples were taken from leaves of similar age, the highly significant values in the first season were obtained by sampling in December whereas, samples taken in April or August gave similar values without any significant difference between them. In the second season samples taken in August gave the highest values of manganese content although there were no significant differences between the different sampling dates. Thus, time of sampling seems to have a minor effect on Mn content.

The interaction between iron level and sampling date. Removing iron gave the highest values of manganese content in December and April in the first season and in all months in the second season. Other treatments in general gave more or less similar values.So, on any sampling date removing iron from the nutrient solution increased the content of Mn.
Similar work in the literature was not available.

REFERENCES

Brown, J.D. and O. Lilleland. (1946). Rapid determination of potassium and sodium in plant material and soil extracts by flame-photometry. Proc. Amer. Sco. Hort. Sci., 48: 341-346.

Duncan, D.B. (1955). Multiple range and multiple F tests. Biometrics, 11: 1- 42

Hewitt, C.W. (1955). Leaf analysis as a guide to the nutrition of bananas. Emp. J. Exp. Agric.23. (c.f. Hort. Abst., 25:4346)

Hewitt, E.J. (1966). Sand and water culture methods used in the study of plant nutrition. (2nd ed.). Commonwealth Agricultural Burdeaux Farnham Royal, Bucks, England. Pp 430-450.

Jackson, M.L. (1967). Soil chemical analysis. Prentice Hall Inc. Englewood Cliffs, N.J.P. 331.

Lahav, E. and D.W. Turner (1984). The effect of temperature on the iron content of banana suckers. J. of Plant Nutrition, 7 (1-5) : 725-731.

Murray, D.B. (1960). The effect of deficiencies of the major nutriets on growth and leaf analysis of the banana. Trop. Agric., Trin., 37 (2): 97-106.

Pregl, F. (1945). Quantitative organic micro- analysis. 4th ed. J.A. Churchill, LTD. London

Snedecor, G.W. and W.G. Cochran (1980). Statistical methods. 7th ed. Iowa State, Univ. Press. Ames, Iowa, U.S.A. Pp. 507.

Truog, E. and M. Meyer (1929). Improvements in the Deniges colorimetric method for phosphorus and arsenic. Ind. Eng. Chem., Anal. Ed. 1 : 136-139.

تأثير المستويات المختلفة من الحديد على النمو الخضرى و المحتوى المعدنى لنباتات موز الوليامز النامية فى مزرعة رملية

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أجريت هذه الدراسة خلال موسمي 2005/2006 –2007/2008 على نباتات الموز صنف وليامز ناتج زراعة الانسجة و النامية فى مزرعة رملية تحت صوبة بلاستيكية بكلية الزراعة جامعة عين شمس بشبرا الخيمة. و ذلك بهدف دراسة تأثير المستويات المختلفة من الحديد فى المحلول الغذائى على النمو والمحتوى المعدنى لنباتات الموز و اشتمل البحث على خمسة معاملات هى (0%, 50%, 100 %, 200% 400% Fe) من الحديد فى المحلول الغذائى .

أدى ازالة الحديد من المحلول الغذائى الى نقص النمو الخضرى و لم يظهر على النباتات أى أعراض نقص على الاوراق. فى حين أدت زيادة الحديد الى زيادة معنوية فى النمو الخضرى لتعطى المعاملتان (100%, 200%Fe) أعلى القيم بدون فارق معنوى بينهما . فى حين أدت زيادة مستوى الحديد الى (400%Fe) الى نقص النمو الخضرى عن المعاملتين السابقتين.

بالنسبة لتأثير معاملات الحديد على العناصر الاخرى فقد أدى ازالة أو نقص الحديد فى المحلول الغذائى الى نقص محتوى النتروجين والحديد و زيادة محتوى المنجنيز فى أنصال الاوراق ومع زيادة مستوى الحديد فى المحلول الغذائى حدثت زيادة تدريجية فى محتوى الحديد مع المعاملات(200%Fe) و (400%Fe) على التوالى. فى حين حدث نقص تدريجى فى محتوى المنجنيز بأنصال الاوراق. لكن لم يكن هناك تأثير واضح لمعاملات الحديد المختلفة على محتوى الفوسفور و البوتاسيوم و الزنك.

بالنسبة لتأثير معاملات الحديد على محتوى الحديد فى أنصال الاوراق فقد تم أخذ المستويات المختلفة اعتمادا على قيم التفاعل بين المعاملات و ميعاد أخذ العينة فى كلا الموسمين فكانت المستويات المتحصل عليها هى (71.4-119 ppm) و(153-281ppm) و(213-308ppm)و (360-640ppm)و (447-853ppm) و ذلك للنباتات النامية تحت حد النقص والمستوى المنخفض و المستوى الامثل و المستوى المرتفع و المستوى المرتفع جدا من الحديد على التوالى.