ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.9, No.04 pp 51-61, 2016

Effect of some Potassium Fertilizer Sources on Growth, Yield and Fruit Quality of Grand Nain Banana Plants

[1]*Merwad M.A., [2]R.A. Eisa and [3]A.M.M. Merwad

[1]Pomology Dept., National Research Centre, Cairo, Egypt
[2]Hort. Tech. Crop Dept., National Research Centre, Cairo, Egypt
[3]Soil. Dept., Fac. Agric., Zagazig Univ., Zagazig, Egypt

Abstract: This study was carried out on Grand Nain banana plants grown in sand clay loamy soil and irrigated with flood system during 2012/2013 and 2013/2014 seasons. This experiment aimed to study the effect of two potassium sources on growth, yield and fruit quality. The obtained results showed that, using feldspar as a source of potassium gave the highest values concerning leaf mineral content, vegetative growth, yield and fruit characteristics, as compared with potassium sulphate. Also, plants treated with 100 % feldspar took a shorter time to bunch shooting, bunch maturation and cropping cycle in the two seasons of the study.
Key words: potassium sulphate, feldspar, silicate dissolving bacteria (SDB), Grand Nain banana.

Introduction:

Banana (*Musa spp*) is one of the most important and popular fruit crops in Egypt for its high nutritive value. Banana plays an important role in the economy of tropical and subtropical countries.

In Egypt, large amounts of K- chemical fertilizers are used (such as potassium sulphate or chloride) to maximize crop yield per area unit and to compensate K-decreases in soils due to crop uptake, runoff, leaching and soil erosion[1]. The high prices of these fertilizers are responsible for increasing production cost. The use of natural potassium fertilizer and / or bio-fertilizer are considered as low cost resources for providing plants with K which could alternate the expensive applied of K-chemical fertilizers[2].

Bacillus circulanc bacteria can be able to solubilize rock – K mineral powder, such as mica, illite and orthoclases (feldspar) through production and excretion of organic acids or chelate silicon ions to bring K into solution[3].

Potassium plays a vital role in enhancing sugar translocation, which consequently resulting in increasing weight and pulp diameter. As well as, the increment in dry matter accumulation in the pulp may be attributed to more synthesis and translocation of photosynthetic products from the leaves to the pulp. Similarly, higher rate of photosynthesis due to higher dose of potassium enhanced the vegetative growth and accumulated more food, and increased total yield[4].

Potassium is necessary for many plant functions such as carbohydrate metabolism enzyme activation, osmotic regulation, N uptake, protein synthesis, photosynthesis and translocation of assimilates[5]. Potassium is usually applied in forms of chemical fertilizers mainly sulphate, chloride and nitrate[6]. In Egypt, K is added as sulphate. Recently, addition of these fertilizers has been criticized environment[7]. The alternative is to exploit other natural resources such K-bearing minerals which include K-feldspar, lecuite, K-mica (e.g. biotite, plogopite and glauconite) and clays minerals such as illite[8]. These materials weather slowly, thus replenish the native pool of available K, therefore acting as slow release K-fertilizers. Also, the effectiveness of K-bearing minerals as K-fertilizers in agriculture is low due to their slow availability[9]. Some microorganisms play important roles in the weathering processes of silicate minerals through solubilizing nutrients (including K) from these minerals[10]. Using feldspar at 1000g as K_2O/tree plus *Bacillus circulans* recorded the maximum values of yield kg/tree, fruit weight, leaf area, leaf fresh weight, leaf dry weight and leaf mineral contents of Valencia orange[11].

Microorganisms which are commonly known as potassium solubilizing bacteria (KSP) or potassium dissolving bacteria (KDP) or silicate dissolving bacteria (SDP) solubilize K-bearing minerals to free K for plants.

The aim of this study was to compare the effect of different potassium sources on growth, yield and fruit quality of Grand Nain banana plants.

Materials and Methods

This study was conducted during two successive seasons (2012/2013 and 2013/2014) on Grand Nain banana plants grown in sand clay loamy soil and irrigated with flood irrigation system in a private banana orchard located at Aga district, Dakahlia governorate. The plants were spaced at 3x3 m apart, similar in growth, free from any diseases and in good physical condition as possible. The physical and chemical properties of the experimental soil are shown in Table 1.

Table (1): Some physical and chemical properties of the investigated soil

Depth / Soil characteristics	0 -30 cm	30 – 60 cm	60 -90 cm
Soil particles distribution			
Sand %	35.45	36.60	35.70
Silt %	37.62	34.21	38.97
Clay %	26.93	29.19	25.33
Textural class	**Sandy Loam**	**Sandy Loam**	**Sandy Loam**
Field capacity (FC) %	11.32	10.95	11.75
$CaCO_3$ (g kg^{-1})	14.5	13.52	12.23
Organic matter (g kg^{-1})	5.4	4.95	4.99
pH*	8.13	7.98	7.97
EC (dSm^{-1}) **	0.67	0.65	0.65
Soluble cations and anions, (mmolc L^{-1}) **			
Ca^{++}	2.34	2.19	2.25
Mg^{++}	1.59	1.44	1.58
Na^{+}	1.62	1.74	1.68
K^{+}	1.13	1.12	1.15
$CO_3^{=}$	-	-	-
HCO_3^{-}	2.65	2.72	2.69
Cl^{-}	1.79	1.89	1.84
$SO_4^{=}$	2.24	1.88	2.07
Available nutrient, (mg kg^{-1}soil)			
N	103	102.5	98.57
P	6.65	6.42	6.25
K	84.62	80.57	80.09

* Soil paste ** Soil past extract

Twenty holes were chosen to evaluate the effect of different potassium sources (potassium sulphate (PS) and feldspar) on vegetative growth, leaf mineral content, yield and fruit quality of Grand Nain banana plants.

The experiment was set in a completely randomized block design with four replicates. Each replicate was presented as one hole, which contains two plants for yielding in the current season and two offshoots for yielding in the following season. The normal technocultural practices used in the commercial banana orchards were applied for all plants, except those dealing with potassium fertilization according to the recommendations of National Program Banana Development. The recommended dose of banana plant is 600g K_2O/ plant.

The chosen banana plants were subjected to five potassium fertilization treatments as follows : T_1: 100 % K_2O in the form of potassium sulphate (K_2SO_4) (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar plus silicate dissolving bacteria (SDB) , T_3: 75 % K_2O in the form of feldspar plus SDB+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar plus SDB+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar plus DSB + 75 % K_2O in the form of K_2SO_4.

K-feldspar is low grade rock potassium samples from a sedimentary rock materials deposit as raw mining after grinding to affine powder by Al-Ahram mining and natural fertilizer company in Egypt. Rock potassium as a filed spare and littlie powder contains 10.6 % K_2O.

Schedule 1. The chemical composition of feldspar.

Feldspar rock	Components (%)
SiO_2	67.94
Al_2O_2	13.92
Fe_2O_2	0.09
CaO	0.32
MgO	8.08
K_2O	10.6
Na_2O	1.94
TiO_2	0.01
MnO_2	0.01
P_2O_5	0.04
Cl	0.03

Feldspar was mixed with SDB *(Bacillus circulanc)* at 20 ml SDB per kg /feldspar (one ml of SDB contain 10^6 cells). The mixtures were regularly moistened and covered with plastic layer to keep the moisture content at about 60-70 % throughout the composting period for 90 days before application treatment according to **Bader (2006)**[7]. SDB was obtained by the unit of Bio-fertilizer, Fac. Agric., Ain Shams University.

The amounts of potassium in the form of PS or feldspar were added in three equal doses (April, June and August) in each season.

All plants under investigation received the traditional and regular fertilization program applied in that location such as 500 g nitrogen as ammonium sulphate (20.5 % N) per plant added monthly intervals from April to October 250 g superphosphate (16-18 % P_2O_5) and 40 kg of farmyard manure per plant were added yearly at December. Other culture practices (irrigation, weed control…. etc.) were done for all plants.

The following parameters were considered:

1. Vegetative growth :

After the emergence of inflorescences (about end of August in both seasons), vegetative growth parameters such as : Pseudostem length, girth of the pseudostem at 20 cm from the soil surface, leaf length, width and leaf area (m^2) using the third full expanded leaf from the top according to the equation of **Murry (1960)**[12]: Leaf area = length x width x 0.8 number of green leaves per plant at shooting stage were counted.

2- **Vegetative parameters of offshoot**: length (m), **girth (cm)** and **Number of green leaves of offshoot were determined at harvest of mother plant**.

Crop cycle

. The period from offshoot emergency to flowering (day).

. The period from emergency of inflorescence to harvest (E-H day).

. The period from offshoot emergency to harvest (Crop cycle).

4. Leaf chemical composition:

Leaf samples were taken from the upper third leaf from the top of the plant after shooting in September of each season. The following chemical constituents were determined:

4.1. Photosynthetic pigments:

Chlorophyll *a*, *b* and carotene (mg/ g fresh weight) were estimated according to **Wettestein (1957)[13].**

4.2. Leaf mineral content:

Total nitrogen and phosphorus were calorimetrically determined according to the methods described by **Bremner and Mulvaney (1982)[14], Olsen and Sommers (1982)[15],** respectively. Potassium was determined flame photometrically according to the method advocated by **Brown and Lilleland (1946)[16].**

Calcium and magnesium elements were determined in the previous digested solution using the atomic absorption apparatus, Unicom SP 1900 absorption Spectrophotometer according to **A.O.A.C., (1990)[17]**.

5. Yield and fruit properties: .

Bunches were harvested at the full maturity stage. Bunch weight (kg), bunch length (cm), bunch circumference (cm), number of hands/bunch, hand weight (kg), number of fingers/ hand were recorded. Three hands were taken from the base, middle and distal end of each bunch as sample for each replicate and artificially ripened. After ripening, the following fruit physical and chemical characteristics were determined: Average finger weight (g), length (cm), diameter (cm), pulp weight (g), peel weight (g) and pulp fruit ratio. Total soluble solids in the fruit pulp juice (TSS) using a hand refractometer. Total titratable acidity was estimated according to **A.O.A.C. (1990)[17].** TSS/ acid ratio was calculated. Vitamin C content (mg / 100 g pulp) was determined in fruit pulp by titration against 2, 6- dichlorophenol-indophenol dye according to **A.O.A.C. (1990)[17].** Total soluble sugar was determined according to the method described by **Forsee (1938)[18].**

Statistical analysis:

All the obtained data were subjected to statistical analysis as noted by **Snedecor and Cochran (1980**)[19]. Treatments means were compared using Duncan's multiple range test at 5 % level of probability[20].

Results and Discussion

1. Plant vegetative growth

The presented data in Table (2) indicate the effect of some potassium fertilization treatments on vegetative growth of Grand Nain banana plants in 2012/2013 and 2013/2014 seasons.

The obtained results show that fertilization treatments had a significant effect on pseudostem length and girth, leaf length and width, leaf area, and number of green leaves at flowering in both seasons, except pesudostem length in the second season and leaf width in the first one.

Table 2. Effect of different potassium sources on vegetative growth of Grand Naine banana (2012/2013 and 2013/2014 seasons).

Treatments	Pesudostem length (cm)	Pesudostem girth (cm)	Leaf length (cm)	Leaf width (cm)	leaf area (m^2)	Number of green leaves at flowering
	2012/2013 season					
T1	275.0 b	31.6 b	169.0 d	90.0 a	1.21 c	15.0 b
T2	290.0 a	33.6 a	219.6 a	96.3 a	1.69 a	16.3 a
T3	235.0 c	28.6 c	188.6 c	83.0 a	1.25 bc	14.6 b
T4	265.0 b	31.3 b	200.3 b	93.6 a	1.50 ab	15.3 ab
T5	265.0 b	30.3 bc	186.6 c	89.6 a	1.34 bc	16.3 a
	2013/2014 season					
T1	264.0 a	33.0 a	168.3 c	88.6 c	1.19 c	15.3 ab
T2	251.6 a	34.6 a	221.3 a	103.3 a	1.82 a	15.6 a
T3	256.6 a	27.6 b	189.3 b	77.0 d	1.16 c	14.0 b
T4	264.0 a	32.3 a	193.6 b	95.3 b	1.47 b	15.6 a
T5	263.3 a	30.6 ab	193.3 b	93.0 bc	1.43 b	16.3 a

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

Results indicate that, treatment 4 (50 % potassium in the form of feldspar + 50 % in the form of mineral potassium) had significantly increased the most measurement characters of plant growth in both seasons with no significant differences with 25 % fildsapr+75 % mineral potassium regarding pesudostem girth in the 2^{nd} season and number of green leaves at flowering stage in both seasons.

The increases in plant growth may be due to that K-feldspar containing about 67 % silicon. The positive effect of silicon on growth characters might be attributed to its important roles in protecting plants against (drought, cold, diseases and fungal attack), alleviating a biotic stress (heavy metals toxicity and salinity) and improving root development, uptake of water and nutrients and plant pigments[21].

2- Vegetative growth of offshoots

Results in Table (3) clear the effect of different potassium sources on offshoot (length, girth and number of green leaves) in both seasons. Fertilization of potassium sources had no reflected any significant effect on length , girth and number of green leaves of offshoot in both seasons, except length of offshoot in the second season only, whereas, T3 (potassium at 75 % in the form of feldspar +25 mineral potassium) recorded the highest length of offshoot with no significant differences than 100 % feldspar or 50 % feldspar + 50 % mineral potassium in the second season only.

Table 3. Effect of different potassium sources on offshoot characteristics of Grand Naine banana (2012/2013 and 2013/2014 seasons).

Treatments	Offshoot length (m)	Offshoot girth (cm)	Number of green leaves of offshoot
	2012/2013 season		
T1	174.3 b	22.3 a	12.6 a
T2	196.6 a	24.3 a	14.3 a
T3	195.0 a	22.6 a	13.3 a
T4	198.3 a	23.3 a	13.3 a
T5	200.0 a	26.0 a	14.0 a
	2013/2014 season		
T1	161.6 c	21.3 a	12.6 a
T2	188.0 ab	23.3 a	13.6 a
T3	195.0 a	23.0 a	13.0 a
T4	194.3 a	23.0 a	13.0 a
T5	180.6 b	22.0 a	12.3 a

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

The obtained results are in agreement with those showed that using feldspar at 1000g K_2O/tree plus *Bacillus circulans* recorded the maximum values of leaf area, leaf fresh weight and leaf dry weight of Valencia orange[11].

3- Crop cycle

Results in Table 4 show the effect of different potassium sources on Grand Nain banana during both experimental seasons, since the time to bunch shooting was significantly affected by different potassium sources in both seasons. The shortest period to bunch shooting (473 and 471 days) was recorded by T2 (100 % K_2O in the form of feldspar) in the 1st and 2nd seasons, respectively. The longest period to bunch shooting was obtained from T3 (75 % K_2O in the form of feldspar +25 % K_2O in the form of K_2SO_4) since it was 495 and 492 days in both seasons, respectively. The other treatments ranged between 477-485 days in the first seasons and 473-487 in the second one.

Table 4. Effect of different potassium sources on crop cycle of Grand Naine banana (2012/2013 and 2013/2014 seasons).

Treatments	Period (days) from offshoot emergency to flowering	E-H (days)	Crop cycle (days)
	2012/2013 season		
T1	485 ab	120 b	605 b
T2	473 c	93 c	566 c
T3	495 a	140 a	635 a
T4	477 bc	118 b	595 b
T5	480 bc	125 b	605 b
	2013/2014 season		
T1	480 bc	120 b	600 c
T2	471 d	91 c	563 d
T3	492 a	138 a	630 a
T4	473 cd	121 b	595 c
T5	487 ab	125 b	612 b

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

Results from Table (4) show that period to bunch harvesting was affected significantly by different potassium sources in both experimental seasons. The longest period to bunch maturation was recorded by T3 (75 % K_2O in the form of feldspar +25 % K_2O in the form of K_2SO_4) since it was 140 and 138 days in the first and second seasons, respectively. The shortest period to bunch maturation was recorded by T2 (100 % K_2O in the form of feldspar), since it was 93 and 91 days in the first and second seasons, respectively. The other treatments ranged between (118-125 days) and (120-125 days) in the first and second seasons, respectively.

Cropping cycle was significantly affected by different potassium sources in both experimental seasons. The least values were recorded by T2 (100 % K_2O in the form of feldspar), since it was 566 and 563 days in the first and second seasons, respectively. Generally, T2 was earlier to bunch shooting, bunch maturation and cropping cycle in both experimental seasons.

4. Leaf chlorophyll and leaf mineral contents

Results in Tables (5 and 6) show the effect of potassium sources on both chlorophyll and mineral content in the leaves .

Table 5. Effect of different potassium sources on leaf pigments (mg/g FW) of Grand Naine banana (2012/2013 and 2013/2014 seasons).

Treatments	Chlorophyll a	Chlorophyll b	Total chlorophyll (a+b)	Carotenoides
	2012/2013 season			
T1	1.77 abc	0.71c	2.48 c	0.63 b
T2	1.92 a	0.98 a	2.90 a	0.84 a
T3	1.65 bc	0.65 c	2.30 d	0.61 bc
T4	1.84 ab	0.84 b	2.68 b	0.75 a
T5	1.55 cd	0.52 d	2.07 e	0.50 c
	2013/2014 season			
T1	2.09 ab	0.64 b	2.80 ab	0.71 bc
T2	1.61 c	0.42 c	2.03 d	0.91 a
T3	2.01 ab	0.58 b	2.59 bc	0.68 cd
T4	2.24 b	0.76 a	3.00 a	0.84 ab
T5	1.89 bc	0.47 c	2.36 cd	0.56 de

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

Table 6. Effect of different potassium sources on leaf mineral contents (%) of Grand Naine banana (2012/2013 and 2013/2014 seasons).

Treatments	N%	P%	K%	Ca%	Mg%
	2012/2013 season				
T1	3.26 bc	0.30 b	4.05 b	1.50 bc	0.64 b
T2	4.22 a	0.41 a	5.62 a	1.82 a	0.91 a
T3	2.97 bc	0.28 b	3.21 c	1.35 c	0.60 bc
T4	3.56 ab	0.33 ab	4.12 b	1.65 ab	0.82 a
T5	2.66 c	0.25 b	3.00 c	1.27 c	0.52 c
	2013/2014 season				
T1	3.49bc	0.33 ab	4.66b	1.61b	0.72 b
T2	4.47 a	0.46 a	6.46 a	1.91 a	1.00 a
T3	3.18cd	0.31 b	3.69 c	1.44 c	0.67 b
T4	3.81 b	0.36 ab	4.67 b	1.77 ab	0.92 a
T5	2.85 d	0.28 b	3.45c	1.36 c	0.58c

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

The highest leaves chlorophyll (a), chlorophyll b , total chlorophyll ($a + b$) and carotenoids were obtained from T2 (100 % K_2O in the form of feldspar), followed by T4 (50 % K_2O in the form of feldspar +50 % K_2O in the form of K_2SO_4) in the first and second seasons , respectively

The lowest values of leaf pigments chlorophyll *a*, chlorophyll *b*, total chlorophyll and carotenoids were recorded by T5 (25 % K_2O in the form of feldspar +75 % K_2O in the form of K_2SO_4) in the first season. Meanwhile, in the second season, the highest leaf chlorophyll *a*, chlorophyll *b* and total chlorophyll were obtained from T4 (50 % K_2O in the form of feldspar +50 % K_2O in the form of K_2SO_4), followed by T1 (100 % K_2O in the form of potassium sulphate). The lowest values were recorded by T2 (100 % K_2O in the form of feldspar).

As for leaf mineral content, results in Table (6) clearly ravel that there was a significant increase in N, P, K and Ca as well Mg in both seasons. The highest values were obtained by T2 (100 % K_2O in the form of feldspar), meanwhile the lowest value was recorded from T5 (25 % K_2O in the form of feldspar +75 % K_2O in the form of K_2SO_4) in both experimental seasons .

The obtained results concerning the influence of different potassium forms on leaf mineral contents are in a harmony with those reported by many researchers on Balady mandarin and mango [22-24].

5. Bunch characteristics

Results in Table (7) show the effect of potassium sources on bunch characteristics of Grand Nain banana plants in 2012/2013 and 2013/2014 seasons. Data clearly show that potassium sources had significantly affected bunch weight, bunch length, bunch circumference, number of hand/ bunch and hand weight in both seasons. In general , T2 (100 % potassium in the form of feldspar) recorded the highest values of bunch weight, bunch length, bunch circumference, number of hand/ bunch and hand weight in both seasons while the lowest values of these traits were recorded with T3 (potassium at 75 % in the form of feldspar + 25 % mineral potassium) . The increases in bunch weight were about 29.28 and 32.25% for T2 (100 % potassium in the form feldspar over the control (100 % in the form of mineral potassium) in the first and second seasons, respectively.

Table 7. Effect of different potassium sources on bunch characteristics of Grand Naine banana (2012/2013 and 2013/2014 seasons).

Treatments	Bunch weight (kg)	Bunch length (cm)	Bunch circumference (cm)	Number of hands/bunch	Hand weight (kg)
	2012/2013 season				
T1	35.00 b	125.0 b	96.0 c	12.0 ab	2.76 a
T2	45.25 a	136.3 a	112.6 a	12.0 ab	3.23 a
T3	25.93 c	110.0 d	92.0 d	10.3 b	1.75 b
T4	29.93 bc	122.6 bc	105.3 b	12.6 a	3.28 a
T5	35.73 b	117.3 c	97.0 c	12.0 ab	2.78 a
	2013/2014 season				
T1	34.10 c	126.3 b	93.6 b	12.6 ab	2.67 c
T2	45.10 a	141.3 a	108.3 a	13.3 a	3.52 a
T3	25.56 d	111.0 c	91.6 b	10.0 c	1.79 d
T4	35.83 bc	122.6 b	106.6 a	12.6 ab	2.99 b
T5	36.16 b	119.3 b	95.3 b	12.0 b	2.48 c

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant control), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

2. Fruit physical characteristics

Results in Table (8) show the effect of potassium sources on fruit physical characteristics of Grand Nain banana plants in 2012/2013 and 2013/2014 seasons. The results show that potassium fertilization treatments had a significant effect on number of fingers/hand, finger weight, finger circumference, pulp and peel weight in both seasons, except number of fingers/ hand and finger circumference and pulp fruit ratio in the second seasons. In general, T2 (100 % potassium in the form of feldspar) recorded the highest values of the most traits without significant differences than T4 (potassium fertilization in the form of feldspar at 50 % + mineral potassium at 50 %) regarding finger length and peel weight in both seasons. In general, it could be concluded that application of potassium at 100 % in the form of feldspar was the most superior treatments for enhancing fruit physical characters of Grand Nain banana plants in 2012/2013 and 2013/2014 seasons.

These results are in harmony with those obtained on citrus and mango trees since different potassium sources had a significant effect on yield as number of fruits or weight (kg/tree) and increased fruit weight and pulp weight[24-26].

Table 8. Effect of different potassium sources on finger characteristics of Grand Naine banana (2012/2013 and 2013/2014 seasons).

Treatments	Number of fingers/hand	finger weight (g)	finger length (cm)	finger circumference (cm)	Pulp weight (g)	Peel weight (g)	Pulp/fruit ratio
	2012/2013 season						
T1	23.0 a	121.6 b	23.2 b	3.3 a	83.0 ab	38.6 b	0.68 a
T2	23.3 a	143.0 a	25.2 a	3.2 ab	94.5 a	48.5 a	0.66 a
T3	17.3 b	101.6 c	21.6 c	3.0 b	71.3 b	30.3 c	0.69 a
T4	24.6 a	136.0 ab	25.6 a	3.2 ab	90.6 a	45.3 a	0.66 a
T5	23.0 a	126.0 b	22.1 c	3.2 ab	89.6 a	36.3 b	0.70 a
	2013/2014 season						
T1	22.6 a	118.6 c	23.9 b	3.04 a	82.3 c	36.3 b	0.69 a
T2	23.0 a	146.0 a	25.8 a	3.30 a	97.5 a	48.5 a	0.67 a
T3	20.6 a	93.3 d	21.7 c	3.29 a	63.6 d	29.6 c	0.68 a
T4	23.3 a	134.3 b	24.9 ab	3.19 a	85.3 b	49.0 a	0.63 a
T5	22.0 a	120.3 c	21.7 c	3.27 a	86.3 b	34.0 bc	0.71 a

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

3. Chemical characteristics

The presented results in Table (9) show the effect of potassium sources on chemical characteristics of Grand Nain banana plants in 2012/2013 and 2013/ 2014 seasons.

Table 9. Effect of different potassium sources on chemical characteristics of Grand Naine banana pulp (2012/2013 and 2013/2014 seasons).

Treatments	TSS	Acidity (%)	TSS / acid ratio	Vit. C content (mg/ 100 g fruit pulp)	Total sugars (%)
	2012/2013 season				
T1	18.3 e	0.066 a	278.9 d	7.2 c	15.6 b
T2	21.0 a	0.037 d	567.6 a	14.5 a	19.1 a
T3	18.7 d	0.054 b	347.2 c	10.3 c	16.1 bc
T4	20.5 b	0.036 d	569.4 a	11.3 b	18.3 a
T5	19.0 c	0.048 c	397.5 b	10.4 b	17.7 ab
	2013/2014 season				
T1	18.5 d	0.070 a	265.4 d	9.5 d	15.9 b
T2	21.5 a	0.034 d	632.4 a	15.5 a	17.9 a
T3	19.8 c	0.051 b	388.8 c	12.0 c	16.0 b
T4	20.3 b	0.033 d	616.1 a	13.2 bc	17.3 a
T5	20.4 b	0.044 c	466.6 b	14.4 ab	17.8 a

T_1: 100 % K_2O in the form of K_2SO_4 (600 g/K_2O/plant), T_2: 100 % K_2O in the form of feldspar, T_3: 75 % K_2O in the form of feldspar+ 25 % K_2O in the form of K_2SO_4, T_4: 50 % K_2O in the form of feldspar+ 50 % K_2O in the form of K_2SO_4, T_5: 25 % K_2O in the form of feldspar+ 75 % K_2O in the form of K_2SO_4.

The results show that potassium fertilization treatments had a significant effect on TSS, total acidity, TSS/acid ratio, vitamin C content and total sugars, in the fruits in both seasons.

Results indicate that, application of T2 (potassium in the form feldspar at 100 %) significantly increased TSS (%), TSS/acid ratio, vitamin C content and total sugars, also recorded the highest values (21.0 and 21.5%) for TSS , (14.5 and 15.5 mg/100 g fruit pulp) for vitamin C. and (19.1 and 17.9 %) for total sugars in the first and second seasons, respectively with no significant differences than T4 (50 % feldspar+ 50 % mineral potassium) regarding TSS acid ratio and total sugars in both seasons. On the other hand, T1 (100 % mineral potassium recorded the lowest values in these respect.

As for total acidity , data illustrate that, T 1(potassium at 100 % in the form of mineral potassium) gave the highest values (0.066 and 0.070 %) in both seasons , while the lowest acidity value was obtained from T4 (50 % feldspar and 50 % mineral potassium), since it was 0.036 and 0.033 % in both seasons, respectively.

Potassium plays an important role in banana fruit quality by involves in metabolic processes, such as the enzyme activation, synthesis of proteins, membrane transport processes and the generation of turgor pressure. Furthermore, it involves in the translocation of photosynthetic products from sources to sinks[27]. The beneficial effects of silicon on protecting the plants from unfavorable effects of environment during maturity surely reflected on improving fruit quality[28].

As for the effect of different potassium application on fruit chemical properties, the obtained results are in agreement with those on mango, since it found that potassium improved fruit chemical properties as TSS, acidity and vitamin C[24, 29-30].

In general, It could be concluded that application of potassium in the form of 100 % feldspar was superior treatment for increasing vegetative growth, yield and its components as well as fruit quality and increased bunch weight by about 30.76 % than the application of 100 % potassium in the form K_2SO_4. These results were detected with Grand Nain banana plants grown under the conditions of this study.

References

1. Sheng X.F., Huang W.Y. (2002). Mechanism of potassium release from feldspar affected by the strain NBT of silicate bacterium. Acta Pedol. Sin., 39: 863–871.
2. Labib, B.F.; K. Ghabour; I. S. Rahim and M. M. Wahba (2012). Effect of potassium bearing rock on the growth and quality of potato crop (*Solanum tuberosum*). J. Agric. Biotech. Sustainable Dev., 4(1) 7 -15.
3. Bennett, P.C., W.J. Choi and J.R. Rogera (1998). Microbial destruction of feldspars. Miner. Manage, 8 (6): 149–150.
4. Dilruba, S. M.M. Alam , M.A. Rahman and M.F. Hasan (2006) . Influence of Nitrogen and Potassium on Yield Contributing Bulb Traits of Onion. Intr. J. Agric. Res. (1):85-90.
5. Pettigrew, W.T. (2008). Potassium influences on yield and quality production for maize, wheat, soybean and cotton. Physiol. Plant, 133: 670-681.
6. Perrenoud, S. (1993). Fertilizing for higher yield potato. IPI Bull. No.8.2 Ed. International Potash Institute, 2nd Berne, Switzerland.
7. 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.
8. Sanz-Scovino, J.I. and D.L. Rowell (1988). The use of feldspar as potassium fertilizers in the savannah of Columbia. Fertilizer Research, 17: 71-83.
9. Harley, A.D. and R.J. Gilkes (2000). Factors influencing the release of plant nutrient elements from silicate rock powders: a geochemical overview. Nutr. Cycl. Agroecosyst., 56: 11-36.
10. Bakker, M.R., E. George, M.P. Turpault, J. Zhang and B. Zeller (2004). Impact of Douglas-fir and Scots pine seedlings on plagioclase weathering under acidic conditions. Plant Soil, 266: 247-259.
11. Abdel-Hak, R. S., S. El-Shazly, A. El-Gazzar, E.A. Shaaban and M.S. El-Shamma (2012). Response of Valencia orange trees to rock-feldspar applications on in reclaimed soils. J. Appl. Sci. Res., 8(7): 3160-3165.
12. Murry, D.B. (1960). The effect of deficiency of major nutrients on growth and leaf analysis of the banana. Trop. Agric. Trin, 37: 97-106.
13. Wettestein, D.V. (1957). Chlorophyll, Lethal und der Submikroscobische Formwechsell der Plastiden. Exptl Cell-Res. 12: 427-433.
14. Bremner, J. M. and C. S. Mulvaney (1982). Total nitrogen In: Page, A. L., R. H. Miller, and D. R. Keeney (Eds). Methods of Soil Analysis. Part 2, Amer. Soc. Agron. Madison, W. I. USA. pp. 595- 624.
15. Olsen, S.R. and L.E. Sommers (1982). Phosphorus. In: Page. A.L., R.H. Miller, and D.R. Keeney (Eds). Methods of Soil Analysis. Part 2 Am. Soc. Agron. Madison, W.I. USA, pp. 403-430.
16. Brown, J. D. and O. Lilleland (1946). Rapid determination of potassium and sodium in plant material and soil extract by flame photometer. Proc. Amer. Soc. Hort. Sci, 48: 341-346.
17. A.O.A.C. (1990). Association of Official Agricultural Chemists. Official systems of analysis. 10th ed. A.O.A.C., Wash., DC.

18. Forsee, W. T. Jr. (1938). Determination of sugar in plant materials: A. photometeric method. Indus. Eng. Chem. Anal. Ed., 10: 411- 418.
19. Snedecor, G.W. and W.G. Cochran (1980). Statistical Systems. 7th ed. Iowa State Univ., Press, Ames., Iowa, U.S.A.
20. Duncan, D.B. (1958). Multiple rang and multiple F test. Biometrics, 11: 1- 42.
21. Qin, Z. and S.P. Tian (2009). Enhancement of biocontrol activity of Cryptococcus laurentiiby Silicon and the possible mechanisms involved. Phytopathology, 95:69-75.
22. Mostafa, E.A.M. and M.M.S. Saleh (2006). Response of Balady mandarin trees to girdling and potassium sprays under sandy soil conditions. Res. J. Agric. and Biol. Sci., 2(3): 137-141.
23. Taha R.A., H.S.A. Hassan, and E.A Shaaban (2014). Effect of different potassium fertilizer forms on yield, fruit quality and leaf mineral content of Zebda Mango trees. Middle-East Journal of Scientific Research. 21 (3): 518-524.
24. Baiea M. H. M., El -Sharony T. F., Eman A.A. Abd El-Moneim (2015). Effect of different forms of potassium on growth, yield and fruit quality of mango cv. Hindi. Int. J. ChemTech Res. 2015,8(4),pp 1581- 1587.
25. Mostafa, E.A.M., H.S.A. Hassan and A.S. El Sabag (2005). Influence of spraying GA and KNO_3 on yield, fruit quality and leaf mineral contents of Balady mandarin trees. Minufiya J. Agric. Res., 30(1): 283-295.
26. Alva, A.K.; J.R. Mattos, D., S. Paramasivam, B. Patil, H. Dou, and K. Sajwan (2006). Potassium management for optimizing citrus production and quality. International Journal of Fruit Science, 6: 3-43.
27. Cakmak, I., C. Hengeler and H. Marschner (1994). Partitioning of shoot and root dry matter and carbohydrates in bean plants sufering from phosphorus, potassium and magnesium deficiency. J. Exp. Bot. 45: 1245-1250.
28. Ma, J.F., Y. Miyake and E. Takahashi (2001). Silicon as a beneficial effect for crop plants. In silicon. Agriculture (Datnoff, L.E., Snyder, G.H. and Komdorfer, G.H.)pp 17-40, Elsevier Amsterdam.
29. Ebeed, S. and M.M.M. Abd El-Migeed, 2005. Effect of spraying sucrose and some nutrient elements on Fagri Kalan mango trees. J. App. Sci. Res., 1: 341-346.
30. Abd El-Razek, E., A.S.E. Abd-Allah and M.M.S. Saleh (2013). Foliar spray of some nutrient elements and antioxidants for improving yield and fruit quality of Hindi mango trees. Middle-East J.