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INFLUENCE OF BIOFERTILIZERS APPLICATION ON GROWTH, YIELD, YIELD COMPONENTS, QUALITY AND MARKETABILITY OF BANANA FRUITS UNDER EGYPTIAN SOIL CONDITION

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ABSTRACT: *This study was conducted during 2011 and 2012 seasons in Williams banana plantation belong to Horticulture Research Station at El-Kanater Elkharia, Kaluobia Governorate, Egypt. The third and fourth rations of Williams banana plants were subjected to the effect of biofertilizers application at two different types of microorganism the first one was bacterial culture from Bacillus circulans (BC) as potassium releasing bacteria and the second was a mixed cultures (MX) from, Bacillus megaterium (BM) as phosphate dissolving bacteria, Azotobacter chroococcum (AZ) as free N_2-fixing bacteria and BC at rate (1:1:1) under different levels of mineral K-fertilizers (100, 75, 50 and 0) from recommended dose, on 1) soil microflora of rhizospher of banana plants and 2) growth, yield, yield component, fruit quality and marketability of banana plants. Samples and fruits were collected from each treatment from the experimental site and the obtained data indicated that application of biofertilizers had an activation effect on microbial status and gave higher values of total bacteria, fungi and actinomystices as compared to untreated treatment. Application of biofertilizers led to enhancement all vegetative growth parameters tested and recorded significant difference at number of leaves (per plant), leaf area (m^2), Pseudostem height (cm), as well as, bunch characteristics i.e. bunch length (cm), number of hands/bunch, bunch weight and number of fingers/bunch. Moreover, application of biofertilizers recorded highest yield (up to 26 tons fed^{-1}) as compared to mineral NPK fertilizers. Application of biofertilizers resulted in high fruit quality which led to reduce weight loss (%), moisture percentage (increasing dry weight (%)) and acidity (%), also increasing TSS (%), total sugar (%) as well as rising firmness as compared to control fruits. Generally, application of both biofertilizers types in presences of 75% K-mineral fertilizer led to obtain banana fruits with high quality and more marketability as well as rational of using mineral K-fertilizers (by 25%) and reducing the danger of environmental pollution due to excessive use of chemical fertilizers as well as reduce production coast.*

Key words: *Williams banana, biofertilizers, growth, fruiting, fruit quality and marketability*

INTRODUCTION

Banana (*Musa spp.*) is considered one of the most important and favorite fruits in the world. The world's production exceeded 91 million tons (F.A.O., 2012). Since it has an excellent flavor with high nutrition value. The area has enormously increased through the last decade because it gives the highest economic revenue per Feddan comparing with other fruits. In Egypt banana plantation occupied about 62318 (with fruitful of 55941 feddan) in 2012 season which gave a total production of about 1,054,243 tons (Ministry of Agriculture, 2012). Many problems encounter Egyptian banana production, banana plant has shallow root system; thereupon it draws nutrients from a very limited soil depth (Saleh, 1996), consequently, the major problems facing banana growers are the high costs of excessive mineral fertilizers needed for banana plants.

These chemical fertilizers are consider as air, soil and water polluting agents, induced finally negative effects on human health. Therefore we are using biofertilizers instead of chemical fertilizers. Plant Growth Promoting Rhizobacteria (PGPR) are used

as biofertilizers; *Bacillus circulans* (BC) as potassium release bacteria, *Bacillus megaterium* (BM) as phosphorus dissolving bacteria and *Azotobacter chroococcum* (AZ) as N2-Fixing bacteria. PGPR can play an important role for development, production and improvement the physical and chemical characteristics of banana fruits quality (total soluble solid, total sugar and vitamin C) as well as marketing quality (Gutiérrez-Miceli *et al.,* 2007; Hegazi *et al.*, 2007; Lin *et al.*, 2008; and Vázquez-Ovando *et al.*, 2012).

Potassium is fundamental for banana plants because it catalyzes important reactions in respiration, photosynthesis, chlorophyll formation, water regulation and its role in the transport and accumulation of sugars inside the plants and produce rising in the total yield.

The present study aims to evaluate the effect of using different types of Plant Growth Promoting Rhizobacteria (PGPR) on plant growth, fruiting, fruit quality and marketability of banana plants.

MATERIALS AND METHODS

This study was conducted on the 3rd and 4th Williams banana rations grown in clay loamy soil of banana plantation belonging to Horticulture Research Station at El-Kantar El-Khairia, Kaluobia Governorate, Egypt, during 2011 and 2012 experimental seasons. The mechanical, physical and chemical analyses of soil used according to Jackson (1973) were shown in Table (1). Mats (plantation holes) were 3.5 x 3.5 meters with 3 a part productive rations per each (3 suckers were annually selected and remained to grow for the consecutive cropping) were devoted to this study.

Table (1): The mechanical, physical and chemical properties of the studied soil.

Property	Values
Mechanical analysis:	
Sand %	32.98
Silt %	37.11
Clay %	28.75
TEXTURE	Clay loamy
Physical analysis:	
pH	7.8
EC.dsm^2	0.59
O.M. %	1.08
Total N %	0.18
W.H.C. %	37%
Total carbonate %	2.71
Chemical analysis:	
Available macro- Nutrients	
P ppm	17
K ppm	0.57
Ca ppm	2.97
Available micro- Nutrients	
Zn ppm	0.97
Cu ppm	1.13
Fe ppm	5.7

Bacterial used (PGPR):

Bacillus circulans (BC) as potassium release bacteria, *Bacillus megaterium* (BM) as phosphate dissolving bacteria and *Azotobacter chroococcum* (AZ) as free N2-fixing bacteria were used as biofertilizers. These strains were kindly obtained from Biofertilizers Production Unit (BPU), Microbiology Department, Soil, Water and Environment Research Institute (SWERI). Bioferilizers were used at two types, 1) BC as such and 2) mixed culture (MX) from BC+BM+AZ at the rate of 1:1:1 and the microbial load for each culture from BC or MX was – x 10^9 cell forming unit (CFU). The effect of soil drench application of two different biofertilizers types were added once monthly from March to July at rate of 5 Liters from liquid culture per Feddan. Nine treatments with three replicates were applied as follows:

1. 100% of the recommended dose of NPK (600kg N_2 fed^{-1},100 kg P_2O_5 fed^{-1} and 500 kg K_2O fed^{-1}) control.
2. *Bacillus circulans* (BC)+100% K_2O as recommended dose.
3. *Bacillus circulans* (BC) culture + 75% K_2O as recommended dose.
4. *Bacillus circulans* (BC) culture + 50% K_2O as recommended dose.
5. *Bacillus circulans* (BC) culture + 0 % K_2O.
6. Mixed culture of PGPR (MX) +100% K_2O as recommended dose.
7. Mixed culture of PGPR (MX) + 75% K_2O as recommended dose.
8. Mixed culture of PGPR (MX) + 50% K_2O as recommended dose.
9. Mixed culture of PGPR (MX) + 0% K_2O.

At the end of both studied seasons soil samples were collected from the experimental site for each treatment to determine the microbial status at soil plant rhizospher by estimated the values (CFU soil g^{-1}) of total bacteria, actinomycetes and fungi according to Page *et al.* (1982).

The response of banana plants to different treatments was investigated through determining the following measurements:

1. Vegetative growth:

After inflorescence emergence, some vegetative growth parameters were measured as follows:

1.1. Pseudostem high: Pseudostem length in cm was measured from the soil surface up to the petiole of the last emerged leaf.

1.2. Pseudostem circumference, which measured at 20 cm height above the soil surface.

1.3. Number of green leaves at bunch shooting stage (number of green leaves presented per plant was recorded).

1.4. Leaf area: The area of the third full sized leaf (from the top) was calculated in square meters according to Murray (1959) using the following equation:
Leaf area= length x width x 0.8.

Leaves mineral content:

Leaves samples of one leaf was collected from every pseudostem during each season. They were dried at 70°c until reached a constant weight and then ground by using a manual mill and 0.2g of the ground material were taken and digested using a mixture of 1:10 percholoric:sulphoric acid (v/v) for determination the following nutrient elements; total nitrogen (N%), Phosphorus (P%) and Potassium (K%) according to Page *et al.* (1982).

2. Bunch characteristics and yield:

2.1. Time from bunch shooting to harvesting. Duration needed from bunch shooting till harvesting (Maturation) in days was calculated.

2.2. Bunch weight (kg), number of hands per bunch, number of fingers per bunch, bunch length (cm), number of fingers per hand and yield (ton fed^{-1}) were estimated.

3. Fruit ripening:

Banana bunches for every treatment were harvested at maturity stage and held 24 hours in the laboratory at room

temperature. Bunches were divided into hands, washed with tap water and air dried then packed in plastic boxes and placed on shelves in ripening room at 20°C±2 and 90%±2 relative humidity. Subjected to acetylene gas generated from calcium carbide (5 gm calcium carbide in boiling water / m^3 ripening room) for 24 hours then transferred to be held at 15°C±2.

At 7 days intervals, Samples of all treatments were examined for the following characters:

3.1. Physical properties:

3.1.1. Pulp weight; peel weight; pulp percentage; finger diameter; finger weight and peel thickness were determined in sample of 10 fruits replicated in the three period (7days).

3.1.2. Fruit firmness (kg/cm^2) was determined by LFRA texture analyzer using a penetrating needle of 1mm diameter with 10 mm in distance, speed of 2mm per second and the peak of resistance was recorded as g/mm^2.

3.1.3. Fruit peel color: Peel color of fruit was measured by averaging two measurements taken on two opposite points of each fruit equator with a Minolta Colorimeter (Minolta Co.Ltd; Osaka, Japan) on the basis of the CIELAB color system. In this system values of (a&b) specify the green-red and blue-yellow axis, respectively. Values were determined and Hue angle was calculated according to McGuire (1992).

3.1.4. Loss in fruit weight percentage: The loss in mass fruit weight was recorded and calculated as percentage.

3.2. Chemical properties:

3.2.1. Fruit moisture percentage was determined by weight of 100g from fresh banana fruits then oven dried at 70°C until constant weight reached.

3.2.2. Freshly prepared juice of banana fruits samples were used for TSS, total acidity and total sugars determination as described by A.O.A.C. (2005).

4. Statistical analysis:

The obtained data were subjected to analysis of variance according to Snedecor and Cochran (1980) and the significant differences among the various treatments were comparing using L.S.D values at 5% level.

RESULTS AND DISCUSSION

1. Microbial status:

Soil microbial status as affected by bacterial inoculation (biofertilizers) of two types PGPR BC or MX among both tested seasons is presented in Table (2). Data demonstrated that the untreated treatment initially possesses very few numbers of all microorganisms which were $20x10^6$, $9x10^4$ and $13.5x10^5$ CFU g $soil^{-1}$ for total bacteria, fungi and actinomycetes respectively. Application of biofertilizers (PGPR), in regarded the two seasons tested, stimulated the counts of soil microorganisms in banana rhizospher soil particularly in the treatments which received 50% K_2O + MX or BC recorded 49.5, 27.5 and 37 CFU g $soil^{-1}$ for total bacteria, fungi and actinomycetes, respectively. Generally, soil microflora values were increased at season (2) as compared to values which recorded at season (1), these increases may due to the various activation mechanisms for different microbial PGPR used as well as to the root exudates which increased by increasing plant growth. The data are in agreement with those of Pandey *et al.*, 1998; Mona *et al.*, 2000; Abotaleb *et al.*, 2002; Mahmoud *et al.*, 2006 and El-Mehrat *et al.*, 2012 who reported that application of PGPR had an active effect on the population of soil microflora and increased their number by more than 50% among growth stage period. Moreover, they added that *Azotobacter sp* (AZ), *Bacillus megaterium* (BM) and *Bacillus circulans* (BC) have the ability to produce secondary metabolites such as, Inodol Acetic Acid, Hydrogen cyanide and Siderophors, which increase plant growth, yield and yield component for different plants.

Table (2): Effect of biofertilizers application on soil microflora at banana rhizospher plants during two seasons (2011& 2012).

Soil content / Treatments	B –X10^6 CFU			F –X10^4 CFU			A –X 10^5 CFU		
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Control	15	25	20	8	10	9	12	15	13.5
K_2O 100% + BC	20	30	25	11	15	13	15	20	17.5
K_2O 75 % + BC	35	40	37.5	20	25	22.5	20	28	24
K_2O 50 % + BC	40	50	45	25	30	27.2	27	35	31
K_2O 0 % + BC	25	35	30	15	20	17.5	18	20	19
k_2O 100 %+ MX	35	45	40	12	15	13.5	20	24	22
K_2O 75% + MX	45	50	47.5	22	25	23.5	32	38	36
K_2O 50% + MX	47	52	49.5	25	30	27.5	36	38	37
K_2O 0% + MX	25	30	27.5	15	20	17.5	20	22	21

S1= First season B= bacteria A= actinomycetes
S2= Second season F= fungi CFU= cell forming unit

2. Vegetative growth:

Data in Table (3) show the vegetative characters; number of leaves /plant, leaf area (m^2), Pseudostem height (m), Pseudostem circumference (cm) and time from bunch shooting to harvest (days) of the Williams banana in the two successive seasons. Untreated treatment and received 100% of K-mineral fertilizers recorded the lowest values at all vegetative growths parameters tested and scored significantly affect as compared to other tested treatments. Application of others PGPR BC or PGPR MX in presence of K-mineral fertilizer (at rates of 50 and 75 % from recommended dose) recorded no significantly differences as compared to fertilized with 100% of recommended K-fertilizer. Moreover, fertilized banana plants with 75% of K-mineral and application of PGPR (BC) or PGPR (MX) gave higher values of leaves number (11.67), leaf area (1.63), Pseudostem high (2.45), Pseudostem circumference (79.33) and time from bunch shooting to harvest (124.67) at the second season as compared to plants fertilized with 100% of recommended K-mineral dose and there is no significant differences found.

3. Plant mineral uptake (N, P and K %):-

Results in Table (4) show that the soil application of different types of biofertilizers (BC or MX) induced significant increases of plant N, P and K content as compared to untreated treatment (control) in both seasons.

Plants which received 75% K-mineral fertilizers scored the higher N, P and K values in presences of MX PGPR and these values were 7.97, 0.92 and 7.36 for N, P and K respectively, and recorded no significant as compared to the treatment that received 100% K-mineral fertilizer.

In general, application of MX PGPR gave higher values as compared to BC PGPR in both seasons. These findings are in harmony with these of Abd El-Naby and Gomaa, 2000; Abd El-aziz, 2002; El-Kafrawy, 2005 and El-Kafrawy, *et al.,* 2011.

Table (3): Effect of biofertilizers application on vegetative growth parameters during two seasons (2011&2012).

Parameters / Treatments	Number of leaves/plant	Leaf area (m^2)	Pseudostem height (m)	Pseudostem circumference (cm)	Time from bunch shooting to harvest (days)
1st Season					
Control	10.00	1.52	2.39	74.67	135.33
K_2O 100 % + BC	12.00	1.64	2.46	80.00	113.67
K_2O 75 % + BC	11.67	1.64	2.43	77.00	123.33
K_2O 50 % + BC	11.00	1.57	2.38	72.67	130.67
K2O 0 % + BC	10.83	1.56	2.36	69.33	143.00
k_2O 100 %+ MX	11.83	1.60	2.46	79.67	112.67
K_2O 75% + MX	11.17	1.64	2.42	79.33	122.67
K_2O 50% + MX	10.83	1.57	2.37	72.33	132.33
K_2O 0% + MX	10.67	1.54	2.35	70.00	140.67
LSD at 5%	1.270	0.155	0.087	2.991	6.112
2nd Season					
Control	10.50	1.55	2.41	74.67	130.67
K_2O 100 % + BC	11.83	1.68	2.46	80.00	110.33
K_2O 75 % + BC	11.67	1.63	2.45	79.33	124.67
K_2O 50 % + BC	11.33	1.57	2.38	75.00	133.33
K2O 0 % + BC	10.67	1.52	2.35	70.00	141.33
k_2O 100 %+ MX	12.00	1.62	2.15	79.67	113.67
K_2O 75% + MX	11.17	1.62	2.42	77.67	121.67
K_2O 50% + MX	10.67	1.57	2.39	72.67	131.67
K_2O 0% + MX	10.83	1.54	2.37	72.33	139.00
LSD at 5%	0.899	0.077	0.337	3.490	6.091

Table (4): Effect of biofertilizers application on Plant mineral uptake (N, P and K %) during two seasons (2011&2012).

Parameters / Treatments	Nitrogen (N %)	Phosphor (P %)	Potassium (K %)
1st Season			
Control	5.88	0.67	5.24
K_2O 100 % + BC	6.43	0.76	5.79
K_2O 75 % + BC	6.24	0.72	5.43
K_2O 50 % + BC	5.64	0.66	5.09
K2O 0 % + BC	5.07	0.58	4.76
k_2O 100 %+ MX	7.69	0.92	6.69
K_2O 75% + MX	6.20	0.89	5.68
K_2O 50% + MX	5.83	0.67	5.23
K_2O 0% + MX	5.18	0.58	5.01
LSD at 5%	0.919	0.055	1.000
2nd Season			
Control	6.95	0.68	6.49
K_2O 100 % + BC	7.65	0.83	7.58
K_2O 75 % + BC	7.06	0.76	6.87
K_2O 50 % + BC	5.98	0.70	6.19
K2O 0 % + BC	5.86	0.60	5.51
k_2O 100 %+ MX	8.94	1.00	8.71
K_2O 75% + MX	7.97	0.92	7.36
K_2O 50% + MX	7.43	0.84	6.47
K_2O 0% + MX	5.94	0.63	5.69
LSD at 5%	0.836	0.067	1.889

4. Bunch characteristics:

The data in Table (5) revealed that plants of control treatment received no biofertilizers (PGPR)) recorded lower values of bunch length (cm), number of hands / bunch, number of fingers / bunch and bunch weight (Kg) as compared to plants received various PGPR types with applied K-mineral fertilized at rates 100% and 75% from recommended dose. On the other word, plants received different two types of PGPR in presences of 100 and 75% mineral K fertilized show significantly positive effect as compared to plants received recommended mineral fertilizers NPK doses among the two-experimental seasons. Regardless of various K-mineral levels applied and the two seasons application of biofertilizers at types

of BC did support the bunch characteristics as compared to MX biofertilizers and recorded 99.1, 10.38, 170.55 and 19.96 for bunch length, number of hands, number of fingers / bunch and bunch weight (Kg), respectively and the corresponding values at MX biofertilizers were 98.96, 10.01, 167.15 and 19.88 at the same order. The abovementioned data of vegetative growth and bunch characteristics are in agreement with Gomaa, 2000; El-Kafrawy, 2005 and Maklad, 2010 who reported that the application of biofertilizers and some plant growth promoters gave a significant effect on the most vegetative and bunch characteristics of banana plants.

Table (5): Effect of biofertilizers application on bunch characteristics during two seasons (2011&2012).

Parameters / Treatments	Bunch length (cm)	Number of hands / bunch	Number of fingers / bunch	Bunch weigh (kg)
1st Season				
Control	96.83	9.83	178.33	20.50
K_2O 100 % + BC	118.83	11.83	198.00	26.00
K_2O 75 % + BC	102.33	10.67	185.47	21.50
K_2O 50 % + BC	90.17	10.00	161.97	18.67
K2O 0 % + BC	88.67	9.33	154.00	15.50
Mean BC	100.00	10.46	174.86	20.42
K_2O 100 %+ MX	121.00	12.33	202.00	25.67
K_2O 75% + MX	107.67	10.50	162.33	20.00
K_2O 50% + MX	89.67	9.67	152.33	17.67
K_2O 0% + MX	85.00	6.33	154.20	15.33
Mean MX	100.84	9.71	167.72	19.67
LSD at 5%	3.629	0.869	11.60	1.742
2nd Season				
Control	94.67	9.83	172.97	19.00
K_2O 100 % + BC	113.00	12.50	205.97	24.67
K_2O 75 % + BC	101.33	9.67	165.27	21.33
K_2O 50 % + BC	93.00	9.67	148.57	16.33
K2O 0 % + BC	85.33	9.33	145.10	15.67
Mean BC	98.17	10.29	166.23	19.50
K_2O 100 %+ MX	110.00	11.67	189.47	25.83
K_2O 75% + MX	106.00	10.17	171.10	22.00
K_2O 50% + MX	90.00	9.67	157.03	17.00
K_2O 0% + MX	82.33	9.67	148.73	15.50
Mean MX	97.08	10.30	166.58	20.08
LSD at 5%	6.446	0.795	19.82	1.888

5. Yield and fruit quality:-

The results presented in Table (6) show the effect of application both two types of PGPR on yield and fruit quality of banana plants (Williams cv.) i.e. number of fingers / hand, finger length (cm), finger diameter (cm), finger weight (g), peel thickness (mm), peel weight (g), pulp weight (g), pulp percentage (%) and yield (ton fed^{-1}).The soil application of two types of PGPR (BC and MX) at rate 5L fad^{-1} significantly produced a higher values of all tested fruit quality and yield in presences of 75% of recommended K-mineral fertilizers in comparison with plants which received 100% of recommended NPK fertilizers (control) among the two experimental seasons. It is clear from Table (6) that the treatment which received 75% K-mineral fertilizer in presence of BC or MX biofertilizers gave a higher values up to 17.10, 21.00, 5.87, 114.97, 2.23, 39.13, 75.83, 65.97 and 21.33 at the second season for number of finger hand, finger length (cm), finger diameter (cm), finger weight (g), peel thickness (mm), peel weight (g), pulp weight (g), pulp percentage (%) and yield (ton fed^{-1}), respectively and had no significant difference as compared to treatment which received 100% K–mineral fertilizers. In this respect, these data are in agreement with Soliman, 2001; Abd El Moniem *et al.,* 2008; El-Kholy, 2010 and El-Kafrawy *et al.,* 2011 who reported that the soil application of some biofertilizers, organic fertilizers and plant growth substances (plant hormones) did support and produce increasing at yield obtained and fruit quality i.e. yield (ton fed^{-1}), finger weight (g), pulp weight (g) and pulp percentage (%).

6. Effect of PGPR on marketability:

Results obtained at Tables (7and 8) clearly indicated that continuous loss in fruit weight (%) and fruit firmness (g/mm^2) with the extend of the ripening period in all treatments to attain the maximum at the end of ripening period (14 days after harvest). Application of different types of biofertilizers (BC or MX PGPR) recorded positive effect at weight loss (%) and firmness and recorded significant difference as compared to control plants in both seasons. At the end of ripening period banana fruits of treatment which received 75% K-mineral fertilizers in presence of MX biofertilizers were more firm than control plant and there is no significant difference found as compared to applied of 100% K-mineral fertilizer in both seasons. For moisture percentage (%) and peel color, the same trend was found as compared to which obtained at weight loss (%) and firmness (g/mm^2). The best result was obtained at treatments, which received 75% K-mineral fertilizer in presence of MX PGPR fertilizer. Weight loss (%), firmness (g/mm^2), moisture percentage (%) and peel color were affected by many physiological processes that occurred during ripening i.e. starch hydrolysis, accompanied water loss, breakdown of insoluble pectic substances to soluble forms and polygalacturonase, which biofertilizers had a positive effect on these physiological processes. In this respect, these finding are in harmony with these of Abd El-aziz, 2002; Abd El Moniem *et al.,* 2008; El-Kafrawy *et al.,* 2011 and El-Mehrat *et al.,* 2012.

The results presented in Table (9) show the effect of application of two different biofertilizers types (BC and MX PGPR) on total acidity (%), total sugar (%) and TSS (%). The obtained results suggest that acidity (%) changes may be connected with the changes in the mechanism of respiratory process throughout storage period and applied of PGPR produced decreasing values of total acidity (%). As shown in Table (9) the total sugar percentage of Williams banana cv was rapidly increased at the beginning of ripening period within 7 days and followed by a gradual and slight increase during the late ripening period to attain the maximum values at the end of the storage period (14 days). Moreover, application of PGPR did support the values of total sugar (%) and recorded highest values between the two seasons, rising up to 18.73%. Total soluble solids (TSS) gave the same trend of total sugar (%) in the presence of PGPR used as biofertilizers at various of K-mineral fertilizers levels. Generally, application of biofertilizers recorded a positive effect on fruit total acidity (%), total sugars (%) fruit total soluble solid (TSS%), in this respect these data are harmony with findings of El-Morsy, 1997; Abd El Moniem *et al.,* 2008; El-Koly, 2010 and El-Kafrawy *et al.,* 2011.

Table (6): Effect of biofertilizers application on yield and fruit quality during two seasons (2011&2012).

Parameters / Treatments	Number of fingers/hand	Finger length(cm)	Finger diameter(cm)	Finger weight (g)	Peel thickness (mm)	Peel weight (g)	Pulp weight (g)	Pulp percentage	Yield (ton / fed.$^{-1}$)
1st Season									
Control	18.17	20.00	5.83	98.25	2.17	40.63	57.62	58.67	20.50
K_2O 100 % + BC	16.70	22.33	6.17	113.80	2.13	39.68	74.13	65.10	26.00
K_2O 75 % + BC	17.37	21.33	5.73	103.26	2.33	40.56	62.70	60.73	21.50
K_2O 50 % + BC	16.17	19.33	5.40	98.85	2.03	36.32	62.54	63.23	18.67
K2O 0 % + BC	16.50	18.00	4.83	81.25	1.87	31.00	50.25	61.83	15.50
k_2O 100 %+ MX	16.43	22.40	6.37	115.19	2.43	43.36	71.82	62.37	25.67
K_2O 75% + MX	15.50	21.83	6.00	112.12	2.30	42.40	69.71	62.13	20.00
K_2O 50% + MX	15.80	20.67	5.07	96.58	1.97	41.02	55.56	57.53	17.67
K_2O 0% + MX	16.23	17.67	4.90	83.26	1.80	30.49	52.77	63.37	15.33
LSD at 5%	0.926	0.970	0.314	6.307	0.219	3.878	3.957	2.310	1.638
2nd Season									
Control	17.03	20.67	5.70	99.83	2.10	38.83	61.00	61.07	19.00
K_2O 100 % + BC	16.47	21.67	6.13	104.57	2.23	40.83	63.73	60.87	24.67
K_2O 75 % + BC	17.10	21.00	5.87	114.97	2.23	39.13	75.83	65.97	21.33
K_2O 50 % + BC	15.40	19.50	5.30	93.23	1.83	35.73	57.67	61.53	16.33
K2O 0 % + BC	15.50	18.33	4.93	89.33	1.60	29.17	60.17	67.30	15.67
k_2O 100 %+ MX	16.67	23.50	6.43	127.27	2.63	46.17	81.10	63.67	25.83
K_2O 75% + MX	16.80	22.33	5.93	115.07	2.53	44.40	70.67	61.40	22.00
K_2O 50% + MX	16.20	19.50	5.13	88.33	2.13	34.00	54.33	61.43	17.00
K_2O 0% + MX	15.30	18.33	5.00	86.83	1.70	31.67	55.17	63.23	15.50

LSD at 5%	1.840	1.111	0.251	5.977	0.205	3.712	4.666	2.699	1.888

Table (7): Effect of biofertilizers application on Firmness (g/mm^2) and Weight loss percentage (%) in banana fruits during marketing period for two seasons (2011&2012).

Parameters / Treatments	Firmness				Weight loss			
	0	7	14	Mean	0	7	14	Mean
1st season								
Control	284.67	187.33	76.67	182.89	0.00	2.37	10.83	4.40
K_2O 100%+BC	309.00	196.00	95.00	200.00	0.00	1.80	9.13	3.64
K_2O 75% + BC	300.00	185.33	87.67	191.00	0.00	2.00	10.00	4.00
K_2O 50 %+ BC	234.67	169.00	63.00	155.56	0.00	2.23	10.20	4.14
K_2O 0% + BC	219.00	160.00	52.67	143.89	0.00	2.57	10.87	4.48
k_2O 100%+MX	317.00	204.00	95.00	205.33	0.00	1.83	8.67	3.50
K_2O 75%+ MX	307.33	188.67	89.00	195.00	0.00	2.13	9.70	3.94
K_2O 50%+ MX	253.00	165.00	71.00	163.00	0.00	2.53	10.00	4.18
K_2O 0% + MX	227.67	164.00	66.67	152.78	0.00	2.63	10.60	4.41
Average	272.48	179.93	77.41		0.00	2.23	10.00	
LSD at 5%	A	B	A*B		A	B	A*B	
	9.436	5.448	16.34		0.3249	0.1876	0.5628	
2nd season								
Control	304.33	192.00	81.00	192.44	0.00	4.10	12.47	5.52
K_2O 100%+BC	307.67	195.00	87.33	196.67	0.00	2.27	10.33	4.20
K_2O 75% + BC	302.33	181.33	90.00	191.22	0.00	2.73	11.13	4.62
K_2O 50% + BC	294.00	165.33	57.33	172.22	0.00	3.27	11.67	4.98
K_2O 0 % + BC	264.00	160.00	53.67	159.22	0.00	3.87	12.10	5.32
k_2O 100%+MX	313.33	200.67	96.67	203.56	0.00	2.07	9.93	4.00
K_2O 75%+ MX	309.67	184.33	90.00	194.67	0.00	2.60	10.67	4.42
K_2O 50%+ MX	295.00	169.00	70.00	178.00	0.00	3.20	11.47	4.89
K_2O 0% + MX	273.67	156.67	66.67	165.67	0.00	3.73	12.00	5.24
Average	296.00	178.26	76.96		0.00	3.09	11.31	
LSD at 5%	A	B	A*B		A	B	A*B	

	7.956	4.593	13.78	0.2336	0.1349	0.4047

Table (8): Effect of biofertilizers application on Moisture percentage and Peel color in banana fruits during marketing period for two seasons (2011&2012).

Parameters Treatments	Moisture percentage				Peel color			
	0	7	14	Mean	0	7	14	Mean
1st season								
Control	72.40	74.20	76.42	74.34	115.42	98.33	92.00	101.92
K_2O 100 % + BC	70.37	72.57	73.97	72.30	114.72	100.41	92.65	102.59
K_2O 75 % + BC	70.97	71.89	74.49	72.45	115.71	99.70	91.47	102.29
K_2O 50 % + BC	71.47	71.64	74.56	72.56	115.35	98.87	90.37	101.53
K_2O 0 % + BC	71.60	71.92	75.20	72.91	114.72	96.24	88.71	99.89
k_2O 100 %+ MX	70.87	71.37	72.74	71.66	116.59	99.33	91.50	102.47
K_2O 75% + MX	69.97	70.40	73.66	71.34	115.46	97.55	89.77	100.93
K_2O 50% + MX	69.60	69.50	70.19	69.76	114.02	96.02	89.33	99.79
K_2O 0% + MX	69.97	70.13	73.30	71.13	111.55	95.25	88.03	98.28
Average	70.80	71.51	73.83		114.84	97.97	90.43	
LSD at 5%	A	B	A*B		A	B	A*B	
	0.589	0.340	1.021		0.804	0.464	1.392	
2nd season								
Control	72.27	73.63	75.87	73.92	105.08	96.73	90.60	97.47
K_2O 100 % + BC	70.20	72.47	73.70	72.12	105.31	98.47	91.40	98.39
K_2O 75 % + BC	71.00	71.60	74.43	72.34	106.44	98.52	91.00	98.65
K_2O 50 % + BC	71.23	71.40	74.23	72.29	105.77	96.87	89.42	97.35
K_2O 0 % + BC	71.33	72.33	74.73	72.80	106.06	95.87	88.47	96.80
k_2O 100 %+ MX	70.63	71.57	72.50	71.57	107.59	97.61	92.20	99.13
K_2O 75% + MX	69.67	70.40	73.40	71.16	106.46	96.97	89.83	97.75
K_2O 50% + MX	69.87	70.20	70.67	70.25	107.69	96.14	90.03	97.95
K_2O 0% + MX	69.83	70.00	73.00	70.94	105.16	95.10	88.73	96.33
Average	70.67	71.51	73.61		106.17	96.92	90.19	
LSD at 5%	A	B	A*B		A	B	A*B	

	0.452	0.261	0.782	0.849	0.490	1.470

Table (9): Effect of biofertilizers application on Acidity%, Total Sugar % and TSS% in banana fruits during marketing period for two seasons (2011&2012).

Parameters / Treatments	Acidity				Total Sugar				TSS			
	0	7	14	Mean	0	7	14	Mean	0	7	14	Mean
1st Season												
Control	0.469	0.313	0.212	0.331	2.46	15.97	16.56	11.66	2.90	18.67	19.13	13.57
K_2O 100%+BC	0.491	0.403	0.271	0.388	2.69	16.15	18.02	12.29	3.13	19.00	21.20	14.44
K_2O 75 % + BC	0.424	0.331	0.245	0.333	2.29	16.02	17.62	11.98	2.70	18.87	20.73	14.10
K_2O 50 % + BC	0.380	0.301	0.209	0.297	2.83	15.44	16.32	11.53	3.33	18.13	19.20	13.55
K2O 0 % + BC	0.380	0.283	0.162	0.275	3.09	14.85	15.49	11.14	3.63	17.47	18.07	13.06
k_2O 100 %+ MX	0.558	0.405	0.264	0.409	2.86	16.78	18.36	12.67	3.37	19.67	21.60	14.88
K_2O 75% + MX	0.447	0.333	0.258	0.346	2.69	16.83	17.72	12.41	3.13	19.80	20.87	14.60
K_2O 50% + MX	0.424	0.296	0.220	0.313	2.24	15.13	16.49	11.29	2.63	17.80	19.40	13.28
K_2O 0% + MX	0.380	0.283	0.153	0.272	2.80	14.96	15.81	11.19	3.30	17.67	18.60	13.19
Average	0.439	0.328	0.222		2.66	15.79	16.93		3.13	18.56	19.87	
LSD at 5%	A	B	A*B		A	B	A*B		A	B	A*B	
	0.051	0.029	0.089		0.160	0.480	0.3263		0.326	0.188	0.565	
2nd Season												
Control	0.581	0.424	0.253	0.419	2.58	16.17	16.70	11.82	3.03	19.00	19.47	13.83
K_2O 100 % + BC	0.558	0.424	0.268	0.417	2.78	17.81	18.45	13.01	3.27	20.87	21.60	15.25
K_2O 75 % + BC	0.504	0.380	0.259	0.381	2.32	17.17	17.60	12.36	2.73	20.07	20.53	14.44
K_2O 50 % + BC	0.424	0.357	0.192	0.324	2.52	16.66	17.21	12.13	2.93	19.60	20.13	14.22
K2O 0 % + BC	0.357	0.319	0.151	0.276	2.97	15.22	16.05	11.41	3.50	17.87	18.67	13.35
k_2O 100 %+ MX	0.593	0.424	0.304	0.440	3.00	17.62	18.73	13.12	3.50	20.60	21.93	15.34
K_2O 75% + MX	0.526	0.417	0.259	0.401	2.66	17.27	17.91	12.61	3.13	20.20	20.93	14.75
K_2O 50% + MX	0.447	0.380	0.216	0.348	2.38	16.31	17.35	12.01	2.80	18.13	19.53	13.49
K_2O 0% + MX	0.397	0.277	0.162	0.279	2.69	15.62	16.12	11.48	3.07	18.27	18.73	13.36
Average	0.487	0.378B	0.229		2.66	16.65	17.35		3.11	19.40	20.17	
LSD at 5%	A	B	A*B		A	B	A*B		A	B	A*B	

	0.042	0.024	0.07327	0.235	0.136	0.4080	0.2642	0.152	0.4576

Conclusion

From the obtained results it can concluded that, application of PGPR as biofertilizers as mono culture (BC); *Bacillus circulans* as potassium (K) release bacteria or mixed cultures (MX); *Bacillus circulans* (BC), *Bacillus megaterium* (BM) and *Azotobacter spp.* (AZ) as soil application at rate 5L fed^{-1} were more pronounced effect on vegetative growth, mineral N, P and K uptake, bunch characteristics, yield and fruit quality as well as fruit marketability of banana plants under Egyptian soil condition. Moreover, by application different two types of biofertilizers induced relatively reduction in K-mineral by about 25% from recommended dose fed^{-1}.

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تأثير تطبيق المخصبات الحيوية علي النمو والمحصول ومكونات المحصول والجودة والقدرة التسويقية لثمار الموز تحت ظروف الأراضي المصرية

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الملخص العربي

أجريت هذه الدراسة خلال موسمين متتاليين هما ٢٠١١ و ٢٠١٢ علي الخلفات الثالثة والرابعة للموز الوليامز والمنزرعة في تربة طمبية بمزرعة محطة بحوث البساتين بالقناطر الخيرية محافظة القليوبية.

تم دراسة تأثير استخدام نوعين من السماد الحيوي بمعدل ٥ لتر/فدان الأول مزارع بكتيرية من ميكروب الباسلس سيركيولونس والخاص بتوفير عنصر البوتاسيوم والثاني خليط (١:١:١) من المزارع البكتيرية – أزوتوباكتر كروكوكم كمصدر للنتروجين والباسلس ميجاتيريم كمذيب وميسر للفوسفور والباسلس سيركيولونس مع مستويات ١٠٠%، ٧٥%، ٥٠%، صفر% بوتاسيوم من المقررات السمادية الموصي بها مقارنة بالتسميد المعدني الموصي به وذلك علي مدي تأثير التسميد الحيوي علي المجتمع الميكروبي المتواجد في منطقة جذور أشجار الموز ومن ناحية أخري نمو الخلفات والمحصول كما ونوعا وجودة الثمار وقدرتها التسويقية. تم جمع الثمار من كل معاملة علي حدة عند اكتمال النمو وتم دراسة الصفات الطبيعية والكيماوية للثمار.

أظهرت النتائج المتحصل عليها أن استخدام التسميد الحيوي بنوعيه مع كل مستويات التسميد المعدني قد أعطي تأثيرا منشطا وايجابيا علي الأعداد الميكروبية في التربة وذلك مقارنة بالكنترول. أدى أيضا إلي تحسين نمو الخلفات من حيث عدد الأوراق والمساحة الورقية وقطر وطول الساق للخلفات وكذلك طول السوباطة وعدد الكفوف في كل سوباطة ووزن السوباطة وعدد الأصابع في السوباطة وطول الأصبع ووزن الأصبع وسمك القشرة مما انعكس علي زيادة في المحصول كما ونوعا مقارنة بالتسميد المعدني وأكثر من ذلك أدى تطبيق التسميد الحيوى الي تسجيل أعلي محصول (٢٦ طن/فدان). أعطي التسميد الحيوي بنوعية نتائج جيدة من حيث تقليل الفقد في الوزن ونسبة الرطوبة أي (زيادة نسبة المادة الجافة) وزيادة نسبة المواد الصلبة الذائبة الكلية وزيادة السكريات الكلية وتحسين اللون وزيادة الصلابة ونقص في الحموضة مقارنة بالتسميد المعدني الكامل (الكنترول). بصفة عامة أعطي التسميد الحيوي بنوعية في وجود ٧٥% من التسميد البوتاسي ثمار موز ذات جودة عالية وقدرة تخزينية وتسويقية جيدة وأيضا ترشيد استخدام التسميد البوتاسي بنسبة ٢٥% مما يؤدى الي تقليل مخاطر التلوث البيئى الناتج من زيادة استخدام الأسمدة المعدنية وأيضا تقليل تكاليف الإنتاج.