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EFFECT OF DIFFERENT SLOW RELEASE POTASSIUM FERTILIZER RATES ON GROWTH AND PRODUCTIVITY OF BANANA CV. WILLIAMS PLANTS

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ABSTRACT

This study was carried out during the two successive seasons (2017 and 2018) on the first and second ratoon of healthy uniform banana cv. Williams (*Musa spp*.) Plants grown in sandy soil under drip irrigation system in a private orchard located at El-Tahadi region, Cairo Alexandria desert road, Behaira governorate, Egypt. The investigation aimed to study the effect of different slow release potassium fertilizer (SRKF) (50% K_2O) rates (100%, 75% and 50%) were added as soil drench during mid March, mid June and mid September while, potassium sulphate dose used in control treatment was added at monthly intervals as soil application from mid March until mid October on vegetative growth, productivity, total yield income and net return/feddan of banana plants. The obtained results showed that, all treatments had a significant effect on enhancing the vegetative growth parameters, i.e. number of green leaves /plant, plant total assimilation area (m^2/plant), leaf total chlorophyll content (CCI) and leaf macro element content (N, P and K) as (%) as well as leaf micro element content (Fe, Zn and Mn) as (ppm). Also, improving yield (ton/feddan), bunch weight (kg), number of hands/bunch, hand weight (kg), number of fingers/hand, finger weight (g), finger length (cm), finger circumference (cm), finger pulp weight (g), finger pulp/peel (ratio), TSS (%), TSS/TA (ratio), total sugars (%). In addition, the total yield income (1000 LE) and net return/feddan (1000 LE) in both seasons. Moreover, all treatments had no significant effect on plant pseudostem height (cm), pseudostem circumferences (cm) and leaf area (m^2) of plant in both seasons and bunch length (cm) in the first season only. Treatment of: slow release potassium at 100% gave the highest values of physical and chemical properties of banana plants cv. Williams in both seasons compared to, control treatment (100% potassium sulphate) and slow release potassium at 50% gave the lowest values.

Keywords: Banana, Slow release potassium, Growth, Productivity

1. INTRODUCTION

In Egypt, banana plants are considered as the 4th largest fruit crops as total cultivated area, following citrus, grapes and mango. The total area of banana increased up to 82000 feddan, producing 1,365,000tons with average of 16.646 tons/feddan according to the statistics of Egyptian, Ministry of Agriculture and Land Reclamation (**Bulletin of the Agricultural Statistics, 2017).**

Williams banana is one of the giant Cavendish type in the Cavendish subgroup. It is cultivated successfully in the new reclaimed soils because of its excellent performance, and high tolerance to transportation **(Vezina, 2017).**

Banana plants need a large amount of fertilization elements especially potassium **(Kumar and Kumar, 2008b).** Moreover, it draws nutrients from a very limited soil depth due to its shallow root system, in addition, high water requirements which cause a great leaching of most applied elements, particularly potassium **(Mendes et al 2016 and Godoy et al 2018).**

Potassium (K) has many roles in the plants particularly banana such as photosynthesis regulation, protein and starch synthesis, enzyme activities (at least 60 different enzymes) (**Marschner, 1995)**. It plays a major role in the transport of sugar and nutrients through the phloem to other parts of the plant for utilization and storage. Its effect mainly depends on the method, level and the source of application **(Tuner and Barkus, 1983; Mengel and Kirkby, 1987; Ram and Prasad, 1988; Borges, 2004; Kumar and Kumar, 2008a; Patel et al 2017 and Millik et al 2018).** Mineral potassium became a high expensive fertilizer in Egypt, besides; the excessive uses of chemical fertilizers have resulted in serious problems, i.e. soil salinity, pollution of the underground water.

The application of slow release potassium fertilizers was developed mainly to reduce the number of replications per year **(Zekri and Koo, 1991)** minimize the cost of production, and improve the efficiency of (K) used by trees **(Shaviv et al 1997).** The control and continues providing of the trees with their requirements of K can be achieved using slow and controlled release potassium fertilizers which are responsible for releasing their own (K) at a longer period and a critical date of fruit development **(George and Robert, 1996; Bettage and Ben Moimoun, 2010; Oliveira et al 2012; Oliveira et al 2013; Soti et al 2015; Ng et al 2016 and Godoy et al 2018).**

Therefore, this study aimed to investigate the effect of different slow release potassium fertilizer rates on vegetative growth, leaf chemical contents, productivity, fruit physic-chemical characteristics, yield income and net return/feddan of Williams banana plants under sandy soil conditions.

2. MATERIALS AND METHODS

Thirty six healthy uniform plants of banana Williams cultivar (*Musa spp*.) grown in sandy soil under drip irrigation system in a private orchard located at El-Tahadi region, Cairo Alexandria desert road, Behaira governorate, Egypt. Suckers planted as distance of (3.5x3) meters apart, each hole content two suckers (800plants/feddan) and selected during the two successive seasons 2017 (first ratoon plants) and 2018 (second ratoon plants).The soil samples were collected from different locations in the plantation at 0-30 and 30-60cm depths then analyzed for physical and chemical properties**.** Experimental soil texture and deficient

Fertility according to mechanical and chemical analysis shown in **Table (1).**

Table 1. Physical and chemical properties of banana plantation soil at the beginning of the experiment.

Physical Properties	Soil depth (cm)		Chemical Properties	Soil depth (cm)	
	0-30	30-60		0-30	30-60
Coarse sand (%)	48.70	49.00	$CaCO_3$ %	1.20	1.40
Fine sand (%)	36.30	36.20	Na (mg/L)	2.97	3.83
Silt (%)	10.40	10.30	K (mg/L)	0.30	0.90
Clay (%)	4.60	4.50	Ca (mg/L)	2.16	2.30
Texture class	sandy	sandy	Mg (mg/L)	0.92	1.10
Organic matter (%)	0.40	0.35	HCO_3 (mg/L)	3.50	3.88
PH	8.3	8.8	Cl (mg/L)	2.00	3.10
EC (ds/m)	0.85	1.10	SO_4(mg/L)	0.85	1.15

This experiment included six fertilization treatments (added as soil drench) as follow:

T1: Control (100%) potassium sulphate /plant/year (1.6 kg).

T2: (100%) slow release potassium/plant/year (1.6 kg).

T3: (75 %) slow release potassium/ plant/year (1.2 kg).

T4: (75%) slow release potassium (1.2 kg) + (25%) potassium sulphate/plant/year (400 g).

T5: (50%) slow release potassium/plant/year (800 g).

T6: (50%) slow release potassium (800 g) + (50%) potassium sulphate/plant/year (800 g).

Slow release potassium fertilizer (50% K_2O) doses were added during mid-March, mid-June and mid-September. While, potassium sulphate doses were added at monthly intervals from mid-March until mid-October through the two seasons of the study according to (**Saad, 2001**). Each treatment contained three replicates and each replicate had two plants. The following characteristics were estimated.

1. Vegetative growth parameters

After the inflorescences emergence (mid-September), the following vegetative characteristics were determined as follows:

1.1. Pseudostem height (cm): from the soil surface to junction of the first leaf.

1.2. Pseudostem circumference (cm): at 20 cm above soil surface.

1.3. Leaf area (m^2): on the third expanded leaf from the top using the following equation:

Leaf area (m^2) = length x width x area coefficient, area coefficient of Williams banana = 0.86 according to **(Obiefuna and Ndubizu, 1979).**

1.4. Leaves number per plant at bunch shooting.

1.5. Total assimilation area (m^2/plant) was determined using the equation: Total assimilation area (m^2/plant) = leaf area x number of green leaves per plant (**Ibrahim, 1993).**

2. Leaf chemical contents

Leaf samples sized 10x10 cm were taken from the middle part of the blade of the third leaf from from the top of the plant as recommended by **(Hewitt, 1955)** for mineral analysis. The collected leaf samples were dried in the oven at 70˚C until constant weight. The dry matter was finely grinded and wet digested with a mixture of concentrated sulfuric acid and perchloric acid (2:1)(v/v) for 15 minutes until the digestive solution became colorless and then transferred quantitatively to 50 ml volumetric flask. The considered mineral nutrients were determined in dry matter as follows:

2.1. Leaf macro elements content

Total nitrogen content in leaf (%) was colorimetrically determined using microkjeldahl methods according to the method described by **(Pregl, 1945).** Also, phosphorus leaf content (%) was determined by using spectrophotometer (CECIL CE2040) according to the method advocated by **(Champman and Pratt, 1978).** In addition, potassium leaf content (%) was determined by using flame photometer (JENWAY PFP7) according to the method advocated by **(Brown and Lilleland, 1946).**

2.2. Leaf micro elements content

Micro- nutrients (Fe, Zn and Mn) as ppm were determined in the digestive solution using Atomic absorption spectrophotometer Jaril-Ash 850according to (**A.O.A.C., 1995**).

2.3. Leaf total chlorophyll content

Fresh leaf samples were taken from the third upper leaf of the plant top at shooting stage in (mid-September) of each season to determine leaf total chlorophyll content index (CCI) using CCM-200 plus OPTI-SCIENCES chlorophyll content meter .

3. Yield and fruit physical characteristics

Bunches were harvested at the green maturity stage (mid-Jun) then ripened by ethylene method for 24-48 hours at 15-20°C and 90-95% relative humidity **(Kader, 2005)**. Two hands were taken from the bunch after maturity characteristics (fifth ripening color stage) to estimate the following fruit physical and chemical characteristics for each treatment as follows:

Bunch weight (kg), hand number/bunch, hand weight (kg), finger weight (g), finger pulp weight (g), finger peel weight (g), finger pulp/peel ratio(estimated by divining finger pulp weight by finger peel weight),bunch length (cm), finger length and circumference (cm).

4. Fruit chemical content

Total soluble solids (TSS %) were determined in the pulp juice using a digital refractometer according to (**A.O.A.C., 1995**). Total titratable acidity (TA%) as malic acid in the pulp juice was determined by titration with 0.1 N of NaOH solution using phenolphethalein (1%) as an indicator according to **(A.O.A.C., 1995)**, TSS/TA ratio (calculated by divining TSS by TA) and total sugars were determined according to the method described by **(Dubios et al 1956).**

5. Total yield income and net return/feddan (1000 LE)

Total yield income and net return/feddan (1000LE) were estimated using the economic data of williams fruit as follows: ton unit (5000 LE), total production cost/feddan in the first season [(70, 72.65, 68.55, 71.92, 64.72 and 71.28(1000 LE)]and total production cost/feddanin the second season[(80, 82.65, 78.55, 81.92, 74.72 and 81.28) (1000 LE)] to all treatments respectively.

5.1. Total yield income/feddan/year (1000 LE): was estimated using the equation: Total yield income =net yield x ton price (1000LE).
5.2. Net return/feddan (1000 LE): was estimated using the equation: Net return/feddan = total yield income – total production cost (1000 LE).

Experimental design and statistical analysis

The experiment was designed as a randomized complete block design (RCBD), with one factor. The obtained data were tabulated and subjected to analysis of variance (ANOVA) according to **(Snedecor and Cochran, 1990)**. Means of results were compared using the method of Duncan's at 0.05 % level **(Duncan, 1955).**

3. RESULTS AND DISCUSSION

Pseudostem height (cm), no. of green leaves/ plant and pseudostem circumference (cm)

Data in **Table (2),** showed that, all vegetative growth of Williams banana plants i.e., pseudostem height, and pseudostem circumference were not significantly affected by treatments, although a slight increase was detected in all treatments compared to control in both seasons. Whereas, green leaves number was greatly affected by the studied slow release fertilizer treatments in (2017 and 2018) seasons. However, the highest number of green leaves/plant (14.17) was recorded by 100% slow release potassium in the first season, but the highest values (14.83) was recorded by 75% slow release potassium+ 25%potassium sulphate in the second season. On the other hand, the lowest values of this parameter was scored by 50% slow release potassium, compared with control treatment 100% potassium sulphate in both seasons, respectively. The highest number of green leaves/plant may be due to the continues of supply plants by K ions from slow release potassium fertilizer (SRKF), its activates at least (60) different enzymes such as (RuBP carboxylase enzyme) and enhances protein content involved in plant growth **(Marschner, 1995).** These findings are in accordance with those obtained by **Felisberto et al 2010; Oliveira et al 2013; Soti et al 2015**.

Leaf chlorophyll content (CCI), leaf area (m^2) and total assimilation area (m^2)

Leaf chlorophyll content (CCI) and total assimilation area (m^2) of Williams banana plants were positively responded to the studied treatments in shown in **Table (3),** the highest leaf chlorophyll (50.28 and 53.90) (CCI), and total assimilation area (27.63 and 29.19 m^2/plant) were recorded by 100% slow release potassium in the two seasons, respectively. In reverse, the lowest values were scored by control treatment. Whereas, leaf area was not significantly affected by treatments, although a slight increase was detected by all treatments than the control in the two seasons. The increase of leaf chlorophyll (CCI) may be due to the potassium has also a role in synthesizing the precursor of choloro-phyll pigment and photosynthetic efficiency (**Marschner, 1995**). The higher values of total assimilation area (m^2/plant) can be explained by the relation with the increment green leaves number/plant. The illustrated results were in agreement with **Felisberto et al 2010; Oliveira et al 2013; Soti et al 2015**, **Ng et al 2016 and Godoy et al 2018.**

Leaf macro elements content (N, P and K %)

Data presented in **Table (4),** revealed that, leaf N, P and K content were responded to the tested slow release potassium treatments in both seasons. However, the highest leaf N (2.08 and 3.29 %), P (0.35 and 0.53 %) and K (5.20 and 5.25 %) were recorded by the treatment of 100% slow release potassium in both seasons, respectively. Inreverse, control treatment 100% potassium sulphate scored the lowest values of these parameters in the two seasons. **(Tuner and Barkus, 1983)** explained the role of potassium in promoting N, P and K nutrients content in leaves due to the higher nutrient uptake and better transfer to the xylem**.** These results are in harmony with those of **Ng et al 2016**.

Table 2. Effect of different slow release potassium fertilizer rates on pseudostem height, No. of green leaves/ plant and pseudostem circumference (cm) of banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)			Second season (2018)		
	Pseudostem height (cm)	Pseudostem circumference (cm)	No. of green leaves/ plant	Pseudostem height (cm)	Pseudostem circumference (cm)	No. of green leaves/ plant
Control (100% potassium sulphate)	307.70 a	81.00 a	11.34 b	314.00 a	81.33 a	11.67 b
Slow release potassium 100%	326.70 a	85.17 a	14.17 a	331.70 a	85.83 a	14.67 a
Slow release potassium 75%	315.50 a	83.33 a	13.83 a	320.50 a	83.83 a	14.33 a
Slow release potassium 75% + potassium sulphate 25%	317.80 a	84.00 a	14.17 a	322.80 a	84.50 a	14.83 a
Slow release potassium 50%	312.20 a	81.67 a	13.50 a	318.80 a	82.33 a	14.00 a
Slow release potassium 50% + potassium sulphate 50%	315.30 a	82.67 a	13.67 a	321.40 a	83.17a	14.17 a

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

Table 3. Effect of different slow release potassium fertilizer rates on leaf chlorophyll (CCI), leaf area (m^2) and total assimilation area (m^2) of banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)			Second season (2018)		
	Leaf chlorophyll (CCI)	Leaf area (m^2)	Total assimilation area (m^2/plant)	Leaf chlorophyll (CCI)	Leaf area (m^2)	Total assimilation area (m^2/plant)
Control (100% potassium sulphate)	35.56 b	1.82 a	20.63 b	40.02 b	1.87 a	21.82 b
Slow release potassium 100%	50.28 a	1.95 a	27.63 a	53.90 a	1.99 a	29.19 a
Slow release potassium 75%	42.69 ab	1.91 a	26.41 a	46.43 ab	1.95 a	27.94 a
Slow release potassium 75% + potassium sulphate 25%	49.09 a	1.91 a	27.06 a	51.30 ab	1.96 a	29.06 a
Slow release potassium 50%	39.46 ab	1.85 a	24.98 a	42.57 ab	1.90 a	26.60 a
Slow release potassium 50% + potassium sulphate 50%	41.52 ab	1.88 a	25.70 a	45.00 ab	1.94 a	27.49 a

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

Leaf micro elements content (Fe, Zn and Mn as ppm)

Data listed in **Table (5),** indicated that, leaf content of Fe, Zn and Mn expressed as (ppm) were significantly affected by slow release potassium treatments in both seasons. The highest leaf values of Fe (350.10 and 353.20 ppm), Zn (33.37 and35.57 ppm) and Mn (358.30 and 359.00 ppm) were recorded by 100%slow release potassium in both seasons, respectively. In counter, control treatment 100% potassium sulphate scored the lowest values of these parameters in the two seasons. The leaves higher Fe, Zn and Mn contents may be due to the role of potassium in increase the nutrients absorption through the xylem **(Tuner and Barkus, 1983).**

Yield (ton/feddan), bunch weight (kg), and bunch length (cm)

Results given in **Table (6),** pointed out that, the highest yield (26.18 and 28.10 ton/feddan) and bunch weights (32.73 and 35.13 kg) were recorded by 100% slow release potassium in the first and second seasons, respectively. In addition, the bunch length was not significantly affected by all treatments in the first season, whereas, in the second season; the tallest bunch (91.67 and 94.67 cm) was recorded by slow release potassium at 100%. In reverse, control treatment 100% potassium sulphate scored the lowest values of these parameters in both seasons, respectively. The increase in bunch weight was also associated with the corresponding significant increase in the number of hands, number of fingers and finger weight. Beside, the increase of yield was related to the increase in the bunch weight (**Kumar and Kumar, 2008 a).**These results are in agreement with the results obtained by **George, and Robert, 1996; Oliveira et al 2012; Oliveira et al 2013; Ng et al 2016 and Godoy et al 2018 .**

No. of hands/bunch, no. of fingers/hand and hand weight (kg)

The effect of different slow release potassium fertilizer treatments on no. of hands/bunch, no. of fingers/hand and hand weight (kg) were presented in **Table (7),** the data clearly indicated that, the highest number of hands /bunch (11.17 and 11.33 hands) number of fingers/ hand (17.33 and 17.83 fingers) and the heaviest hand (2.44 and 2.58 kg) were recorded by treatment of slow release potassium 100% in both seasons, respectively. Compared with control treatment. However, the highest values of hand weigh (kg) (2.44 and 2.58) were recorded by 100% slow release potassium in both seasons, respectively. In reverse, the lowest values of these parameters were registered by control treatment at conc.100% of potassium sulphate in both seasons.The highest no. of hands/ bunch, no. of fingers / hand and hand weight may be due to the role of potassium in increase the translocation of carbohydrates from the leaves to fruits **(Borges, 2004).** The obtained results were in agreement with finding of **Oliveira et al 2012; Oliveira et al 2013; Ng et al 2016 and Godoy et al 2018.**

Finger weight (g), finger length (cm), finger circumference (cm)

Data in **Table (8),** cleared that, the heaviest finger (141.00 and 145.00 g), the highest values of finger length (20.51 and 20.63 cm) and finger circumference (11.70 and 11.72 cm) were corded by 100% slow release potassium in both seasons. On the other hand, the lowest values were registered by control treatment 100% potassium sulphate in the two seasons, respectively. Higher finger weight was associated with increase of finger pulp weight as in table (9). In addition, the increase of finger length and finger circumference clearly indicated that potassium was involved in cell enlargement and the increase of finger circumference might be due to the constant potassium supply from (SRKF) which acted as an activator of several enzymes **(Millik et al 2018).**The results are confirmed by those obtained of **Oliveira et al 2012; Oliveira et al 2013; Ng et al 2016 and Godoy et al 2018.**

Finger pulp weight (g), finger peel weight (g) and pulp/peel (ratio)

Finger pulp weight and pulp/peel ratio were significantly affected by slow release potassium fertilizer treatments during the study in as shown in **Table (9)**, fertilized plants by 100% slow release potassium significantly gave the highest finger pulp weight (105.80 and 112.80 g) and pulp/peel ratio (3.00 and 3.50 %) in the two seasons, respectively compared to control treatment. On the other hand, control treatment 100% potassium sulphate scored the lowest value of finger peel weight (g) in the first

Table 4. Effect of different slow release potassium fertilizer rates on leaf macro element content (N, P and K %) of banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)			Second season (2018)		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
Control (100% potassium sulphate)	1.24 b	0.27 b	3.05 f	2.30 c	0.30 c	3.10 f
Slow release potassium 100%	2.08 a	0.35 a	5.20 a	3.29 a	0.53 a	5.25 a
Slow release potassium 75%	1.77 a	0.33 ab	4.40 c	2.95 ab	0.46 ab	4.45 c
Slow release potassium 75% + potassium sulphate 25%	1.89 a	0.33 ab	4.75 b	3.13 a	0.50 a	4.80 b
Slow release potassium 50%	1.27 b	0.28 ab	3.55 e	2.70 b	0.34 bc	3.60 e
Slow release potassium 50% + potassium sulphate 50%	1.76 a	0.29 ab	4.00 d	2.77 b	0.43 abc	4.05 d

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

Table 5. Effect of different slow release potassium fertilizer rates on leaf micro element content (Fe, Zn and Mn ppm) of banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)			Second season (2018)		
	Fe (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)	Mn (ppm)
Control (100% potassium sulphate)	226.30 e	20.03 d	225.20 f	229.40 d	21.10 d	226.20 f
Slow release potassium 100%	350.10 a	33.37 a	358.30 a	353.20 a	35.57 a	359.00 a
Slow release potassium 75%	331.50 b	26.40 b	266.60 c	336.70 a	28.60 b	267.50 c
Slow release potassium 75% + potassium sulphate 25%	348.70 ab	31.70 a	302.40 b	352.90 a	33.23 a	303.90 b
Slow release potassium 50%	246.90 d	21.90 cd	239.60 e	256.00 c	23.93 cd	240.90 e
Slow release potassium 50% + potassium sulphate 50%	288.20 c	23.97 bc	250.70 d	292.50 b	25.27 c	251.70 d

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

Table 6. Effect of different slow release potassium fertilizer rates on yield (ton /feddan), bunch weight (kg) and bunch length (cm) of banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)			Second season (2018)		
	Yield (ton / feddan)	Bunch weight (kg)	Bunch length (cm)	Yield (ton / feddan)	Bunch weight (kg)	Bunch length (cm)
Control (100% potassium sulphate)	19.16 c	23.95 c	78.50 a	20.71 c	25.89 c	80. 33 b
Slow release potassium 100%	26.18 a	32.73 a	91.67 a	28.10 a	35.13 a	94.67 a
Slow release potassium 75%	22.61 b	28.27 b	86.33 a	24.20 b	30.26 b	89.67 ab
Slow release potassium 75% + potassium sulphate 25%	25.19 a	31.50 a	87.67 a	26.69 a	33.37 a	90.67 ab
Slow release potassium 50%	19.07 c	23.84 c	85.00 a	20.54 c	25.68 c	87.67 ab
Slow release potassium 50% + potassium sulphate 50%	20.20 c	25.25 c	85.83 a	21.58 c	26.97 c	88.67 ab

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

Table 7. Effect of different slow release potassium fertilizer rates on No. of hands/bunch, No. of fingers /hand and hand weight (kg) of banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)			Second season (2018)		
	No. of hands/ bunch	No. of fingers/hand	Hand weight (kg)	No. of hands/ bunch	No. of fingers / hand	Hand weight (kg)
Control (100% potassium sulphate)	11.00 ab	15.33 c	1.81 c	11.33 a	15.67 c	1.90 c
Slow release potassium 100%	11.17 a	17.33 a	2.44 a	11.33 a	17.83 a	2.58 a
Slow release potassium 75%	10.83 ab	16.00 bc	2.18 b	11.00 ab	16.50 bc	2.29 b
Slow release potassium 75% + potassium sulphate 25%	11.00 ab	17.00 ab	2.38 a	11.17 ab	17.50 ab	2.49 a
Slow release potassium 50%	10.33 b	16.00 bc	1.93 c	10.50 b	16.50 bc	2.04 c
Slow release potassium 50% + potassium sulphate 50%	10.83 ab	16.00 bc	1.94 c	11.00 ab	16.50 bc	2.04 c

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

Table 8. Effect of different slow release potassium fertilizer rates on finger weight (g), finger length (cm) and finger circumference (cm) of banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)			Second season (2018)		
	Finger weight (g)	Finger length (cm)	Finger circumference (cm)	Finger weight (g)	Finger length (cm)	Finger circumference (cm)
Control (100% potassium sulphate)	118.40 c	16.26 c	10.33 d	121.70 c	16.45 c	10.36 c
Slow release potassium 100%	141.00 a	20.51a	11.70 a	145.00 a	20.63 a	11.72 a
Slow release potassium 75%	136.3 b	19.77 a	11.41 b	139.30 b	19.89 a	11.44 b
Slow release potassium 75% + potassium sulphate 25%	140.40 a	20.00 a	11.41 b	142.40 ab	20.17 a	11.44 b
Slow release potassium 50%	120.90 c	17.67 b	11.46 b	123.80 c	17.83 b	11.49 ab
Slow release potassium 50% + potassium sulphate 50%	121.70 c	18.41 b	10.58 c	124.00 c	18.58 b	10.59 c

Means in each column with similar letter (s) are not significantly different at Duncan, P ≤ 0.05 level of probability.

Table 9. Effect of different slow release potassium fertilizer rates on finger pulp weight (g), finger peel weight (g) and pulp/peel (ratio) of banana cv. Williams in 2017 and 2018 seasons.

Characters / Treatments	First season (2017)			Second season (2018)		
	Finger pulp weight (g)	Finger peel weight (g)	Pulp/Peel (ratio)	Finger pulp weight (g)	Finger peel weight (g)	Pulp/Peel (ratio)
Control (100% potassium sulphate)	84.87 c	33.50 c	2.53 b	86.96 d	34.78 a	2.50 c
Slow release potassium 100%	105.80 a	35.25 a	3.00 a	112.80 a	32.22 b	3.50 a
Slow release potassium 75%	102.20 b	34.12 bc	2.99 a	104.40 b	34.82 a	3.00 b
Slow release potassium 75% + potassium sulphate 25%	105.30 a	35.10 a	3.00 a	110.80 a	31.60 bc	3.50 a
Slow release potassium 50%	86.24 c	34.53 ab	2.49 b	88.43	35.37 a	2.50 c
Slow release potassium 50% + potassium sulphate 50%	86.91 c	34.76 ab	2.50 b	93.00 c	31.00 c	3.00 b

Means in each column with similar letter (s) are not significantly different at Duncan, P ≤ 0.05 level of probability.

Table 10. Effect of different slow release potassium fertilizer rates on total soluble solids TSS (%), total acidity TA(%),TSS/TA (ratio) and total sugars (%) of banana cv. Williams in 2017 and 2018 seasons.

Characters / Treatments	First season (2017)				Second season (2018)			
	TSS (%)	TA (%)	TSS/TA (ratio)	Total sugars (%)	TSS (%)	TA (%)	TSS/TA (ratio)	Total sugars (%)
Control (100% potassium sulphate)	17.75 e	0.33 a	53.78 c	15.20 e	17.78 e	0.34 a	52.29 c	15.80 d
Slow release potassium 100%	20.75 a	0.25 bc	83.00 a	19.20 a	20.79 a	0.26 c	79.96 a	19.74 a
Slow release potassium 75%	19.75 bc	0.25 bc	79.00 b	17.80 bc	19.79 bc	0.26 c	76.11 b	18.05 b
Slow release potassium 75% + potassium sulphate 25%	20.00 ab	0.25bc	80.00 b	18.25 ab	20.05 ab	0.26 c	77.11 b	18.60 b
Slow release potassium 50%	18.25 de	0.33 a	55.30 c	15.90 de	18.28 de	0.34 a	53.76 c	16.02 d
Slow release potassium 50% + potassium sulphate 50%	19.00 cd	0.30 ab	63.33 bc	16.85 cd	19.05 cd	0.31 ab	61.45 bc	17.01 c

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

Table 11. Effect of some slow release potassium fertilizers on total yield income (1000 LE) and net return/feddan (1000 LE) in banana cv. Williams in 2017 and 2018 seasons

Characters / Treatments	First season (2017)		Second season (2018)	
	Total yield income (1000 LE)	Net return/feddan (1000 LE)	Total yield income (1000 LE)	Net return/feddan (1000 LE)
Control (100% potassium sulphate)	95.80 c	25.80 e	103.60 e	23.55 d
Slow release potassium 100%	130.90 a	58.34 a	140.50 a	57.94 a
Slow release potassium 75%	113.10 b	44.50 c	121.00 c	42.45 c
Slow release potassium 75% + potassium sulphate 25%	125.90 a	54.03 b	133.40 b	51.53 b
Slow release potassium 50%	95.35 c	30.63 d	102.70 e	27.98 d
Slow release potassium 50% + potassium sulphate 50%	101.00 c	29.72 d	107.90 d	26.92 d

Means in each column with similar letter (s) are not significantly different at Duncan, $P \leq 0.05$ level of probability.

season but, 50% slow release potassium + 50% potassium sulphate gave the lowest value in the second season. The increase in pulp/peel ratio by the higher supply of potassium was mainly due to the increase in pulp weigh which was the consequence of satisfactory activity of the enzymes involved in starch and protein synthesis **(Patel et al 2017).** These results were in harmony with **Bettage and Ben Mimoun 2010; Oliveira et al 2012; Oliveira, et al 2013; Ng et al 2016.**

Total soluble solids (TSS %), total acidity (TA %), TSS/TA (ratio) and total sugars (%)

Results given in **Table (10),** during the two successive seasons revealed that, the highest values of fruits TSS (20.75 and 20.79 %), TSS/TA (83.00 and 79.96 %) and total sugars (19.20 and 19.74 %) were recorded by 100% slow release potassium during the two seasons, respectively. On the other hand, the lowest values were registered by control treatment 100% potassium sulphate in the two seasons. Whereas, total acidity parameter registered the highest values (0.33 and 0.34 %) by 50% slow release potassium and control treatments in both seasons, respectively. The Increase in TSS may be due to respiration demand and adequate supply of nutrients, synthesis of inverters and starch splitting enzyme **(Ram and Prasad, 1988)**.The higher sugar content can be explained by the role of potassium in activating the enzymes of starch breakdown during banana ripening such as (sucrose synthase and sucrose phosphate synthase enzymes) **(Mengel and Kirkby, 1987; Cordenunsi and Lajolo, 1995).** The finding data were in agreement with **Ng et al 2016.**

Total yield income (1000 LE) and net return/feddan (1000 LE)

Data presented in **Table (11),** showed that, the highest values of total yield income/feddan (130.90 and 140.50 /1000 LE) and net return /feddan (58.34 and 57.94 / 1000 LE) were recorded by 100%slow release potassium in both seasons, respectively. While, control treatment 100% potassium sulphate and treatment 50% slow release potassium scored the lowest values in both seasons. The increase of total yield income was also associated with the significant increase in the net yield. In addition, the increment of netreturn/feddan was related to the increase in total yield income. The results agreed with repoted finding of **Felisberto et al 2010 and Ng et al 2016.**

4. CONCLUSION AND RECOMMENDATION

From this study, it could be recommended that, Williams banana plants fertilized with 100% slow release potassium recorded the highest values of yield (ton/feddan) and net return /feddan (1000 LE), also, enhanced quality of Williams fruits, i.e. TSS (%) and total sugars (%) under the same conditions of this study in 2017 and 2018 seasons.

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تأثير معدلات مختلفة من الأسمدة البوتاسية بطيئة التحلل على نمو وانتاجية نباتات الموز صنف وليامز

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الموجــــــز

أجريت هذة الدراسة خلال موسمى 2017و2018على الخلفة الأولى والثانية لنباتات الموز صنف وليامز النامية فى أرض رملية تحت نظام الرى بالتنقيط فى مزرعة خاصة بمنطقة التحدى، طريق مصر إسكندرية الصحراوى بمحافظة البحيرة – مصر . يهدف البحث الى دراسة تأثير معدلات مختلفة (100%– 75% –50 %) من الأسمدة البوتاسية بطيئة التحلل (50% أكسيد بوتاسيوم) والتى إضيفت فى ثلاثة مواعيد (نصف مارس– نصف يونيو – نصف سبتمبر)، بينما إضيف سماد سلفات البوتاسيوم شهريا من نصف مارس الى نصف أكتوبر وذلك على النمو الخضرى، الإنتاجية، إجمالى دخل وصافى عائد الفدان لنباتات الموز . أظهرت النتائج المتحصل عليها وجود تأثير معنوي لجميع المعاملات السابقة على تحسين النمو الخضرى المتمثل فى عدد الأوراق الخضراء على النبات، إجمالى مسطح النبات، محتوى الأوراق من الكلوروفيل وكذلك محتوى الأوراق من العناصر الكبرى (النيتروجين– الفوسفور– البوتاسيوم %) ومحتوى الأوراق من العناصر الصغرى (الحديد– الزنك– المنجنيز جزء فى المليون) وتحسين صفات المحصول المتمثل فى كمية المحصول (الطن/الفدان)، وزن السباطة (كجم)، عدد الكفوف فى السباطة، وزن الكف (كجم)، عدد الأصابع فى الكف، وزن الأصبع (جم)، طول الأصبع (سم)، محيط الأصبع (سم)، وزن اللب (جم)، نسبة اللب الى القشرة، المواد الصلبة الذائبة الكلية (%)، نسبة المواد الصلبة الذائبة الكلية الى الحموضة الكلية، السكريات الكلية (%)، إجمالى دخل الفدان (1000 جنية مصرى) وصافى عائد الفدان (1000 جنية مصرى) فى كلا الموسمين المتتاليين. بينما لم تؤثر جميع المعاملات السابقة تأثيرا معنويا على طول النبات (سم)، محيط النبات (سم) ومساحة الورقة (م^2) فى كلا الموسمين المتتاليين وكذلك على طول السباطة (سم) فى الموسم الأول. حققت معاملة الأسمدة البوتاسية بطيئة التحلل بمعدل 100% أعلى القيم للصفات الطبيعية والكيمائية لنباتات الموز صنف وليامز خلال موسمى الدراسة، مقارنة بمعاملة 100% سلفات بوتاسيوم و معاملة 50% أسمدة بوتاسية بطيئة التحلل والتى أظهرت أقل القيم وذلك تحت ظروف التجربة فى كلا الموسمين المتتاليين.

الكلمات المفتاحية: الموز، بوتاسيوم بطئ التحلل، النمو، الإنتاجية

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