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EFFECT OF DIFFERENT SOURCES OF NITROGEN, PHOSPHORUS, POTASSIUM AND IMPROVEMENT SOLUTION ON PRODUCTIVITY AND FRUIT QUALITY OF WILLIAMS BANANA PLANTS

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Abstract

This study was carried out on 1st and 2nd Williams banana raccoons grown in clay loamy banana orchard soil belonging to the Horticultural Research Station at Al-Kanatir Al-Khairia, Qaliobia Governorate, Egypt during the 2017/2018 and 2018/2019 experimental seasons-Mats (plantation holes) were 3 × 4 meters apart. To compare the impact of different sources of nitrogen, phosphorus, potassium and improvement solution on productivity and fruit quality of Williams banana plants**.** Anyhow, the experiment consisted of ten treatments as follows: T1- control (100% of chemical), NPK T2- 100% mineral (NPK) + improvement solution at a rate of 3 cm/l, T3- 75% mineral NPK + 25% of natural mixture elements (NME), T4- 75% mineral NPK + 25% of NME + improvement solution, T5- 50% mineral NPK + 50% of NME, T6- 50% mineral + 50% of NME + improvement solution at, T7- 25% mineral NPK + 75% of NME, T8- 25% mineral NPK + 75% of NME+ improvement solution, T9- 100% of NME and T10- 100% of NME + improvement solution. The results obtained showed a positive correlation between the values of the studied parameters (productivity and fruit quality) and the investigated treatments. Herein, T4: 75% mineral NPK (2.01, 0.525 and 1.50 kg per plant, respectively) + 25% 25% of NME (N: 0.67; P: 0.125 and K: 2.25 kg/plant, respectively) + improvement solution at a rate of 3 cm/L was statistically the superior. On the contrary, the lowest values of these parameters were obtained by T9: 100% of NME (N: 4.0; P: 0.5 and K: 9.0 kg/plant). Besides, the remaining treatments have occupied an intermediate position between the treatments mentioned above in both seasons. Finally, it can be recommended that, the possibility of reducing the high cost of chemical fertilizers (NPK) which directly impacts on human health by cheaper alternative and environment friendly such as of natural mixture elements (NME).

Key words: Banana, Williams, nitrogen, phosphorus, potassium, improvement solution, productivity and fruit quality.

Introduction

Banana **(***Musa* spp.**)** is a monocotyledonous plant, botanically belonging to family Musaceae, order Zingiberales which contains hundreds of banana varieties (Simmonds, 1966). Banana is considered one of the most important, popular and favorite fruits in the world since it has an excellent flavour, nice taste, high nutritional value and permanent production along the year around. Banana is consumed either as fresh ripe fruits or after cooking. In addition to other miscellaneous uses as banana, juice, dried catsup, ships, vinegar, beers, as a source of carbohydrates and confections (Palmer, 1979).

Banana plants need an intensive fertilization program. The importance of chemical fertilization to the nutrition of banana could be indicated by high concentrations of nutrient elements found in all plant tissues, thus it is well known that banana needs, a large amount of fertilization especially nitrogen, phosphorus and potassium. Moreover, it draws nutrients from every limited soil depth because of its relatively shallow root system (Saleh, 1996).

Chemical fertilization is an important and limiting factor for the growth and production of banana plants which remove large amounts of nutrients from the soil. Among these nutrients, nitrogen, phosphorus and potassium are considered the prime nutrients for the growth of plants. Sandy soils are considered recently, as the main area for agricultural extinction, under such conditions, it is necessary to use the improved irrigation fertilization (fertigation) by adding the dissolved nutrients through a drip (trickle) irrigation system (Ibrahim, 2003).

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For growth and fruit production, bananas require high amounts of nutrients which are often supplied only in part by the soil. These nutrients have to be enriched with organic and biofertilizers to maintain soil fertility and to permit the continuous production of high yields (Gowen, 1995). El-Gioushy, (2016) on young pomegranate trees consequently, the present work is mainly directed towards investigating the possibility of replacing the expensive, highly dispersible soluble three major commercials concentrated mineral NPK fertilizers usually adopted by an alternative cheaper and environment-friendly one either those of organic or mineral rocky nature. Since all alternative sources are characterized by the slow-releasing ability of their nutrients content which representative as a continuous gradual supply along the growing season around for the fruit trees. Several investigators reported that combined application of organic with biofertilizers or inorganic fertilizers increased soil N, P and K availability and decreased soil PH compared with the treatments with inorganic fertilizers alone of banana plants (Athani and Hulamani, (2000); El-Shammaa, (2001); Suresh and Hasan, (2001); Hammam *et al*., (2003); Abd El-Moniem and Radwan, (2003); Gogoi *et al*., (2004); Abd El-Moniem *et al*., (2008); Mohamed *et al*., (2010); Barakat *et al*., (2011) and Vazquez-Ovando and Andrino-Lopez, (2012).

Feldspar rock contains potassium in ranges from 10 to 13% and not easily suitable for direct application where Feldspar structure is Aluminum silicate combined with potassium to make Orthoclase ($KAlSi_3O_8$) (Aisha and Taalab, 2008). It is a slow-release fertilizer, so several laboratory studies have shown that microbes can increase the dissolution rate of silicate and aluminum silicate minerals, primarily by generating organic and inorganic acids (Barker *et al.,* 1997 and Aisha and Taalab, 2008). Also, the direct contact between bacteria and minerals may be important in mineral alteration and can enhance K mineral dissolution rate by producing and excreting metabolic by-products that elevate carbonic acid concentration at mineral surfaces (Chapelle *et al.,* 1987 and Paris *et al.,* 1996). So, the silicate dissolving bacteria (*Bacillus circulans*) are generally used to release potassium from rock-feldspar (Balabel, Naglaa, 1997 and Sheng and Huang, 2002).

Natural elements compound as feldspar, Sulphur and magnetite are used as a source of some nutrient minerals. Their use in nutrients management is considered clean and according to organic agriculture since these compounds improve soil aggregation, structure, permeability, infiltration, electrical conductivity (EC) and may overcome the harmful effect of saline water application. Moreover, Egyptian soils having alkaline pH are low in their available nutrients. Sulphur is frequently considered the essential amendment for soil reclamation and improvement through, reducing soil pH, improving water relations and the increasing availability of some nutrient elements needed for growth and yield Harhash and Abdel-Nasser, (2000) and El-Dsouky *et al*. (2002). To decrease the dependence on imported potash, feldspar a potash mineral, containing 11.25% KO_2 could be a potential K-source for crop production. The utilization of potassium feldspar or crushed granite gave a yield response, although no higher than the usage of conventional fertilizers Badr, (2006).

The main purpose of this study was to compare the effect of different sources of nitrogen, phosphorus, potassium and improvement solutions on productivity and fruit quality of "Williams" banana plants. Besides, study the possibility of reducing the high cost of chemical fertilizers (NPK) which directly impacts human health by cheaper alternative and environment friendly.

Materials and Methods

This study was carried out was on 1st and 2nd Williams banana ratoons grown in clay loamy soil of banana orchard belonging to Horticultural Research Station at Al-Kanatir Al-Khairia, Qaliobia Governorate, Egypt, during both successive 2017/2018 and 2018/2019 experimental seasons-Mats (plantation holes) were 3× 4 meters apart.

Before experiments had been conducted in 1st season, mechanical and chemical analysis of orchard soil surface (0-30 cm depth) were determined according to

Table 1: Mechanical and chemical analyses of experimental orchard soil 0- 30 cm depth in the 2019 season.

A- Physical analysis

Sand (%)	Silt (%)	Clay (%)	Soil texture	F.C. (%)	W.P. (%)	A.W. (%)
17.7	29.1	53.2	Clay loamy	42.5	21.2	20.1

B- Chemical analysis

	Available nutrients (mg/kg)							E.C. ds/m	pH(1: 2.5)	$CaCO_3$
	N	P	K	Fe	Zn	Mn	Cu			
Total	677	340	452.5	315.6	113	146	47	3.71	7.8	3.6
Avail.	63	13.7	61.2	21.1	5.7	16.6	2.6			

methods described by Piper, (1950) and Jackson, (1967) as shown in table 1. Thus, four field experiments conducted were as follows:

Rate and application method of chemical NPK Fertilizers

Four rates of chemical fertilizers NPK were employed in this study. The first-rate was 100% of chemical NPK from ammonium nitrate 33.5% N, superphosphate 15.5% P_2O_5 and potassium sulphate 48% (K_2O) equal (2.68; 0.7 and 2.0 kg/plant), respectively. The second rate was 75% of chemical NPK (2.01, 0.52 and 1.50 kg per plant), respectively. The third rate was 50% of chemical NPK (1.34, 0.35 and 1.0 kg per plant) and the fourth rate of chemical NPK was 25% (0.67, 0.175 and 0.50 kg/plant), respectively; they applied at four equal batches in the first week of March; May; July and September.

Rate and application method of natural mixture elements (NPK) Fertilizers

Natural mixture elements (NME) contains three alternate NPK sources, i.e., granulated organic N fertilizer; granulated natural raw mineral rocky materials and feldspar for either P or K fertilizers were mixed at four rates. The first-rate was 100% of Natural mixture elements (NME) (4.0; 0.5 and 9.0 kg/plant, respectively). The second rate was 75% of NME (3.0; 0.375 and 6.75 kg/plant, respectively). The third rate was 50% of NME (2.0; 0.25 and 4.50 kg/plant, respectively) and the fourth rate was 25% of NME (0.67; 0.125 and 2.25 kg/plant, respectively); they have added tow equally doses at the half quantity (50%) during December and March.

Improvement solution

Improvement solution contains (0.01% N-Acetyl-Thiazolidine-4-carboxylic acid; GA_3 0.25 and 0.10 folic acid) was added sprinkles monthly six times during the period from first July to first December at a rate of 3 cm/l .

The experiment consisted of ten treatments as follows:

1. T1: Control (100% of chemical NPK from ammonium nitrate 33.5% N, super phosphate 15.5% P_2O_5 and potassium sulphate 48% (K_2O) = (2.68; 0.7 and 2.0 kg/plant), respectively (Ibrahim, 2003).

2. T2: 100% mineral (NPK) + improvement solution at a rate of 3 cm/l.

3. T3: 75% mineral NPK (2.01, 0.52 and 1.50 kg per plant), respectively) + 25% of NME (N: 0.67; P: 0.125 and K: 2.25 kg/plant).

4. T4: 75% mineral NPK (2.01, 0.52 and 1.50 kg per plant), respectively) + 25% 25% of NME (N: 0.67; P: 0.125 and K: 2.25 kg/plant) + improvement solution at a rate of 3 cm/l.

Table 2: The chemical analysis of feldspar and rock phosphate used in the two seasons.

Component (%)	Feldspar		Rock phosphate	
	From	To	From	To
SiO_2	68.56	70.23	10.60	12.78
TiO_2	0.02	0.04	0.02	0.03
Al_2O_3	13.23	16.25	0.35	0.65
Fe_2O_3	0.17	0.40	1.12	1.35
MnO	0.02	0.06	0.07	0.08
MgO	0.03	0.05	0.33	0.61
CaO	0.26	0.47	44.12	48.63
Na_2O	2.25	3.69	0.18	1.12
K_2O	6.20	8.12	0.03	0.05
P_2O_5	0.02	0.03	20.00	22.00
SO_3(%)	-	-	0.32	1.98

Mineral rock analysis by Producer Company

5. T5: 50% mineral NPK (1.34, 0.35 and 1.0 kg per plant) + 50% of NME (N: 2.0; P: 0.250 and K: 4.50 kg/plant).

6. T6: 50% mineral NPK (1.34, 0.35 and 1.0 kg per plant) + 50% of NME (N: 2.0; P: 0.250 and K: 4.50 kg/plant) + improvement solution at a rate of 3 cm/l.

7. T7: 25% mineral NPK (0.67; 0.175 and 0.50 kg/plant) + 75% of NME (N: 3.0; P: 0.375 and K: 6.75 kg/plant).

8. T8: T7: 25% mineral NPK (0.67; 0.175 and 0.50 kg/plant) + 75% of NME (N: 3.0; P: 0.375 and K: 6.75 kg/plant).

9. T9: 100% of NME (N: 4.0; P: 0.5 and K: 9.0 kg/plant).

10. T10: 100% of NME (N: 4.0; P: 0.5 and K: 9.0 kg/plant) + improvement solution at a rate of 3 cm/l.

Experimental layout

The complete randomized block design with three replications was used for arranging the differential investigated treatments. Every replicate was represented by four stools with 3 similar plants (ratoons) left per each for cropping in the current season and following one. The selected stools (mats) required for each experiment were equally classified according to their vigor into 3 categories, whereas plants of each class were similarly subjected to its own investigated treatments.

1. Yield parameters

Bunch length; bunch circumference (cm); bunch weight (kg); number of hands per bunch; number of fingers per bunch and bunch length (cm.) were determined as yield parameters. As well as, yield was

Table 3: Effect of different sources of N, P, K and improvement solution on bunch length and bunch circumference of Williams banana plants.

Treatments \ Parameters	Bunch length (cm)		Bunch circumference (cm)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100%) Minerals	108.5F	112.0CD	118.0B	98.00E
T 2-100% Minerals (NPK) + Improvement solution (3 cm/l)	123.3D	113.0C	116.0C	101.0D
T3-75% Minerals (NPK)+ 25% Natural mixture elements	131.0C	115.0B	114.0D	106.0B
T4-75% Minerals (NPK)+25% Natural mixture elements + Improvement solution (3 cm/l)	138.3A	123.0A	118.3B	109.7A
T5-50% Minerals (NPK)+50% Natural mixture elements	114.0E	111.0DE	123.0A	104.0C
T6-50% Minerals (NPK)+50% Natural mixture elements + Improvement solution (3 cm/l)	136.0B	115.0B	123.3A	110.0A
T7-25% Minerals (NPK)+75% Natural mixture elements	105.0G	108.0F	92.50G	88.00H
T8-25% Minerals (NPK)+75% Natural mixture elements + Improvement solution (3 cm/l)	106.0G	110.3E	97.00E	92.00F
T9-100% Natural mixture elements	95.67H	103.0H	92.00G	80.00I
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	97.00H	105.0G	95.00F	89.00G

Means of each column followed by the same letter/s during every season are not significantly differ at 5% level

calculated according to the following equations both seasons:

Yield (ton/fed.) = bunch weight (kg) × number of plant (1050 plants)/ fed. /1000

2. Fruit quality

Samples each of two hands from the middle portion of every bunch were ripened by wrapping with the newspaper in closed polyethylene bags and kept at room temperature until reaching the ripe stage of yellow flecked with brown. After ripening, the following fruit physical and chemical characteristics were determined:

2.1. Fruit physical characteristics:

2.1.1. Number of hands/bunch: number of fingers/ hand and number of fingers/bunch were counted and recorded.

2.1.2. Finger length in (cm): By measuring the length of the finger with the pedicel.

2.1.3. Finger diameter in (cm): By measuring the middle part of the finger using a vernier-caliper.

2.1.4. Finger weight: It was done by weighing all fingers of each hand then the average weight of each finger/fruit in (gm) was calculated.

2.1.5. Finger pulp, peel weight (gm) and pulp/peel ratio: Fresh pulp and peel weight in (gm) as well as pulp/ peel ratio of the finger were determined.

2.1.6. Pulp and peel percentages: pulp and peel percentages of the finger were calculated.

2.2. Fruit chemical properties:

2.2.1. Total sugars and starch: Percentage of both total sugars and starch in the fresh pulp of ripened fruits were determined calorimetrically according to Smith *et al.*, (1956).

2.2.2. Total soluble solids (TSS): A CarlZeiss hand refractometer was used to determine the total soluble solids percentage in the pulp.

2.2.3. Total Titratable acidity: Total Titratable acidity was determined and calculated as grams of malic acid in 100 grams of fresh pulp by titration with a 0.1 N NaOH solution using phenolphthalein indicator according to the method described by A.O.A.C., (2000).

2.2.4. Total soluble solids content/acid ratio: TSS/acid ratio was estimated from results recorded of fruit juice TSS and total acidity by dividing TSS% over total acidity.

2.2.5. Total sugars and reducing sugars: Percentage of both total sugars and reducing sugars in fresh pulp of ripened fruits were determined coloremetrically according to Smith *et al.*, (1956).

2.2.6. Total carbohydrates and starch: Total carbohydrates and starch% of both in fresh pulp of fruits were determined coloremetrically according to Smith *et al.*, (1956).

3. Statistical Analysis

All data obtained during both seasons of the study were subjected to analysis of variances according to Snedecor and Cochram, (1980) and significant differences among means were determined according to Duncan's multiple test range (Duncan, 1955).

Results and Discussion

1. Bunch length and bunch circumference (cm)

It is obvious from Table (3) that the highest bunch length (cm) was obtained from T4 (75 % minerals + 25 % natural mixture elements + improvement solution) (138.3 and 123.0 cm) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) (136.0 and 115.0 cm) and T3

Table 4: Effect of different sources of N, P, K and improvement solution on bunch weight and estimated yield of Williams banana plants.

Treatments \ Parameters	Bunch weight (kg)		Estimated yield (ton/fed.)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100%) Minerals	24.80E	23.20B	22.32E	20.88B
T 2-100% Minerals (NPK) + Improvement solution (3 cm/l)	25.90D	20.40E	23.31D	18.36E
T3-75% Minerals (NPK)+ 25% Natural mixture elements	23.50F	21.70C	21.15F	19.53C
T4-75% Minerals (NPK)+25% Natural mixture elements + Improvement solution (3 cm/l)	39.60A	28.60A	35.64A	25.74A
T5-50% Minerals (NPK)+50% Natural mixture elements	32.30C	21.10D	29.07C	18.99CD
T6-50% Minerals (NPK)+50% Natural mixture elements + Improvement solution (3 cm/l)	34.00B	23.30B	30.60B	20.97B
T7-25% Minerals (NPK)+75% Natural mixture elements	21.30H	20.40E	19.17H	18.36E
T8-25% Minerals (NPK)+75% Natural mixture elements + Improvement solution (3 cm/l)	22.70G	20.50E	20.43G	18.45DE
T9-100% Natural mixture elements	15.50J	15.80G	13.95J	14.22G
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	17.20I	17.40F	15.48I	15.66F

Means of each column followed by the same letter/s during every season are not significantly differ at 5% level

(75 % Minerals + 25 % natural mixture elements) (131 and 115 cm) during 1st and 2nd season, respectively. On the other side, the lowest bunch length was obtained from T9 (100% natural mixture elements) (95.67 and 103.00 cm) followed by T10 (100% natural mixture elements + improvement solution) (97.00 and 105.00 cm), T7 (25 % minerals + 75 % natural mixture elements) (105 and 108.0 cm) during the first and second season, respectively.

It is obvious from data recorded in table 3 that the values of bunch circumference (cm) were increased over those of T6 (50% minerals (NPK) + 50 % + improvement solution (3 cm/l) by some fertilization combined treatments used in the present study, while other combinations gave values slightly higher or lower than between T5 in the first season and T4 in the second one those of with non-significant differences between them in the two growing seasons. In general, the superiority in the two seasons were for T6 (50 % minerals + 50 % natural mixture elements + improvement solution) in the first season and T5 (50 % minerals + 50 % natural mixture elements) and T6 and T4 in the second season which gave the highest values relative to other treatments in most cases of the two seasons of study.

Bunch weight and estimated yield (ton/fed.)

It is clear from table 4 in both seasons of study that, the highest significant values of bunch weight (kg) and production of yield (ton/fed) were obtained from T4 (75 % minerals + 25 % natural mixture elements + improvement solution) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) On the contrary, the lowest values for bunch weight and yield was obtained from T9 (100% natural mixture elements) followed by T10 (100% natural mixture elements + improvement solution) and T7 (25 % minerals + 75 % natural mixture elements) during both experimental seasons.

2. No. of hands/bunch, No. of fingers/hand and No. of fingers/bunch

Concerning the number of hands/bunch; number of fingers/hand and number of fingers/bunch data in table 5 displayed clearly that, the greatest statistically values of these parameters were recorded with T4 (75 % minerals + 25 % natural mixture elements + improvement solution) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) treatments as compared with either the T9 (100% natural mixture elements) or other investigated treatments. On the other hand, the opposite trend was detected with T9 (100% natural mixture elements) and T10 (100% natural mixture elements + improvement solution) which reflected significantly the lowest values during both experimental seasons. However, the other treatments gave intermediate values in both seasons of study.

Fruit quality:

2.1. Fruit physical characteristics:

2.1.1. Finger length(cm); diameter (cm) and weight (g):

Data in table 6 shows that the highest significant values for finger length, finger diameter and finger weight were detected with T4 (75 % minerals + 25 % natural mixture elements + improvement solution) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) and T1 (control (100 %) minerals), during both experimental seasons. On the other hand, the lowest values were obtained when the plants were treated with T9 (100% natural mixture elements) and T10 (100% Natural mixture elements + improvement solution) treatments compared with the control treatment. The differences

Table 5: Effect of different sources of N, P, K and improvement solution on No. of hands/bunch; No. of fingers/hand and No. of fingers/bunch of Williams banana plants.

Treatments \ Parameters	No. of hands/ bunch		No. of fingers/ hand		No. of fingers/ bunch	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	11.67C	11.67CD	15.00C	15.00C	175.00D	174.0C
T 2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	11.33C	11.67CD	11.00F	14.00D	125.0G	163.0D
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	12.33C	12.00BC	13.00E	14.50CD	160.0E	174.0C
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	15.00A	14.67A	18.00A	17.33A	269.0A	254.0A
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	12.00C	11.67CD	15.00C	15.00C	180.7C	174.0C
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	13.33B	13.00B	17.00B	16.33B	227.0A	212.0B
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	10.33D	10.67DE	14.00D	14.00D	145.0F	149.0E
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	9.67D	10.00E	15.00C	14.33D	145.0F	144.0F
T9- 100% Natural mixture elements	9.33D	9.67E	11.00F	11.33F	103.0H	110.0H
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	9.67D	10.00E	13.00E	12.00E	125.0G	120.0G

Means of each column followed by the same letter/s during every season are not significantly differ at 5% level

between all used treatments were significant as each treatment compared with T9 (100 % natural mixture elements). In addition, the other treatments gave intermediate values during both seasons of study.

2.1.2. Pulp weight; peel weight and pulp/peel ratio:

Concerning pulp weight, results in table 7 showed that T4 (75 % minerals + 25 % natural mixture elements + improvement solution) and T6 (50 %minerals + 50 % natural mixture elements + improvement solution). As exhibited statistically the highest values of pulp weight as compared to other investigated treatments during both seasons of study.

the On the other side, the lowest values of pulp weight in the two seasons of study recorded by T9 (100% natural mixture elements) and T10 (100 % natural mixture elements + improvement solution).

Data in table 7 mentioned that, the highest values of peel weight were obtained from T4 (75 % minerals + 25 % natural mixture elements + improvement solution) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) and T5 (50 % minerals + 50 % natural mixture elements) during both experimental seasons. On the contrary, the lowest values of peel weight were

Table 6: Effect of different sources of N, P, K and improvement solution on finger length, diameter and finger weight of Williams banana plants.

Treatments \ Parameters	Finger weight (g)		Finger length (cm)		Finger diameter (cm)	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	109.3C	110.8C	23.50C	22.00C	3.37B	3.15C
T 2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	105.3E	107.3D	25.00B	23.67B	3.21C-E	3.20BC
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	107.3D	105.3E	25.50B	24.67B	3.33BC	3.23B
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	119.2A	116.0A	27.00A	25.67A	3.73A	3.65A
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	106.7D	105.0E	23.00C	22.33C	3.40B	3.14CD
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	116.0B	112.2B	25.00B	24.00B	3.39B	3.21BC
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	99.70G	100.8F	20.00D	20.33D	3.17DE	2.90E
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	101.3F	96.80G	23.00C	21.67C	3.30B-D	3.07D
T9- 100% Natural mixture elements	84.30I	87.00I	18.00E	18.00E	3.01F	2.85E
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	86.00H	89.20H	20.00D	19.67D	3.10EF	2.88E

Means of each column followed by the same letter/s during every season are not significantly differ at 5% level

Table 7: Effect of different sources of N, P, K and improvement solution on some fruit quality of Williams banana plants.

Treatments \ Parameters	Pulp weight (gm)		Peel weight (gm)		Peel/Pulp ration	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	72.90D	73.20B	36.43CD	37.60BC	2.00D	1.95C
T 2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	75.55C	70.00C	29.75E	37.30C	2.54A	1.88C
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	70.47E	67.40D	36.86C	37.93BC	1.91E	1.78D
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	79.92A	76.37A	39.28A	39.63A	2.03CD	1.93C
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	70.23E	67.00D	36.47CD	38.00B	1.93E	1.76DE
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	78.10B	76.00A	37.90B	36.20D	2.06C	2.10AB
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	62.80G	63.20F	36.90C	37.60D	1.70G	1.68E
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	65.25F	65.00E	36.05D	31.80F	1.81F	2.05B
T9- 100% Natural mixture elements	55.50I	54.47H	28.80F	32.53E	1.93E	1.67E
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	60.90H	61.00G	25.10G	28.20G	2.43B	2.16A

Means of each column followed by the same letter/s during every season are not significantly differ at 5% level

obtained from T10 (100% natural mixture elements + improvement solution). In addition to that, other treatments gave intermediate values during both two seasons of study.

It is clear from table 7 that in the first season, the highest value of pulp/peel ratio was obtained from T2 100 % minerals + improvement solution followed by T10 (100% natural mixture elements + improvement solution) and T6 (50 % minerals + 50 % natural mixture elements + improvement solution). Meanwhile, the lowest value of pulp/peel ratio from T7 (25 % minerals + 75 % natural mixture elements) followed by T9 (100% natural mixture elements). On the other hand, the highest value of pulp/peel ratio in the second season was obtained from T10 (100% natural mixture elements + improvement solution) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) and T8 (25 % minerals + 75 % natural mixture elements + improvement solution).

2.1.3. Pulp and peel percentages:

Data presented in table 8 obvious that, in the first season, the highest value of pulp and peel parentages was obtained from T2 (100% Minerals + improvement solution) and T7 (25% minerals + 75% natural mixture elements). On the contrary, the lowest value of pulp and peel percentages were obtained from T7 (25% minerals + 75% natural mixture elements) and T2 (100% minerals + Improvement solution). For the second season; the highest values of pulp and peel percentages from (T10 and T6) and (T9 and T7), respectively. On the opposite, the least values recorded in the second season from T9 and T10. The rest of the treatments were intermediate between the highest and lowest limited during both seasons of the experimental.

Table 8: Effect of different sources of N, P, K and improvement solution on some fruit quality of Williams banana plants.

Treatments \ Parameters	Pulp (%)		Peel (%)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100%) Minerals	66.68C	66.07C	33.32D	33.93D
T 2-100% Minerals (NPK) + Improvement solution (3 cm/l)	71.75A	65.24D	28.25G	34.76C
T3-75% Minerals (NPK)+ 25% Natural mixture elements	65.56D	63.99E	34.34C	36.01B
T4-75% Minerals (NPK)+25% Natural mixture elements + Improvement solution (3 cm/l)	67.05C	65.83CD	32.95DE	34.17D
T5-50% Minerals (NPK)+50% Natural mixture elements	65.82D	63.80E	34.18C	36.20B
T6-50% Minerals (NPK)+50% Natural mixture elements + Improvement solution (3 cm/l)	67.33C	67.73AB	32.67E	32.27F
T7-25% Minerals (NPK)+75% Natural mixture elements	62.99F	62.70F	37.01A	37.30A
T8-25% Minerals (NPK)+75% Natural mixture elements + Improvement solution (3 cm/l)	64.42E	67.14B	35.58B	32.86E
T9-100% Natural mixture elements	65.83D	62.61F	34.17C	37.39A
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	70.72B	68.38A	29.18F	31.62G

Means of each column followed by the same letter/s during every season are not significantly differ at 5% level

Table 9: Effect of different sources of N, P, K and improvement solution on some fruit quality of Williams banana plants.

Treatments / Parameters	TSS (%)		Total acidity (%)		TSS/Acid ratio	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	17.20D	18.00C	0.345E	0.357D	49.86C	50.39D
T 2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	16.50D	17.00D	0.335E	0.360D	49.27C	47.27E
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	19.00BC	19.50B	0.350E	0.350D	54.29B	55.75B
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	22.00A	21.00A	0.300F	0.315E	73.33A	66.83A
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	18.60C	18.00C	0.380D	0.405C	48.97C	44.44F
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	19.70B	19.33B	0.400C	0.362D	49.27C	53.45C
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	15.00E	15.33E	0.425B	0.429B	35.31DE	35.75H
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	16.50D	17.80C	0.442AB	0.451A	37.35D	39.47G
T9- 100% Natural mixture elements	15.00E	13.67F	0.458A	0.459A	32.73F	29.79J
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	15.67E	15.00E	0.450A	0.458A	34.83E	32.72I
Means of each column followed by the same letter/s during every season are not significantly differ at 5% level						

2.2. Fruit chemical characteristics:

2.2.1. TSS and total acidity (%) and TSS/acid ratio:

It is obvious from table 9 that the highest values of TSS (%) and TSS/acid ratio were obtained from T4 (75 % minerals + 25 % natural mixture elements + improvement solution) and followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) and T3 (75 % minerals + 25 % natural mixture elements) during both experimental seasons. Concerning total acidity, the highest values were obtained by T9; T10 and T8 with non-significant differences between them. On the other hand, the lowest values of TSS % and TSS/acid ratio were obtained from T9 (100% Natural mixture elements) followed T10 (100% natural mixture elements + improvement solution) during two experimental seasons. However, the lowest values for total acidity were obtained from T4 and T3 during both seasons of study.

4.1.2. Total sugars and reducing sugars percentages:

It is clear from table 10 that the highest values of total sugars (%) and reducing sugars (%) were obtained from T4 (75 % minerals + 25 % natural mixture elements + improvement solution) and followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) and T2 (100 % minerals + improvement solution) as well as T1 (control) during both experimental seasons. On the contrary, the lowest values of total sugars and reducing sugars (%) were obtained from T9 (100% natural mixture elements) followed by T10 (100% natural mixture elements) during both experimental seasons of study.

Total carbohydrates and starch (%):

It is quite evident data presented in table 11 that, total carbohydrates was increased significantly by all studied treatments, where the highest significant values of total carbohydrates and starch were obtained from T4 (75 % minerals +

Table 10: Effect of different sources of N, P, K and improvement solution on some fruit quality of Williams banana plants.

Treatments / Parameters	Total sugars (%)		Reducing sugars (%)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100%) Minerals	13.70C	13.80D	6.65C	6.35C
T 2-100% Minerals (NPK) + Improvement solution (3 cm/l)	14.25B	14.40C	6.20D	6.40C
T3-75% Minerals (NPK)+ 25% Natural mixture elements	12.90D	12.83E	6.01D	6.13C
T4-75% Minerals (NPK)+25% Natural mixture elements + Improvement solution (3 cm/l)	17.53A	17.60A	7.89A	7.95A
T5-50% Minerals (NPK)+50% Natural mixture elements	12.50E	12.81E	6.22D	6.24C
T6-50% Minerals (NPK)+50% Natural mixture elements + Improvement solution (3 cm/l)	14.22B	14.68B	6.90B	7.03B
T7-25% Minerals (NPK)+75% Natural mixture elements	11.30G	11.77G	4.60F	3.62F
T8-25% Minerals (NPK)+75% Natural mixture elements + Improvement solution (3 cm/l)	11.90F	11.98F	5.04E	5.24D
T9-100% Natural mixture elements	10.60H	10.85I	3.79G	3.90E
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	10.80H	11.05H	3.85G	4.08E
Means of each column followed by the same letter/s during every season are not significantly differ at 5% level				

Table 11: Effect of different sources of N, P, K and improvement solution on some fruit quality of Williams banana plants.

Treatments \ Parameters	Total carbohydrates (%)		Starch (%)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100%) Minerals	9.78F	8.93F	1.94DE	1.88E
T 2-100% Minerals (NPK) + Improvement solution (3 cm/l)	11.30C	10.33C	2.06C	2.03C
T3-75% Minerals (NPK)+ 25% Natural mixture elements	9.87E	9.73E	1.99D	1.95D
T4-75% Minerals (NPK)+25% Natural mixture elements + Improvement solution (3 cm/l)	18.23A	16.80A	2.25A	2.31A
T5-50% Minerals (NPK)+50% Natural mixture elements	10.67D	10.07D	2.00D	2.02C
T6-50% Minerals (NPK)+50% Natural mixture elements + Improvement solution (3 cm/l)	16.65B	15.60B	2.15B	2.17B
T7-25% Minerals (NPK)+75% Natural mixture elements	8.08H	8.18G	1.84F	1.81G
T8-25% Minerals (NPK)+75% Natural mixture elements + Improvement solution (3 cm/l)	9.11G	9.05F	1.91E	1.84F
T9-100% Natural mixture elements	6.60J	6.15I	1.68G	1.59I
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	7.70I	7.25H	1.81F	1.78H

Means of each column followed by the same letter/s during every season are not significantly differ at 5% level

+ improvement solution) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) and T2 (100 % minerals + improvement solution) during both seasons of study. On the contrary, the lowest significant values of total carbohydrates and starch % were obtained from T9 (100% natural mixture elements); followed by T10 (100% natural mixture elements + improvement solution) and T7 (25 % minerals + 75 % natural mixture elements) during two experimental seasons.

Discussion

These obtained results regarding the increment in productivity and different fruit quality parameters exhibited by differential treatments goes in the line with those found by Abou El-Khashab, (2003) on olive, Abd-Rabou, (2006) on avocado and mango, Baiea *et al.*, (2015) on mango, Abd El-Migeed *et al.*, (2007) on Washington Navel orange, Abd El-Moneim, Eman *et al.*, (2008) on Washington Navel orange trees, Aseri *et al.*, (2008) on pomegranate, Dheware and Waghmare, (2009) on sweet orange, Abdelaal *et al.*, (2010) on orange, Rivera-Cruz *et al.*, (2010) on sour orange, Barakat *et al.*, (2011) on Williams banana, Abdel-Salam and Shams, (2012) on Potato, Barakat *et al.*, (2012) on orange, Petry *et al.*, (2012) on Valencia orange, Vazquez-Ovando and Andrino-Lopez, (2012) on banana. Abdallah Dina, (2013) on peach, Slim, (2014) on Valencia orange. Mansour and Shaaban, (2007) on Washington Navel Orange trees, Khafagy *et al.*, (2010) on Navel orange, Baiea *et al.*, (2015) on banana cv. Grande Naine, El-Badawy *et al.*, (2017) on Washington Navel Orange trees and EL-Gioushy *et al.*, (2018) on Fagri Kalan Mango trees. Gill *et al.*, (2005) on Kinnow mandarin, El-Gioushy and Baiea, (2015) on Canino apricot, Abd-El-Latif *et al.*, (2017) on "Le-Conte" pear trees and Salama *et al.*, (2017) on Washington Navel orange trees.

Baiea *et al.*, (2015) on banana cv. Grande Naine obviously that the highest bunch weight, yield, bunch height and the bunch circumference were recorded by using (8 Kg Feldspar + 10 ml potassin two dose) also showed to be the most effective treatment for producing the highest number of hands/bunch. Furthermore, the heaviest hand, the highest number of fingers/hand and the heaviest finger were registered by the same treatment. El-Gioushy and Eissa, (2019) on Washington Navel orange trees excess mineral nitrogen fertilization application enhances vegetative tree growth and productivity as well as fruit quality. Moreover, Alva *et al.*, (2006) reported that Potassium is necessary for essential physiological functions such as the formation of sugars and starch, synthesis of proteins and growth, Obreza, (2003) and Abbas and Fares, (2008) found that it is crucial in fruit formation and enhances fruit size, flavor and color by using potassium. Obreza, (2001) showed that phosphorus is a prerequisite for many processes such as photosynthesis, synthesis and breakdown of carbohydrates and the transfer of energy within the plant.

Conclusion

In conclusion, it can be proposed that there be a possibility of reducing the high cost of chemical fertilizers (NPK) that directly affect human health by cheaper alternatives and environmentally friendly, such as natural mixture elements (NME). Generally, 75 % mineral NPK + 25 % of NME + improvement solution at a rate of 3 cm/L or 50 % mineral NPK + 50 % of NME + improvement solution at a rate of 3 cm/L offering the best productivity and fruit quality performance of Williams banana plants.

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