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Response of Banana Plants to Soil and Foliar Applications of Magnesium

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Abstract: The effect of soil magnesium fertilization either as sulphate or chelate form with or without $MgSO_4$ foliar sprays was studied on vegetative growth, mineral and leaf chlorophyll content, yield and fruit quality of Grand naine banana plants grown under clay loam soil conditions. Results indicated that Mg fertilization treatments showed a positive effect on vegetative growth parameters, N, Mg, chlorophyll a and b content in the leaves; also improved yield as bunch weight and fruit properties comparing with the control. In this respect, the chelate form was more pronounced than the sulphate form. In addition, treatments included $MgSO_4$ as foliar sprays were more effective than those without it. So, fertilizing Grand naine banana plants with 100 g Mg chelate + foliar sprays of 2% $MgSO_4$ seems to be the promising treatment under this experiment conditions.

Key words: Grand naine banana plants · magnesium fertilization · sulphate · chelate · $MgSO_4$ foliar sprays · leaf minerals · chlorophyll · yield · fruit quality

INTRODUCTION

Banana is considered as one of the most popular and favorite fruits for child and adult. Increasing banana yield, consequently the final profit is the main target for banana producers. They can get their goal through the good orchard management especially fertilization program. In this respect, banana needs a large amounts of nitrogen and potassium fertilization, which depressed magnesium and reduced the ability of trees to Mg uptake [1, 2]. In addition, many symptoms of Mg deficiency have been recently noticed on trees, that received heavy doses of potassium [3, 4]. In this concern, magnesium is a major element and essential on chlorophyll molecule structure, introduce as a co-factor with most enzymes related to active phosphorylation process, also acts as a bridge between pyrophosphate structures of ATP or ADP, the enzyme molecule and stabilizes the ribosome particles in the configuration for protein synthesis [5]. On the other hand, the effect of magnesium on productivity and fruit quality of fruit trees has been documented in Egypt by many investigators on oranges, pear and banana plants, [6-10]. The aim of this study is to investigate the effect of soil magnesium fertilization either as sulphate or chelate form with or without $MgSO_4$ foliar sprays on vegetative growth, mineral and leaf chlorophyll content, yield and fruit quality of Grand naine banana plants grown under clay loam soil conditions.

MATERIALS AND METHODS

This investigation was carried out during 2003-04 and 2004-05 seasons on second and third ratoon Grand naine banana plants grown on clay loam soil in a private plantation at Kfr El-Ziat district, Gharbia Governorate Egypt. Soil physical and chemical analysis are shown in Table 1.

Plants were spaced at 3.5x3.5 meters and three suckers were selected per each hole. Plants under investigation were treated with 100 g of magnesium fertilizer as soil application per each plant either at sulphate (9.8% Mg) or chelate (12.5% Mg EDTA) form with or without foliar sprays of 2% $MgSO_4$. Soil application of magnesium fertilizers was added once at mid May of each season, while the foliar sprays of $MgSO_4$ were applied twice at mid June and mid August of each season. So, this investigation included five treatments as follows:

- Control.
- 100 g of Mg sulphate as soil application.
- 100 g of Mg chelate as soil application.
- 100 g of Mg sulphate as soil application + 2% $MgSO_4$ as foliar sprays.
- 100 g of Mg chelate soil application + 2% $MgSO_4$ as foliar sprays.

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Table 1: Soil physical and chemical analysis

Sand		Silt			Clay		
Course 2000-200 µ%		Fine 200-20 µ%		20-2 µ%	<2 µ%		Soil texture
8.25		21.30		19.70	50.75		Clay loam
pH (1:2.5)	Ec dsm^{-1} (1:5)	$CaCO_3$%	OM%	N%		ex. P%	ex. K%
8.23	0.46	2.33	1.88	0.40		0.20	0.42
Soluble cations and anions (meq L^{-1})							
Na^+	K^+	Mg^{++}	Ca^{++}	CO_3	HCO_3	Cl	SO_4^-
1.58	0.53	0.68	1.51	----	0.39	3.52	0.39

Each treatment was replicated four times with three plants per each replicate and the randomized complete block design was arranged. The other fertilizing program was the same for all treatments, where each plant received 500 g N/year as ammonium sulphate (20.5% N), 250 g calcium super phosphate (15.5% P_2O_5)/year and 1200 g potassium sulphate (48-52% K_2O)/year. The other cultural practices were the same for all plants.

At shooting stage, leaf sample was taken from the middle of the third leaf from the top of each plant [11], washed with tap water then with distilled water and dried at 70°C till constant weight and finally ground and digested to determine total nitrogen, phosphorus, potassium, calcium and magnesium percentages as the methods described in A.O.A.C. [12]. Chlorophyll a and b were determined according to the method described by Bruinsma [13]. Also the following parameters were determiend for each plant.

- Length and girth of pseudostem.
- Number of green leaves per plant.
- Third leaf area.

At harvest stage, yield as bunch weight (kg) was estimated; also hand and finger weight (g), length and diameter of the finger (cm) were measured. Number of hands and fingers per bunch were calculated for each plant.

After artificial ripening, finger samples were used to determine total soluble solids percentage using hand refractometer. Acidity was measured as g malic acid/100 g pulp, also total sugars percentage was determined according to the methods described in A.O.A.C. [12]. Vitamin C content in the fruit was estimated and expressed as mg of ascorbic acid/ 100 g pulp according to Freed [14].

The data were subjected to analysis of variance and the method of Duncan's was used to differentiate means [15].

RESULTS AND DISCUSSION

Vegetative growth: Results in Table 2 showed that all treatments significantly increased length, girth of pseudostem, number of green leaves and third leaf area comparing with the control. On the other hand, it is noticed that the chelate form of Mg fertilization had a positive effect on vegetative growth parameters compared with the sulphate form. Moreover, treatments included foliar sprays of $MgSO_4$ had a significant effect with respect to pseudostem length and third leaf area compared with the same treatments without foliar sprays. However, foliar sprays seemed to be ineffective on pseudostem girth and number of green leaves. The higher values of length, girth of pseudostem, number of green leaves and third leaf area were obtained when the plants fertilized with 100 g Mg chelate + 2% $MgSO_4$ foliar sprays, while the lower values of these parameters were recorded with the control plants.

The positive effect of magnesium fertilization on vegetative growth parameters are in harmony with those obtained by Abd El-Kader *et al.* [16], Turner and Barker [17] and Guillier [18] on different banana varieties.

Mineral and chlorophyll content in the leaves: Data in Table 3 showed mineral and chlorophyll content in the leaves as affected by Mg fertilization forms with or without foliar sprays of $MgSO_4$. As for nitrogen, all treatments significantly increased N leaf content than the control. However, it is clear that the chelate form of Mg fertilization recorded higher N values compared with the

Table 2: Vegetative growth of grand naine banana plants as affected by soil and foliar sprays of magnesium

	Pseudostem							
	Length (cm)		Girth (cm)		No. of green leaves		Third leaf area (m^2)	
Treatments	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05
Control	269e	272e	80c	82c	11.7c	12.0d	1.75e	1.78e
100 g soil $MgSO_4$	285d	290d	92b	92b	13.1bc	13.3c	2.05d	2.08d
100 g soil Mg chelate	297b	300b	98a	98a	13.8a	13.8b	2.13c	2.16c
100 g soil $MgSO_4$+2% foliar $MgSO_4$	292c	295c	94b	94b	13.5ab	13.7b	2.20b	2.24b
100 g soil Mg chelate+2% foliar Mg SO_4	318a	321a	98a	98a	14.1ab	14.4a	2.40a	2.43a
Significance at 5% level	S	S	S	S	S	S	S	S

Means having the same letter(s) within a column are not significantly different at 5% level

Table 3: Minerals and chlorophyll content in Grand naine banana leaves as affected by soil and foliar sprays of magnesium

											Chlorophyll mg g^{-1} fresh weight			
	N (%)		P (%)		K (%)		Ca (%)		Mg (%)		A		B	
Treatments	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05
Control	2.58e	2.63d	0.19	0.20	3.25a	3.38a	0.28	0.25	0.33b	0.32c	0.68d	0.70d	0.19c	0.19d
100 g soil $MgSO_4$	2.85d	2.83c	0.22	0.21	2.81c	2.84c	0.25	0.22	0.39a	0.39b	0.88c	0.91c	0.23bc	0.23cd
100 g soil Mg chelate	3.10b	3.07b	0.21	0.23	2.92b	2.93b	0.25	0.23	0.40a	0.41ab	0.98b	0.97b	0.28ab	0.31ab
100 g soil $MgSO_4$ + 2% foliar $MgSO_4$	2.97c	2.94bc	0.21	0.22	2.94b	2.95b	0.24	0.21	0.41a	0.42ab	0.87c	0.90c	0.24bc	0.26bc
100 g soil Mg chelate + 2% foliar Mg SO_4	3.42a	3.44a	0.23	0.23	2.97b	2.98b	0.23	0.22	0.45a	0.46a	1.16a	1.26a	0.31a	0.33a
Significance at 5% level	S	S	NS	NS	S	S	NS	NS	S	S	S	S	S	S

Means having the same letter(s) within a column are not significantly different at 5% level

sulphate form either with or without foliar sprays. Also, it is noticed that treatments included foliar sprays significantly raised N% compared with the same treatment without it, especially with the chelate form. Moreover, treatment included 100 g chelate Mg+2% $MgSO_4$ as foliar sprays gave the highest value in both studied seasons.

Phosphorus percentage in the leaf was not significantly affected by treatments, although a slight increase was detected by all treatments than the control in the two seasons.

Regarding potassium content in the leaf, results indicated that the control plants recorded the highest significant K% in the leaf than all other treatments. On the other hand, the Mg chelate form increased K value than the sulphate form but this increment was significant only without adding foliar sprays. Similarly, foliar sprays of $MgSO_4$ enhanced K% in the leaves than without spray but the significance was observed when the plants fertilized with sulphate form only.

Calcium content in the leaves was not affected by treatments. However, the control treatment gave the highest Ca value in the leaf compared with the other treatments.

Concerning magnesium content in the leaves, all treatments significantly increased Mg value than the control. However, a gradual increase in Mg content was observed among all Mg treatments, but this increment lacked significance in the first season, while in the second one, Mg chelate fertilizer recorded the highest Mg content in the leaves.

As for chlorophyll a and b content in the leaves, there was a significant effect for treatments on these parameters, since a gradual increment was observed among the treatments in compared with the control which recorded the lowest value, while the highest value was obtained when the plants fertilized with 100 g Mg chelate + 2% $MgSO_4$ foliar sprays. On the other hand, the chelate form show a significant increase compared with the sulphate one. Moreover, using $MgSO_4$ as foliar sprays did not show any effect with respect to chlorophyll b, while it significantly increased chlorophyll a when sprayed with chelate form.

From the previous results, it is clear that Mg fertilization treatments showed a positive effect on N, Mg, chlorophyll a and b comparing with the control. While, it had a negative effect on K% and had no effect on P and Ca content in the leaves. In this respect, the chelate form

Table 4: Yield and fruit quality of Grand naine banana plants as affected by soil and foliar sprays of magnesium

	Bunch wt. (kg)		No. hands/bunch		No. fingers/bunch		Hand wt. (kg)		Finger length (cm)		Finger diameter (cm)		Finger wt. (g)	
Treatments	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05
Control	24.0d	24.7e	9.3d	9.7d	161d	166d	2.60	2.57b	15.7e	15.4e	2.60d	2.77d	148b	158d
100 g soil $MgSO_4$	29.7c	30.7d	11.3c	12.0c	186c	188c	2.60	2.57b	17.4d	17.6d	3.30c	3.37c	159a	162a
100 g soil Mg chelate	34.0b	35.0b	13.0ab	13.0b	210b	212b	2.60	2.70a	19.3b	19.6b	3.63b	3.67b	162a	164a
100 g soil $MgSO_4$ + 2% foliar $MgSO_4$	31.0c	32.3c	12.3bc	13.0b	188c	192c	2.53	2.50b	18.7c	19.2c	3.57b	3.67b	165a	168a
100 g soil Mg chelate + 2% foliar Mg SO_4	35.7a	36.7a	13.7a	14.0a	221a	225a	2.63	2.60ab	20.9a	21.8a	4.13a	4.2a	161a	163a
Significance at 5% level	S	S	S	S	S	S	NS	S	S	S	S	S	S	S

Means having the same letter(s) within a column are not significantly different at 5% level

Table 5: Chemical properties of Grand naine banana fruits as affected by soil and foliar sprays of magnesium

	TSS (%)		Total sugars (%)		Acidity (%)		Ascorbic acid (mg/100 g)	
Treatments	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05	2003/04	2004/05
Control	15.3e	15.8e	15.1e	15.0e	0.29	0.31	15.2c	15.1e
100 g soil $MgSO_4$	17.0d	17.2d	16.7d	17.0d	0.31	0.32	16.4b	16.2d
100 g soil Mg chelate	19.0c	19.9c	18.4c	18.6c	0.32	0.32	16.7b	16.7b
100 g soil $MgSO_4$ + 2% foliar $MgSO_4$	20.5b	21.2b	19.9b	20.2b	0.33	0.34	16.5b	16.4c
100 g soil Mg chelate + 2% foliar Mg SO_4	22.2a	22.9a	21.5a	22.0a	0.35	0.35	17.5a	17.4a
Significance at 5% level	S	S	S	S	NS	NS	S	S

Means having the same letter(s) within a column are not significantly different at 5% level

was more pronounced than the sulphate form; also treatments included Mg sprays were more effective than those without it. These results are agreed with those recorded by Abou Aziz *et al.* [9] and Abd El-Kader *et al.* [16] on banana, El-Safty and Rabeii [8], Maksoud *et al.* [19] and Abd El-Moniem *et al.* [20] on oranges, who mentioned that an increase in N, Mg and chlorophyll, while a reduction in K content in the leaves was observed due to magnesium applications.

Yield and fruit quality: Results in Table 4 indicated that bunch weight was affected by different treatments. However, all treatments significantly increased bunch weight in compared with the control in both seasons. In this respect, the highest significant weight was recorded when the plants fertilized with 100 g Mg at chelate form +2% $MgSO_4$ foliar sprays. Moreover, treatments included the chelate Mg form significantly increased bunch weight than those fertilized with Mg sulphate form either with foliar sprays or not. On the other hand, treatments included $MgSO_4$ as foliar sprays raised bunch weight especially with Mg chelate treatment. Similar results were obtained with respect to number of hands and fingers/bunch. Hand weight was affected in the second season only, since Mg chelate treatments improved hand weight than Mg sulphate treatments, while spraying $MgSO_4$ had no effect on this parameter. In this concern, fertilizing plants with 100 g Mg chelate solely recorded the heaviest hand. This was true in the second season only. Finger weight was affected by treatments, since all Mg fertilization treatments significantly increased finger weight compared with the untreated plants (control). No significant differences were detected between Mg fertilization treatments. This was true in both studied seasons. Regarding length and diameter of the finger, results indicated that, both of the two parameters toke the same trend. Since, all treatments significantly increased length and diameter of finger than the control. Also treatments included Mg chelate form and foliar sprays improved these parameters than those included sulphate form without foliar sprays.

Data in Table 5 indicated that TSS percentage and total sugars in banana fruit followed the same trend, since all treatments significantly increased these parameters comparing with the control plants. On the other hand, chelate treatments increased TSS and Total sugars in comparing with the sulphate treatments, also foliar sprays treatments increased the same parameters than without foliar sprays. Moreover, it is clear that treatment included Mg chelate + $MgSO_4$ foliar sprays gave the highest value for both TSS and total sugars content in the fruit. As for

acidity percentage, treatments had no effect on this parameter although there is an increasing trend through the treatments in compared with the control. Ascorbic acid content in the fruits was significantly increased by all treatments than the control and the highest significant value was obtained when the plants fertilized with Mg chelate and $MgSO_4$ foliar sprays.

The positive effect of magnesium fertilization may be due to the important physiological role of magnesium on chlorophyll molecule structure, enzymes activity and protein synthesis [5] that reflected on increasing growth parameters and consequently improved yield and fruit quality of banana plants.

The previous results are in line with those obtained by Abou Aziz *et al.* [9] and Abd El-Kader *et al.* [16] on banana, El-Safty and Rabeii [8], Maksoud *et al.* [19] and Abd El-Moniem *et al.* [20] on oranges, Attala *et al.* [7] on Le Conte pear and El-Seginy *et al.* [21] on Anna apple.

From the abovementioned results, it could be concluded that soil magnesium fertilization had a positive effect on banana plants with or without Mg spray. However, fertilizing Mg at chelate form was more pronounced than the sulphate one. Moreover, using $MgSO_4$ as foliar sprays was more effective than without it especially when applied with Mg chelate form. So, fertilizing Grand naine banana plants with 100 g Mg chelate as soil application + foliar sprays of 2% $MgSO_4$ seems to be the promising treatment under this experiment conditions.

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