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RESPONSE OF BANANA PLANTS TO SOME BIOLOGICAL AND MINERAL FERTILIZERS 1- EFFECT ON LEAVES AND ROOT CONTENTS OF SOME MACRO- AND MICRO ELEMENTS

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ABSTRACT

The present work was conducted to study the effect of different biofertilizers as well as different combinations of them on growth of banana seedlings as compared with chemical fertilizers and integrated parameters in pot experiments along two seasons 1997 and 1998.

In the first season (1997) banana seedlings were inoculated with mycorrhizae (M), yeast (S), free nitrogen fixing bacteria called Halex (H), M+S, M+H, S+H or M+S+H. In the second season (1998) banana seedlings were inoculated with S, H, S+H or M+S, which induced significant increases in plant growth in the first season. In such of former treatments, each plant received 500 ml of multi mineral fertilizer at different concentrations, namely 0, 125, 250 or 500ppm. The obtained results could be summarized as follow:

- *In The first season (1997), inoculation of banana plants with M+S caused a significant increase of nutrient concentrations in the roots and leaves over the control and the other biofertilizers treatments.*
- *In the second season (1998) treatments with S, H, and S+ H significantly increased N, P or K in roots or leaves of banana plants under 250 or 500 ppm of mineral fertilization.*

INTRODUCTION

In Egypt, agriculture is mainly dependent on chemical fertilizers, which their consumption per hectare exceeds the average of the world. Banana needs large amounts of fertilizers especially N and K (Childers,1966). Recent developments and insights regarding the potential of vesicular arbuscular mycorrhizal (VAM) symbiosis in horticultural practices are discussed by many investigators such as Azcon- Aquilar and Barea (1997). Aboul Nasr(1997), and Giovannetti et al. (1991) who suggested that when *Sacharomyces cerevisiae* added to VAM, might be used as inoculants in order to stimulate desirable processes in soils, including S-oxidation, P-solubilization and increase plant growth parameters. From the economical and environmental problems point of view, utilization of biofertilizers would not only increase soil fertility and crop production through their additional nutrient supply, but would also help in solving sanitary and environmental problems, as well as saving foreign currency for Egypt (El-Ghandour, 1992).

The present work was carried out to evaluate the effect of soil inoculation with different biofertilizers: vesicular arbuscular mycorrhizae (VAM), Halex biofertilizer (nitrogen fixing microorganisms), and yeast, either alone or combined with different levels of mineral fertilization on nutrient contents of roots and leaves of banana seedlings.

MATERIALS AND METHOD

Plants of banana (*Musa cavendishii*) cv. Williams were obtained from tissue culture lab. in Desert Development Center, American University in Cairo (DDC, AUC) at Sadat City. To prepare the VAM inocula as biofertilizer, the wet sieving and decantation methods for AM spores collection described by Gerdemann and Nicolson (1963) was used. The VAM inocula collected was carried on pure sand which air dried and kept in the fridge .The rate of addition/pot was about 50g of this mixture. The Halex biofertilizer was obtained from Plant Diseases Department, Faculty of Agriculture, Alexandria University. The used rate of Halex was 100g / 1 litter of tap water and about 25ml of the suspension was added /pot. In addition, 200 g of yeast produced by the Starch and Yeast Company in Alexandria were mixed with 100 g black syrup (cooked sugarcane juice) and this mixture was completed with tap water to 1 litter and left for 48 hr before using as a biofertilizer, then about 25ml yeast suspension was added/pot.

To study the effect of AM (M), yeast (S) and Halex (H) and their combinations in presence of different doses of mineral fertilizers on banana plant growth and its mineral nutrients content, two pot experiments were conducted. The first experiment was carried out in plastic green house in DDC, AUC at Sadat City and started on 16th December 1997 for 4 months. The second one was carried out on 20th July 1998, for 2 months in Soil & Water Department's green house, Faculty of Agric., Alex. Univ.

The design followed in the first experiment was a complete randomized. Experimental treatments were as follows, using artificial soil (9.5 liters /pot) consisting of sand, vermiculite and peat at 1:1:1 by volume:

1. Soil (control)
2. Soil + M
3. Soil + S

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4. Soil + H
5. Soil + M+S
6. Soil + M+H
7. Soil + S+ H
8. Soil + M+S+H.

The used inocula, were put in 3 holes around the root zone. All pots were irrigated daily, each with 0.5 L of tap water. Eight replicated pots were used. The moisture content of the soil was kept at 80% of water holding capacity (WHC) of the soil by adding tap water weekly. After 4 months of inoculation in the first exp. the plants were harvested and contents of macro and micro nutrients in roots and leaves were determined.

The second pot experiment was carried out to study the effect of 4 biofertilizers, namely, yeast (S), free nitrogen fixing bacteria (H), combinations between H, S and AM fungi (M) and S under 4 levels of mineral fertilizers {0, 125, 250 and 500ppm/plant/day} on growth and mineral nutrients content of "Williams" banana plants. A factorial experiment was designed where the mineral fertilizers treatments were the main factor while the biofertilizers ones were the sub main factors. The main factors included four treatments, namely, 0, 125, 250 and 500 ppm of mineral fertilizers which were added daily to each plant during one month from NPK (multi) fertilizer (14-13-43) and alternatively with the same concentrations of N (ammonium nitrate) source to compensate the lack of N level in the multi fertilizer during the second month. In addition, five sub-main factors, namely, control, S, H, S+H and M+S were applied in addition to the above mentioned amounts of mineral fertilizers. Each sub-main factor in every main factor had 8 replicates; each replicate had a single plant. The used biofertilizers were added to the pots on the 10th July, 1998. After 10 days the rates of multi mineral fertilizer were prepared daily as stock solution, each pot was watered daily with 0.5 L. from the stock solution. After 30 days of fertilization, the plants were fertilized with NPK and N fertilizers alternatively to encourage the rapid banana growth for another 30 days. After that, the vegetative characteristics were recorded and the plants were harvested.

Banana leaves and roots were oven dried at 70°C for 48 hr. weighed, pulverized and stored in plastic bags. Plant roots and leaves were digested by the method of Evenhuis and De-Waard (1980).

Total N, P and K contents of the plants were determined by using the method of Page et al. (1982), Jackson (1973) and Eppendrof et al. (1970), respectively. Micronutrients (Fe, Zn and Mn) were determined according to Jackson (1970). ANOVA procedure of costat was used to analyze the data obtained (CoHort software, 1986) and the means comparison was made by using the least significant difference test, as illustrated by Duncan (1965).

RESULTS

As for the effect of biofertilization alone, irrespective of the effect of chemical fertilizers, data in Table (1a) showed that M+S, S+H, and H treatments significantly increased K and Zn contents in plant roots in both experiments. Moreover, M+S and H treatments significantly increased Mn in banana roots as compared with the other treatments. While M+S treatment increased N in plant roots, S+H treatment increased root content of P in both experiments as compared with control treatment.

In view of the effect of nitrogen fertilizers on nutrients content in banana roots, irrespective of the effect of biofertilizers, data in Table (1b) showed that the treatment of 250 ppm nitrogen increased the root contents of N, Fe, Zn, and Mn in the 2nd experiment, as compared with the other treatments (except that of 500 ppm N only). While treatments of 500ppm N significantly increased N and K contents, 125 ppm N treatment significantly increased P in banana roots.

As for the interactions between bio- and mineral fertilizers, data shown in Table (2) decleared that the different interactions affected differently the root contents of different nutrients. Likewise, the treatment of 250 ppm N differed in its effect in relation to the biofertilizers added. Thus, concentration of N and Fe in root was significantly increased by adding H, whilst Mn was significantly raised by adding S or S+H. Zn was significantly increased by adding M+S while P was significantly higher than those of the other treatments in the second experiment. Moreover, 500 ppm N treatment + (M+S) or +(S+H) significantly increased the root content of K and Zn as compared with other treatments and control.

As for the effect of biofertilizers on leaf content of nutrients, irrespective of the effect of mineral fertilizers, data in Table (3a) revealed that adding M+S significantly increased N and Zn content relative to the other treatments in the 2nd experiment, in addition to increasing K content in the 1st experiment as compared with that of the other treatments. M+H treatment significantly increased leaf P and Mn over that of control in the other treatments and leaf K content over that of control in the 1st experiment. Moreover, S+H treatment significantly increased leaf K content as compared with that of control in both experiments and it significantly raised leaf P content over most of the treatments in the 1st experiment and over control in the second one as well as raising leaf Fe content over that of control in the 1st experiment. However, the concentration of N in leaves differed markedly between the first and second experiment when H or S+H used as biofertilizers. This may be due to adding mineral fertilizers in second experiment and / or growth season for each experiment where it was in winter in the first one and in summer in second as well as the different ages of analyzed plants in both experiments.

Table 1: Effect of different biofertilizers on some nutrient elements content of banana roots after 120days of inoculation in the first experiment (16/12/1997-16/4/1998) and after 60 days of inoculation in the second one (20/7/1998-20/9/1998).

a) biofertilizers in both experiments

Treatment	N		P		K		Fe		Zn		Mn	
	%						ug/g					
	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.
Control	0.65	1.1	0.33	0.3	6.50	3.2	1219	621	136	63.1	54	35.3
M	0.77	------	0.41	-----	7.33	-----	3823	-----	205	------	123	-----
S	0.70	1.5	0.34	0.4	6.77	3.6	1399	889	178	73.4	140	44.3
H	0.75	1.8	0.29	0.5	8.77	3.9	1738	791	276	83.5	90	53.8
M+S	0.92	2.1	0.41	0.4	8.36	4.0	1555	765	218	94.8	132	41.8
M+H	0.88	------	0.28	-----	7.14	-----	2105	-----	185	------	145	-----
S+H	0.82	1.3	0.47	0.5	8.14	4.4	1568	850	193	98.5	93	42.2
M+S+H	0.95	-----	0.41	-----	7.88	-----	1780	-----	20	-----	123	------
L.S.D.0.05	0.24	0.27	0.05	0.07	0.63	0.57	111	137	41	11.7	32	3.3

b) chemical fertilizers in the 2nd experiment

Treatment 500ml/plant/day at ppm	N	P	K	Fe	Zn	Mn
	%			ug/g		
0	0.8	0.3	3.2	502	78.6	31.3
125	1.6	0.6	3.3	919	82.3	40.2
250	1.9	0.4	3.8	1118	95.8	50.5
500	1.8	0.4	4.9	595	73.9	37.3
L.S.D.0.05	0.24	0.06	0.51	122	10.5	3.0

Table 2: Effect of interaction between biofertilizers and chemical fertilizers on some nutrient elements content of banana roots after 60 days of inoculation in the second experiment (20/7/1998-20/9/1998).

Treatment (biofertilizers)	Treatment (chemical)	N %	P %	K %	Fe ug/g	Zn ug/g	Mn ug/g
Control	0	0.6	0.2	2.5	316	54	24
	125	1.2	0.5	2.9	676	66	37
	250	1.3	0.4	3.1	908	71	45
	500	1.1	0.3	4.3	586	50	35
S	0	1.4	0.2	2.7	325	77	29
	125	1.5	0.5	3.1	742	69	28
	250	1.5	0.4	3.4	1179	88	63
	500	1.5	0.4	4.6	808	60	57
H	0	0.8	0.5	3.5	464	71	31
	125	1.8	0.6	4.2	674	96	38
	250	2.9	0.5	4.2	1424	95	39
	500	1.7	0.4	3.5	604	71	35
S+H	0	0.6	0.4	3.1	437	87	34
	125	1.3	0.7	3.2	1134	81	47
	250	1.5	0.6	4.5	1272	98	58
	500	1.7	0.4	6.7	556	128	30
M+S	0	0.9	0.4	4.0	466	91	39
	125	2.2	0.6	3.3	1369	99	50
	250	2.4	0.4	3.5	805	127	48
	500	2.9	0.2	5.3	419	61	31
L.S.D.0.05		0.4	0.14	1.15	273	23.5	6.7

S= yeast, H= free nitrogen fixing bacteria and M= vesicular arbuscular mycorrhizae
Chemical fertilizer= NPK and nitrogen fertilizers

Table 3: Effect of different biofertilizers on some nutrient elements content of banana leaves after 120days of inoculation in the first experiment (16/12/1997-16/4/1998) and after 60 days of inoculation in the second one (20/7/1998-20/9/1998).

a)biofertilizers in both experiments

Treatment	N		P		K		Fe		Zn		Mn	
	%						ug/g					
	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.	1st Exp.	2nd Exp.
Control	1.05	2.7	0.42	0.3	4.90	4.9	810	272	210	50.0	150	136.6
M	1.18	-----	0.40	-----	5.37	-----	825	-----	195	-----	170	-----
S	1.05	2.8	0.43	0.5	5.00	6.0	850	331	190	52.7	125	169.9
H	1.20	3.0	0.25	0.4	5.20	5.7	815	383	253	49.0	149	163.3
M+S	1.22	3.7	0.46	0.4	6.13	5.5	835	245	353	50.0	155	141.5
M+H	1.57	-----	0.52	-----	5.63	-----	820	-----	278	-----	203	-----
S+H	1.10	2.9	0.51	0.4	5.74	5.8	870	251	352	56.5	140	147.2
M+S+H	1.32	-----	0.42	-----	5.09	-----	865	------	245	-----	145	------
L.S.D.0.05	0.51	0.25	0.07	0.07	0.54	0.39	67	37	79	7.7	27	19.6

b) chemical fertilizers in the 2nd experiment

Treatment 500ml/plant/day at ppm	N	P	K	Fe	Zn	Mn
	%			ug/g		
0	2.2	0.3	4.7	204	49.8	145.0
125	2.8	0.4	5.4	220	59.4	175.6
250	3.6	0.5	5.6	459	54.8	158.0
500	3.1	0.4	6.6	252	41.5	127.7
L.S.D.0.05	0.23	0.14	0.35	34	6.9	17.5

Table 4: Effect of interaction between biofertilizers and chemical fertilizers on some nutrient elements content of banana leaves after 60 days of inoculation in the second experiment (20/7/1998-20/9/1998).

Treatment (biofertilizers)	Treatment (chemical)	N %	P %	K %	Fe ug/g	Zn ug/g	Mn ug/g
Control	0	1.8	0.2	3.5	183	49	111
	125	1.9	0.4	4.8	178	53	159
	250	2.7	0.4	5.2	492	57	160
	500	2.7	0.3	6.0	244	41	117
S	0	2.3	0.4	4.6	183	50	135
	125	2.7	0.4	5.9	448	55	175
	250	3.5	0.5	5.9	426	57	200
	500	2.8	0.5	8.2	266	49	169
H	0	2.3	0.4	5.0	205	58	187
	125	2.6	0.4	5.5	177	60	212
	250	4.2	0.4	6.0	880	44	133
	500	2.9	0.4	6.4	270	33	121
S+H	0	1.4	0.3	5.3	227	48	160
	125	2.7	0.4	5.6	233	80	166
	250	3.0	0.5	6.0	272	53	136
	500	4.0	0.3	6.3	273	45	127
M+S	0	3.0	0.4	5.0	230	44	134
	125	4.2	0.5	5.1	316	49	166
	250	4.4	0.5	5.6	227	63	161
	500	3.0	0.2	6.2	207	40	105
L.S.D.0.05		0.51	0.14	0.79	75	15.4	39.1

S= yeast, H= free nitrogen fixing bacteria and M= vesicular arbuscular mycorrhizae
Chemical fertilizer= NPK and nitrogen fertilizers

As for the effect of mineral fertilizers, irrespective of the influence of biofertilizers, the data in Table (3b) showed that the concentration of N, P, K and Fe were significantly higher in 250ppmN treatment than that in control treatment. In addition, adding 125 ppmN significantly increased leaf Zn and Mn contents as compared with that of the control treatment. However, leaf K content was significantly higher than that in the other treatment. As for the interaction between bio- and mineral fertilizers, the data in Table (4) showed that adding 125ppm of N + H or S+H increased leaf contents of Mn and Zn, respectively, while 250ppmN increased each of Fe by adding H or S- Mn by adding S, -N by adding M+S, -P by adding S+H as compared with the other treatments. In addition, the treatment of 500 ppm N +S increased leaf content of K as compared with the other treatments.

GENERAL CONCLUSION

From the obtained results, it could generally concluded that, yeast plays an important role either alone or with other inocula (M or H) in increasing root and leaf mineral nutrient contents in the first season or in the second one with the addition of 250 ppm mineral fertilizer daily. This result may be due to the role of yeast in oxidation of soil sulfur which caused activation in other beneficial microorganisms as mentioned by Germida et al. (1993). Also, yeast plays a role in P-solubilization and nitrification in soil as reported by Falih and Wainwright (1995). Moreover Cheah and Marshall (1995) found that yeast reduced the incidence of *Fusarium* rot disease. Fertilizing the plants daily by 250 ppm mineral fertilizers led to the highest activity of the used inocula and gave the best growth of the plants. These findings are in a good harmony with results of El-Gazzar (1993) and Abdul El- Wahad (1999).

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الملخص العربي

استجابة نباتات الموز لبعض الأسمدة الحيوية والمعدنية

١-التأثير على محتوى الاوراق والجذور من العناصر الكبرى والصغرى

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يهدف البحث إلى دراسة تأثير عدد من الأسمدة الحيوية والتي تشمل الفطريات الجذرية الداخلية الميكوريزا (M) والبكتريا الحرة المثبتة للنيتروجين الجوي (H) الخميرة (S) سواء أضيفت منفردة أو مختلطة على نمو نباتات الموز والقياسات المرتبطة به ومقارنتها بتأثير الأسمدة المعدنية على نمو النباتات في أصص خلال موسمي النمو ١٩٩٧و١٩٩٨ . في التجربة الأولى عام ١٩٩٧ تم تلقيح النباتات بالأسمدة الحيوية سالفة الذكر سواء منفردة أو مجتمعة M, S, H, M+S, M+H, S+H, M+S+H بالإضافة إلى معاملة المقارنة بالزراعة في ارض بدون اضافة الأسمدة الحيوية.

ثم أجريت التجربة الثانية خلال عام ١٩٩٨ باستخدام أفضل معاملات التسميد الحيوي والتي أعطت أعلى نمو خضري معنوي لنبات الموز خلال الموسم الأول ١٩٩٧ وهي: S, H, S+H, M+S بالإضافة إلى معاملة المقارنة كما في التجربة الأولى.

وتم تلقيح النباتات بها مع استخدام ٤ مستويات من التسميد المعدني حيث تم ري كل نبات يوميا بـ ٥٠٠ مل من المحلول السمادي المعدني المحضر بتركيزات صفر، ١٢٥، ٢٥٠، ٥٠٠ جزء في المليون.

هذا وقد تم تقدير تركيزات العناصر المغذية(النتروجين والفسفور والبوتاسيوم والحديد والمنجنيز والزنك) في جذور وأوراق النباتات في نهاية التجارب، وكانت أهم النتائج كما يلي:

- تلقيح النباتات باللقاح الحيوي المشترك M+S خلال الموسم الأول الى زيادة تركيزات العناصر المغذية معنويا في الجذور والأوراق عند مقارنتهم بالكنترول وبقية الأسمدة الحيوية الأخرى.
- اظهرت اللقاحات الحيوية S, H, S+H خلال الموسم الثاني زيادة معنوية في محتوى الجذور والأوراق من النتروجين والفسفور والبوتاسيوم تحت مستوى تسميد معدني ٢٥٠، ٥٠٠ جزء في المليون.