Plant Archives Volume 20 No. 2, 2020 pp. 8465-8474 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

IMPACT OF VARIOUS SOURCES OF NITROGEN, PHOSPHORUS, POTASSIUM AND IMPROVEMENT SOLUTION ON VEGETATIVE GROWTH, PHONOLOGICAL PARAMETERS AND NUTRITIONAL STATUS OF WILLIAMS BANANA PLANTS

Abd El-Latif, F.M.[1], Atawia A.A.R.[1], El-Kholy M.F.[2], Emam H.E.A.[1] and EL-Gioushy, S.F.[1*]

[1]Horticulture Department, Faculty of Agriculture (Moshtohor), Benha University, Moshtohor, Toukh, 13736, Egypt.

[2]Tropical Fruit Dept., Horticulture Research Institute, ARC, Giza, Egypt.

* Corresponding Author: S.F. El-Gioushy, Horticulture Department, Faculty of Agriculture (Moshtohor), Benha University, Moshtohor, Toukh, 13736, Egypt. (sherif.elgioushy@fagr.bu.edu.eg), (ORCID, 0000-0003-0796-7006).

Abstract

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. To compare the effect of different sources of nitrogen, phosphorus, potassium and improvement solution on vegetative growth, flowering, and nutritional status of "Williams" cv. banana plants. Anyhow, The experiment consisted of ten treatments as follows: T1-control (100 % of chemical), 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, 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 (growth, and nutritional status) and the investigated treatments. Herein, T4: 75 % mineral NPK (2.01, 0.525 and 1.50 kg per plant, respectively) + 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, vegetative growth and nutritional status.

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 favourite 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).

***Author for correspondence :** E-mail: sherif.elgioushy@fagr.bu.edu.eg

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).

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

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	31.56	113	146	47	3.71	7.8	3.6
Avail.	63	13.7	61.2	21.1	5.7	16.6	2.6			

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).

Thus, the main objective of this investigation was directed towards increasing Williams banana plants vegetative growth, flowering and nutritional status associated with lower its production cost through investigating the different sources of nitrogen, phosphorus, potassium and improvement solution.

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 methods described by Piper, (1950) and Jackson, (1967) as shown in Table 1.

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, and 2.0 kg/plant), respectively. The second rate was 75% of chemical NPK (2.01, 0.525 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, 0.250 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-

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.				

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 consecutive sprinkles every 15 days.

The experiment consisted of ten treatments as follows:

1. T1: Control (100% of mineral NPK) 2 5

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

3. T3: 75% mineral NPK + 25% of NME .

4. T4: 75% mineral NPK + 25% of NME+ improvement solution at a rate of 3 cm/l.

5. T5: 50% mineral NPK + 50% of NME.

6. T6: 50% mineral NPK + 50% of NME + improvement solution at a rate of 3 cm/l.

7. T7: 25% mineral NPK + 75% of NME.

8. T8: T7: 25% mineral NPK + 75% of NME+ improvement solution at a rate of 3 cm/l.

9. T9: 100% of NME.

10. T10: 100% of NME + 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. Vegetative growth measurements:

After the emergence of inflorescence the following vegetative growth parameters were measured:

1.1. Pseudostem height (cm) was measured from the soil surface up to the petiole of the last emerged leaf.

1.2. Pseudostem circumference (cm) was measured at 20 cm height above the soil surface.

1.3. The numbers of green leaves were recorded at bunch shooting stage.

1.4. Leaf area for the third full-sized leaf (from the top) was calculated in square meters according to Murry, (1960) using the following

1.5. Equation: Area = Length × Width ×0.8.

1.6. Assimilation area was determined using the equation = leaf area × number of green leaves (Ibrahim, 1993).

1.7. Leaf length (cm) was measured for mature leaf from the pseudostem up the end of leaf tip.

1.8. Leaf width (cm) was measured at mature leaf at the middle of blade leaf.

2. Some phenological measurements:

2.1. Time to flowering: Duration extended from sucker emergence till shooting of inflorescences in days was estimated.

2.2. Time from bunch shooting to harvesting: Duration needed from bunch shooting till harvesting (maturation) in days was also calculated.

2.3. Life cycle: Duration extended from sucker emergence till harvesting (maturation) in days was also calculated.

3. Nutritional status (leaf mineral composition):

The third leaf (in the descending order from the top) just at bunch shooting was used for leaf mineral analysis. Whereas 10× 10 cm from the middle part of the blade from the third leaf of each plant were collected as recommended by Hewitt, (1955) and adopted by Abou-Aziz *et al.*, (1987), then cleaned and oven-dried at 72ºC till constant weight.

Table 3: Effect of different sources of N, P, K and improvement solution on some vegetative growth parameters of Williams Banana plants during 2017/2018 and 2018/2019 experimental seasons.

Treatments \ Parameters	Pseudostem height (cm)		Pseudostem circumference (cm)		No. of green leaves /plant	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	321.0B	250.0B	81.50B	80.00B	11.00B	11.00B
T 2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	319.0B	249.0B	79.00C	79.58C	10.33C	10.33CD
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	295.0E	243.3C	79.17C	73.67E	11.00B	10.00DE
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	335.0A	275.0A	88.20A	84.00A	13.00A	12.00A
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	297.2DE	243.3C	76.83D	77.50D	10.33C	10.00DE
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	320.0CD	250.0B	80.17BC	80.50B	10.00C	10.67BC
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	300.00CD	237.0E	73.40E	72.00F	9.33D	10.00DE
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	297.3DE	240.0D	78.60C	79.50C	9.67CD	10.05DE
T9- 100% Natural mixture elements	303.3C	232.7F	71.50F	72.00F	9.00D	9.50EF
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	266.0F	238.3DE	73.00EF	72.33F	9.03D	9.33F

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

Thereafter the collected samples from four plants of the same replicate were mixed as a composite sample and finally ground (using an electric mill with a stainless-steel knife). 0.2 g of the ground material was digested using a mixture of 1:5 perchloric: sulphuric acids (v/v) after Jackson, (1967) for determination of the following nutrient elements:

3.1. Total nitrogen was determined by the Micro-Kjeldahl method Pregl, (1945).

3.2. Phosphorus was estimated by the method of Chapman and Pratt, (1961).

3.3. Potassium (K), Calcium (Ca), Zinc (Zn), Magnesium (Mg), Iron (Fe) and Manganese (Mn) were determined by using the Atomic absorption Spectrometer (Per Kin-Elmer, Model 3300).

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

Vegetative growth measurements

Vegetative growth measurements of banana plant "Williams" cv. included; pseudostem height (cm); pseudostem circumference (cm); the number of green leaves/plant; leaf length (cm), leaf width (cm); leaf area, and total leaves assimilation area (m2/plant) have been investigated taking during both experimental seasons 2017/2018 and 2018/2019.

Pseudostem height (cm), pseudostem circumference (cm) and the number of green leaves/plant:

It is clear from data averaged in Table (3) that means of pseudostem height (cm), pseudostem circumference (cm) and the number of green leaves/plant were mostly improved in response to the different fertilization treatments employed in this study with various significant differences compared to T9 (100% natural mixture elements) and T10 (100% natural mixture elements + improvement solution) during both seasons of study. However, the superiority was for T4 (75 % Minerals + 25 % natural mixture elements + improvement solution), which gave the highest values in most cases during the two seasons and followed by T1 (control (100 %) minerals) and T6 (50 % minerals + 50 % natural mixture elements + improvement solution) that recorded means closely near to those of superior treatment with significant differences among them during both seasons of study.

Leaf length and width (cm)

It is obvious from data recorded in Table (4) that the means of leaf length and width (cm) were increased over all the treatments by some fertilization treatments used in the present experimental seasons, while other treatment gave means slightly higher or lower than those of control with significant differences between them in the 2017/2018 and 2018/2019 experimental seasons. In general, the superiority in both seasons was for (T4) 75 % minerals + 25 % natural mixture elements + improvement solution mixture which gave the highest values relative to other treatments in most cases during both seasons of study. A similar trend was also obtained concerning the leaf width (cm), as the previously

Table 4: Effect of different sources of N, P, K and improvement solution on some vegetative growth parameters of Williams Banana plants during 2017/18 and 2018/19experimental seasons.

Treatments \ Parameters	Leaf length (cm)		Leaf width (cm)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100%) Minerals	255.0D	265.0C	88.00C	85.00B
T 2-100% Minerals (NPK) + Improvement solution (3 cm/l)	271.7B	269.5B	84.50EF	82.67E
T3-75% Minerals (NPK)+ 25% Natural mixture elements	256.7D	262.0D	90.0B	83.67CD
T4-75% Minerals (NPK)+25% Natural mixture elements + Improvement solution (3 cm/l)	287.3A	282.0A	93.00A	89.67A
T5-50% Minerals (NPK)+50% Natural mixture elements	265.5C	261.1D	84.33F	83.33D
T6-50% Minerals (NPK)+50% Natural mixture elements + Improvement solution (3 cm/l)	252.0E	264.0C	87.00D	84.00C
T7-25% Minerals (NPK)+75% Natural mixture elements	235.7F	240.1F	85.00E	77.67H
T8-25% Minerals (NPK)+75% Natural mixture elements + Improvement solution (3 cm/l)	230.0G	243.2E	87.33D	80.00G
T9-100% Natural mixture elements	193.4I	203.5H	83.33G	78.00H
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	215.0H	221.4G	85.00E	80.67F

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

mentioned super treatment also scored the utmost high means all treatments and other used treatments in the two studied seasons (2017/2018 and 2018/2019) giving the highest significant values. On the contrary, the lowest recorded statistical values were with the T9 (100% natural mixture elements) and T10 (100% Natural mixture elements + improvement solution), respectively, during both seasons of the study. Such trends were true throughout two seasons of study. On the contrary, the lowest recorded statistical values were with the T9 (100% natural mixture elements) and T10 (100% Natural mixture elements + improvement solution), respectively, during the two seasons of the study. Such trends were true throughout two seasons of study.

Leaf area (m^2) and leaf assimilation area (m^2/plant)

Data in Table (5) for leaf area (m2) and total leaves assimilation area (m2/plant); showed that the superiority of T4 (75 % minerals + 25 % natural mixture elements + improvement solution), followed by both T3 (75 % minerals + 25 % natural mixture elements) and T1 (control (100 %) minerals) in the first season and the opposite trend in the second season T1; T2 and T3, with minor differences between these three treatments during 2017/2018 and 2018/2019 seasons of study. On the other hand, the least significant values were observed with T9, followed by T10, with slight differences between the two lowest treatments during the two seasons of the study. The rest of the treatments were mediate between the highest and lowest limited during both experimental seasons.

Phonological measurements

The period from sucker emergence to bunch shooting (time to flowering), also, the period from bunch shooting to harvesting date were affected by the rate of mineral NPK, natural mixture elements and improvement solution treatments. Data showed significant decreases in time to flowering and harvesting compared to the other treatments. It may be recorded due to the increase in absorption of natural mixture elements + improvement solution from the spray and/or soil and thus promote plant growth.

Results in table 6 showed that using of T4 (75% minerals + 25% natural mixture elements + improvement

Table 5: Effect of different sources of N, P, K and improvement solution on some vegetative growth parameters of Williams Banana plants during 2017/18 and 2018/19 experimental seasons.

Treatments \ Parameters	Leaf area (m^2)		Total leaf assimilation area (m^2/plant)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	1.80C	1.80B	21.27BC	21.32B
T 2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	1.84B	1.78C	20.40CD	19.79CD
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	1.85B	1.75D	21.86B	18.87D
T4- 75% Minerals (NPK)+25% Natural mixture elements+Improvement solution (3 cm/l)	2.14A	2.02A	29.90A	26.11A
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	1.79C	1.74D	19.89A	18.72D
T6- 50% Minerals (NPK)+50% Natural mixture elements+Improvement solution (3 cm/l)	1.75D	1.77C	18.88E	20.35BC
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	1.60E	1.49F	16.08F	16.06E
T8- 25% Minerals (NPK)+75% Natural mixture elements+Improvement solution (3 cm/l)	1.61E	1.56E	16.71F	16.81E
T9- 100% Natural mixture elements	1.29G	1.27H	12.51H	12.99G
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	1.46F	1.43G	14.20G	14.33F

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

Table 6: Effect of different sources of N, P, K and improvement solution on flowering of Williams Banana plants during 2017/18 and 2018/19 experimental seasons.

Treatments \ Parameters	Time to flowering (Days)		Time to harvesting (Days)		Duration cycle (Days)	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	404.0D	415.0C	134.0A	137.0A	538.0C	552.0B
T2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	411.0C	414.0D	113.0G	117.0G	524.0D	531.0D
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	372.0I	375.0H	114.0F	118.0F	486.0G	493.0H
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	345.0J	351.0I	105.0H	107.0J	450.0I	458.0J
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	393.0E	398.0E	110.0G	116.0H	503.0F	514.0F
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	373.0H	375.0H	109.0G	111.0I	482.0H	486.0I
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	380.0G	382.0G	121.0D	126.0D	501.0F	508.0G
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	392.0F	397.0F	119.0E	124.0E	511.0R	521.0E
T9- 100% Natural mixture elements	425.0A	427.0A	130.0B	134.0B	555.0A	561.0A
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	415.0B	418.0B	125.7C	128.0C	540.7B	546.0C

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

solution) followed by T3: (75 % minerals + 25 % natural mixture elements) and T6: (50 % minerals + 50 % natural mixture elements + improvement solution), gradually and significantly shorted the time to flowering. Other treatments were intermediate between T4 and T9 in both seasons of study.

Time to the harvesting of plants was decreased by increasing the rate of NPK fertilization from mineral to natural mixture elements in both seasons. In this respect manner, T4 (75% minerals + 25% natural mixture elements + improvement solution) followed by T6 (50% minerals + 50% natural mixture elements + improvement solution) gave shortest period to harvesting in both 2017/2018 and 2018/2019 seasons, respectively.

Duration cycle

Application of NPK as mineral and organic plus improvement solution reduced the total duration of the crop in two tested seasons table 6. Applied NPK exerted its effect on total crop duration mainly by influencing the days to shooting. There was a reduction of (105 and 103 days) from T4 followed by T6 (73 and 75 days) in the total crop duration.

Table 7: Effect of different sources of N, P, K and improvement solution on nutritional status of Williams Banana plants during 2017/18 and 2018/19 experimental seasons.

Treatments \ Parameters	N (%)		P (%)		K (%)	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	3.05C	2.88B	0.216C	0.205CD	3.24C	3.23B
T2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	2.90D	2.54D	0.195D	0.206CD	3.25C	3.14B
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	2.75E	2.60CD	0.201CD	0.227B	3.12CD	3.17B
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	3.45A	3.38A	0.256A	0.250A	3.78A	3.65A
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	3.09C	2.63C	0.203CD	0.217BC	3.08D	3.07B
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	3.21B	2.92B	0.234B	0.230B	3.41B	3.30B
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	2.37F	2.26EF	0.193D	0.194BC	3.04D	3.04B
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	2.41F	2.30E	0.194D	0.195DE	3.13CD	3.07B
T9- 100% Natural mixture elements	2.00H	2.05G	0.175E	0.183E	2.78E	2.75C
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	2.25G	2.20F	0.190DE	0.193DE	2.90E	2.92C

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

Table 8: Effect of different sources of N, P, K and improvement solution on nutritional status of Williams Banana plants during 2017/18 and 2018/19 experimental seasons.

Treatments \ Parameters	Ca (%)		Mg (%)	
	2017/18	2018/19	2017/18	2018/19
T1- Control (100%) Minerals	0.90B	0.91B	0.41C	0.42B
T 2-100% Minerals (NPK) + Improvement solution (3 cm/l)	0.75EF	0.80D	0.43B	0.40B
T3-75% Minerals (NPK)+ 25% Natural mixture elements	0.75EF	0.89BC	0.32EF	0.33C
T4-75% Minerals (NPK)+25% Natural mixture elements + Improvement solution (3 cm/l)	0.99A	1.14A	0.46A	0.48A
T5-50% Minerals (NPK)+50% Natural mixture elements	0.76E	0.79DE	0.42BC	0.43B
T6-50% Minerals (NPK)+50% Natural mixture elements + Improvement solution (3 cm/l)	0.82C	0.87C	0.39D	0.34C
T7-25% Minerals (NPK)+75% Natural mixture elements	0.74F	0.71G	0.33E	0.34C
T8-25% Minerals (NPK)+75% Natural mixture elements + Improvement solution (3 cm/l)	0.78D	0.75F	0.31FG	0.35C
T9-100% Natural mixture elements	0.70H	0.69G	0.30G	0.30D
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	0.72G	0.77EF	0.33E	0.34C
Means of each column followed by the same letter/s during every season are not significantly differ at 5% level				

Effect on leaf nutritional status

Leaf macro-nutrients N, P, and K

Data in table 7 mentioned that leaf N, P, and K contents were influenced by the tested minerals and natural mixture elements plus improvement solution treatments during 2017/2018 and 2018/2019 seasons. While, the utmost leaf N, P and K contents were recorded by T4 (75 % minerals + 25 % natural mixture elements + improvement solution). As well as, T6 and T1 treatments gave highly significant increments in this regard during two seasons of study. On the reverse, the lowest values of these parameters were scored by T9 (100% Natural mixture elements) and T10 (100% Natural mixture elements + improvement solution) during both seasons of study..

Ca and Mg contents as percentages

Data presented in table 8 revealed that leaf Ca and Mg percentages were responded for the tested mineral NPK and natural mixture elements plus improvement solution treatments during both seasons, The highest values of leaf Ca and Mg were recorded by T4 (75 % minerals + 25 % natural mixture elements + improvement solution) followed by T1 (control 100 % minerals) for Ca and T5 (50 minerals + 50 % natural mixture elements) for Mg during both seasons of study. On the contrary, the poorest values of these parameters were scored by T9 (100% natural mixture elements) and T10 (100% natural mixture elements + improvement solution) treatments during both seasons of study. The rest treatments came in between the aforementioned treatments during both seasons of study

Table 9: Effect of different sources of N, P, K and improvement solution on nutritional status of Williams Banana plants during 2017/18 and 2018/19 experimental seasons.

Treatments \ Parameters	Fe(ppm)		Zn(ppm)		Mn(ppm)	
	2017/18	2018/19	2017/18	2018/19	2017/18	2018/19
T1- Control (100 %) Minerals	187.0C	191.1B	43.47E	44.51E	65.70F	66.45F
T 2- 100 % Minerals (NPK) + Improvement solution (3 cm/l)	183.2D	185.9D	45.50D	46.29D	70.20C	70.35D
T3- 75 % Minerals (NPK) + 25 % Natural mixture elements	182.3D	181.8E	46.20C	42.00F	66.75E	66.45F
T4- 75 % Minerals (NPK) + 25 % Natural mixture elements + Improvement solution (3 cm/l)	195.9A	195.5A	51.09A	51.58A	74.93A	74.65A
T5- 50 % Minerals (NPK) + 50 % Natural mixture elements	182.8D	181.7E	46.73BC	47.24C	68.40D	69.33E
T6- 50 % Minerals (NPK) + 50 % Natural mixture elements + Improvement solution (3 cm/l)	191.9B	190.0C	47.20B	48.20B	72.30B	72.85B
T7- 25 % Minerals (NPK) + 75 % Natural mixture elements	180.4E	180.4F	38.60G	38.33G	58.07H	72.28C
T8- 25 % Minerals (NPK) + 75 % Natural mixture elements + Improvement solution (3 cm/l)	180.8E	181.2E	39.84F	38.10G	60.40G	60.10G
T9- 100% Natural mixture elements	170.0G	171.5H	35.27H	32.57I	48.75J	48.13I
T10- 100% Natural mixture elements + Improvement solution (3 cm/l)	174.3F	173.9G	35.00H	34.00H	50.00I	51.07H
Means of each column followed by the same letter/s during every season are not significantly differ at 5% level						

Leaf micro-nutrients Fe, Zn and Mn (ppm).

Considering the leaf (Fe, Zn and Mn) contents, data in table 9 displayed clearly that, is a positive relationship between all treatments and leaf micro-nutrients under study. Moreover, leaf Fe, Zn, and Mn contents were significantly responded to the effect of all tested treatments while leaf micro-nutrient contents were increased as compared to T9 (100% natural mixture elements). However, the highest leaf Fe, Zn and Mn, contents were statistically exhibited by trees treated with T4 (75 % minerals + 25 % natural mixture elements + improvement solution) followed by T6 (50 % minerals + 50 % natural mixture elements + improvement solution) during the two seasons of study. Whereas, the opposite trend was observed with the T9 and T10 which had significantly the poorest leaves in Fe, Zn, and Mn contents during both seasons of study. In addition, the other remains treatments were in between as compared to the abovementioned two extents. Such trend was true during both seasons of study.

Discussion

This improvement in vegetative growth of banana plants may by attributed to the synergistic effect of organic matter compost which can improve the soil physical and chemical properties, increase water holding capacity, nutrient availability, soil organic matter content, cation exchange capacity and fertility, as well as EC and pH of the soil (Willer and Kilcher, 2011), feldspar which improves soil aggregation, structure, permeability and infiltration corresponding with the reduction of pH, EC, SAR and Na/Ca ratio which leads finally to create better soil conditions Meena *et al*., (2013) and rock phosphate which slowly supplies plants which mono-and di-phosphate, the most absorbing forms by plants (Adak *et al*., 2014). In this concern, Manning, (2010) mentioned that feldspar as a source of K^+ reduced the osmotic pressure and increased water uptake which due to K^+ influx in soil solution, consequently increased the availability of some macro and micronutrients and this may indicate its role in promoting and enhancing the metabolic process and regulating water balance. Moreover, the positive effects of feldspar not only ascribed to the multi-benefits of K^+ ions but also to its containing 70.23% SiO_2, 16.25% Al_2O_3, 8.12% K_2O_3, 69% Na_2O and traces of other elements such as Fe, Mg, P, Mn, Ca and Ti (as indicated in table 2.

Furthermore, the obtained results regarding leaf chemical contents of banana plants were supported by the findings of many investigators Abd El-Naby and Gomaa, (2000) on banana, 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 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 oranges, Vazquez-Ovando and Andrino-Lopez, (2012) on banana. Abdallah Dina, (2013) on Peach, Slim, (2014) on Valencia orange.

Moreover, the present results regarding the great beneficence of NPK bio-fertilizers application on stimulating different growth parameters of Manfalouty pomegranate trees go in line with those found by several investigators *i.e.*, Fawzia-Eissa, (2003) on Canino apricot cv., Kabeel *et al*., (2005) on Canino apricot cv., Kabeel *et al*., (2007) on Anna apple trees, Stino *et al.*, (2009) on Canino apricot cv., Osman and Abd El-Rahman, (2010) on Fig trees and Darwish, (2012) on Costata persimmon All pointed out the suitability of some bio NPK fertilizers.

However, the advancement of natural rocky nutritive materials detected in this work goes partially with that found by Gawad *et al.*, (2012) on Crimson seedless grapevines, who indicated that suitability, importance and favoring of two natural rocks (phosphate and feldspar) applied solely or combined with bio NPK fertilizers above others. Moreover, preference of the investigated alternative NPK fertilizer mixture (granulated organic N and natural rocky PK materials) above the ordinary highly soluble mineral NPK sources could be logically explained depending upon the nature of either investigated NPK source or plant species under study. Herein, slow releasing nature of organo-rocky NPK fertilizer mixture keeps the released NPK nutrients elements from quick leaching from one hand and saves a real guaranty of gradual continuous supply for pomegranate tree (perennial plant) with the required nutrient elements along the growing season (nearly the year-round).

These results are confirmed by those obtained by Abd El-Naby and Gomaa, (2000) on banana, 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 Aseri *et al*., (2008) on Pomegranate, Dheware and Waghmare, (2009) on Sweet orange, Abdelaal *et al.*, (2010) on Orange, Rivera-Cruz *et al.*, (2010) in 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 oranges, Vazquez-Ovando and Andrino-Lopez, (2012) on Banana fruits (Grande Naine). Abdallah Dina, (2013) on Peach, Slim, (2014) on Valencia orange.

The present results are in general accordance with those previously found by Fawzia-Eissa, (2003) on Canino apricot, Kabeel *et al.,* (2005) on Canino apricot, Stino *et al.,* (2009) on Canino apricot, Osman and Abd El-Rahman, (2010) on Fig and Darwish, (2012) on Costata persimmon and Baiea *et al.,* (2015) on Banana. The shift (no coincidence) in the ranking of the investigated NPK fertilization treatments about the effective fertilization treatments was usually lower than the corresponding ones of the vegetative growth measurements. So, such a trend could be logically explained as an expected dilution effect resulted from the relative higher accumulation rate of assimilated dry matter corresponding to the lower rate of increase in most nutrient elements.

Conclusion

In conclusion, it can be recommended that, the possibility of reducing the high cost of chemical fertilizers (NPK) which directly impacts human health by cheaper alternative and environment 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 which provided the best results on vegetative growth, flowering, and nutritional status of Banana plants Williams cv.

References

Abdallah Dina, H.K. (2013). The use of phosphate solubilizing bacteria and antioxidants for improving fruit quality of Earligrande Peach. Ph. D. Thesis Faculty of Environmental Agricultural Sciences, El-Arish, Suez Canal University.

Abd El-Migeed, M.M., M.M.S. Saleh and E.A. Mostafa (2007). The beneficial effect of minimizing mineral nitrogen fertilization on Washington navel orange trees by using organic and biofertilizers. *World Journal of Agricultural Sciences,* **3(1):** 80-85.

Abd El-Moneim-Eman, A. A., A.S.E. Abd-Allah and S. Ebaiad-Sanaa (2008). Effect of some organic and biofertilizer treatments on minimizing mineral nitrogen fertilization of Washington navel orange trees. *Arab Univ. J. of Agric. Sci.,* **16(2):** 451-457.

Abd El-Naby, S.K.M. and A.M. Gomaa (2000). Growth, nutritional status, yield and fruit quality of Maghrabi banana as affected by some organic manures and biofertilizers. *Minufiya J. of Agric. Res.,* 25(4): 1113-1129.

Abdelaal, S.H., E. Mohamed and S.S. Kabeil (2010). Microbial bio-fertilization approaches to improve yield and quality of Washington navel orange and reducing the survival of nematode in the soil; *J. American Sci.,* **6(12):** 264-272.

Abdel-Salam, M.A. and A.S. Shams (2012). Feldspar-K fertilization of Potato (*Solanum tuberosum* L.) augmented by bio-fertilizer. *American-Eurasian J. Agric. & Environ. Sci.,* **12 (6):** 694-699.

Abd-Rabou, F.A. (2006). Effect of microbein, phosphorein and effective micro-organisms (EM) as biostimulants on growth of avocado and mango seedlings. *Egypt J, Appl. Sci.,* **21(6B):** 673 -693.

Abou El-Khashab, A.M. (2003). Growth and chemical constituents of some olives cultivars as affected by biofertilizers and different water regimes. *Egypt J. Agric. Res.,* **1(2):** 243-265.

Abou-Aziz, A.B., M.M. Nagib, M.R. El-Sonbaty and M.M. El-Tanahy (1987). Effect of potassium sulphate as soil application on yield and fruit qualities of pear trees; *Al-Azhar Jour. Agric. Res.,* **8:** 77-26.

Adak, T., K. Kumar, A. Singha, S.K. Shukla and V.K. Singh (2014). Assessing soil characteristics and guava orchard productivity as influenced by organic and inorganic substrates. *J. of Animal and Plant Sci.,* **24(4):** 1157-1165.

Aisha, H.A. and A.S. Taalab (2008). Effect of natural and/or chemical potassium fertilizers on growth, bulbs yield and some physical and chemical constituents of onion (*Allium cepa* L.). *Research Journal of Agriculture and Biological Sciences,* **4(3):** 228-237.

Aseri, G.K., N. Jain, J. Panwar, A.V. Rao and P.R. Meghwal (2008). Bio-fertilizers improve plant growth, fruit yield, nutrition, metabolism and rhizosphere enzyme activities of Pomegranate (*Punica granatum* L.) in Indian Thar Desert. *Scientia Horticulturae,* **117(2):** 130-135.

Badr, M.A. (2006). Efficiency of K- Feldspar combined with organic materials and silicate dissolving bacteria on Tomato Yield. *J. Applied Sci. Res.,* **2(12):** 1191- 1198.

Baiea, M.H.M., S.F. EL-Gioushy and T.F. El-Sharony (2015). Effect of feldspar and bio-fertilization on growth, productivity and fruit Quality of Banana cv. Grande Naine. *International J. of Environment,* **4(4):** 210-218.

Balabel, Naglaa, M.A. (1997). Silicate bacteria as bio-fertilizers. M.Sc. Thesis Fac. Agric. Ain Shams Univ., Egypt.

Barakat, M.R., S. El-Kosary and M.H. Abd-ElNafea (2011). Enhancing Williams banana cropping by using some organic fertilization treatments. *Journal of Horticultural Science & Ornamental Plants,* **3(1):** 29-37.

Barakat, M.R., T.A. Yehia and B.M. Sayed (2012). Response of newhall naval orange to bio-organic fertilization under newly reclaimed area conditions I: Vegetative growth and nutritional status. *Journal of Horticultural Science & Ornamental Plants,* **4(1):** 18-25.

Barker, W.W., S.A. Welch and J.F. Banfield (1997). Geomicrobiology of silicate minerals weathering. *Rev. Mineral,* **35:** 391-428.

Chapelle, F.H., J.L. Zelibor, D.J. Grimes and L.L. Knobel (1987). Bacteria in deep coastal plain sediments of Maryland: a possible source of CO_2 to groundwater. *Water Resources Research,* **23:** 1625-1632.

Chapman, H.D. and P.F. Pratt (1961). Methods of analysis for soils. Plant and Water. Div. of Agric. Sci. Univ. of California.

Darwish, D.R.A. (2012). Physiological studies on persimmon "diospyros kaki" trees. Ph.D. Thesis, Fac. Agric., Benha. Univ.

Dheware, R.M. and M.S. Waghmare (2009). Influence of organic-inorganic and biofertilizers and their interactions on number of fruits per tree and average weight of fruit of sweet orange (*Citrus sinensis Osbeck* L.). *International Journal of Agricultural Sciences*, **5(1):** 251-253.

Duncan, D.B. (1955). Multiple range and multiple F. *Tests. Biometrics*, **11:** 1-41.

El-Dsouky, M.M., K.K. Attia and A.M. El-Salhy (2002). Influence of elemental sulphur application and biological fertilization on nutrient status and fruiting of Balady Mandarin trees and King"s Ruby grapevines. *The 3 Scientific Conf. of Agric. Sci., Assiut*, **3:** 385-403.

Fawzia - Eissa, M. (2003). Use of some biostimulants inactivation of soil microflora for yield and fruit quality improvement of "Canino" apricot. *J. Agric. Res. Tanta Univ.*, **29(1):** 175-194.

Gawad, S.M.A., S.M. Abd El-Wahab, E.A. Hassan and A.M.R. Abd El-Aziz (2012). Effect of some soil conditioners and organic fertilizers on vegetative growth and quality of Crimson seedless grapevines. *J. of Horti. Sci. & Ornamental Plants*, **4(3):** 260-266

Harhash, M.M. and G. Abdel-Nasser (2000). Effect of organic manures in combination with elemental sulphur on soil physical and chemical characteristics, yield, fruit quality, leaf water contents and nutritional status of Flame seedless grapevines. II- Yield, fruit quality, leaf water contents and nutritional status. *J. Agric. Sci. Mansoura Univ.*, **25(5):** 2819.

Hewitt, C.W. (1955). Leaf analysis as a guide to the nutrition of banana. *Emp J. Exp. Agric.*, **23:** 11-16.

Ibrahim, E.G. (1993). Studies on irrigation of banana. Ph. D. Thesis, Fac. Agri. Zagazig Univ.

Ibrahim, E.G., (2003). Productivity, water use and yield efficiency of banana under different irrigation system and water quantity in sandy soil. *Egypt J. Appl. Sci.*, **18(10):** 334-348.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentice- Hall, Inc. *Englewood Cliff, N. J.*, 331.

Kabeel, H., G.S. Abd El-Latif and A.A. Khalil (2005). Effect of soil application of different mineral and bio-fertilizer treatments on growth, fruiting parameters, fruit properties and leaf nutrient contentof "Canino" apricot trees. *J. Agric. Sci. Mansoura Univ.*, **30(3):** 1583-1594.

Kabeel, H., F.I.I. Abou Grah, Sh.M. Hussein and W.M. Abd El-Messeh (2007). Influence of different levels of mineral fertilization and bio-fertilizers on vegetative growth, fruiting, fruit quality and nutritional status of "Anna" apple trees. *Res. J. So. En. Se.*, **1(11):** 54-79.

Manning, D.A. (2010). Mineral sources of potassium for plant nutrition. A review article. *Agronomy for sustainable develop.*, **30:** 208-294.

Meena, R.K., L.N. Mahwer, D.K. Sarolia, P.L. Saroj and R.A. Kaushik (2013). Improving yield and nutrient status of rejuvenated guava orchard byintegrated nutrient management under semi-arid conditions. *Vegetos*; **26(1):** 233-242.

Murry, D.B. (1960). Deficiency symptoms of the major elements in the banana. *Trop. Agric. Trim*. **36:** 100-107.

Osman, S.M. and *I.E.* Abd El-Rhman (2010). Effect of organic and Bio N-fertilization on growth, productivity of Fig tree (*Ficus Carica*, L.). *Research J. of Agric. and Biological Sci.*, **6(3):** 3195-328.

Palmer, J.K. (1979). Banana products. In tropical foods: Chemistry and Nutrition (G.B. Inglett and G. Charalambous, eds.) 625-635. Academic press, New York.

Paris, F., B. Botton and F. Lapeyrie (1996). *In vitro* weathering of phlogopite by ectomycorrhizal fungi. *Plant and soil*, **179:** 141-150.

Petry, H.B., O.C. Koller, R.J. Bender and S.F. Schwarz (2012). Fruit quality of 'Valencia' oranges harvested from organic and conventional production systems. [Portuguese], *Revista Brasileira de Fruticultura*, **34(1):** 167-174.

Piper, C.S. (1950). Soil and plant analysis. Inter. Sci. Publishers. NewYork. 213-217.

Pregl, E. (1945). Quantitaive Organic Micro Analysis. 4th Ed. Chundril, London.

Rivera-Cruz, M.C., A. Trujillo-Narcia and D.E. Alejo Pereyra, (2010). Biofertilizers integrated with N-fixing and P solubilizing bacteria and organic substrates in Sour orange. *Interciencia*, **35(2):** 113-119.

Saleh, M.M.S. (1996). Effect of fertilization with different forms of nitrogen fertilizers on growth, flowering, mineral content and yield of banana. Ph. D. Thesis. Fac. Agric., Ain Shams Univ., Cairo, Egypt.

Sheng, X.F. and W.Y. Huang (2002). Mechanism of potassium release from feldspar affected by the strain NBT of silicate bacterium. *Acta Pedologica Sinica*, **39(6):** 863-871 (in Chinese, with English abstract).

Simmonds, N.W. (1966). Bananas. Longman, Green and Co. Ltd. London. 2nd Edition.

Slim, M.A.F. (2014). Response of Valencia orange trees to antioxidants and biofertilization. Ph. D. Thesis Faculty of Agriculture, Suez Canal University.

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

Stino, R.G., A.T. Mohsen, M.A. Maksoud, M.M. El-Migeed, A.M. Gomaa and A.Y. Ibrahim (2009). Bio-organic fertilization and its impact on apricot young trees in newly reclaimed soil. *American-Eurasian J. of Agric. and Environmental Sci.*, **6(1):** 62-69.

Vazquez-Ovando, J.A. and D.K. Andrino-Lopez (2012). Sensory and physic-chemical quality of banana fruits (Grande Naine) grown with biofertilizer. *African J. of Agric., Res.* **7(33)**.

Willer, H. and L. Kilcher (eds.) (2011). The World of Organic Agriculture. Statistics and Emerging Trends. FiBL, Frick and IFOAM Bonn.