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Effect of different rates of slow-release potassium fertilizers on growth and fruiting of banana var. Grand Nain plants

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Abstract

This study was carried out during the two successive seasons (2021and 2022) on the first and second ratoon of healthy uniform banana var. Grand Nain (*Musa* spp.), to study the effect of different slow-release potassium fertilizers (15% K_2O) on vegetative growth, productivity and fruit quality. Plants grown in silty clay soil under flood irrigation system in a private orchard at Al-Badari, Assiut, Egypt. The rates were (2, 4 and 8 kg slow-release potassium) + 400 g potassium sulphate / plant /year were added as soil drench during mid-March, mid-June and mid- September while, (1,6 kg) potassium sulphate dose used in control treatment was added at monthly intervals as soil application from mid-March until mid-October. The obtained results showed that, all treatments had a significant effect on enhancing the vegetative growth parameters, *i.e*. number of green leaves /plant and plant total leaf area (m^2 /plant). Also, improving yield, 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) and finger peel weight (g). Treatment of slow-release potassium at 8 kg + 400 g potassium sulphate gave the highest values of physical properties of banana plants (cv. Grand Nain) in both seasons compared to control treatment (1.6 kg potassium sulphate). On the light of previous results, it could be concluded that fertilizing the banana by K fertilization via slow-release form to get high yield with good fruit quality.

Keywords: banana, Grand Nain, slow-release potassium, potassium sulphate, growth, productivity.

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1. Introduction

In Egypt, banana plants are considered as the 4th largest fruit crops as total cultivated area, following citrus, mango and grapes. The total area of banana increased up to 77848 feddan (feddan = 4200 m² = 0.420 hectares = 1.037 acres), producing 1,212,568 tons with average of 18.376 tons/feddan according to the statistics of Egyptian, Ministry of Agriculture and Land Reclamation (M.A.L.R, 2022). The Grand Nain banana is one of the most commonly cultivated bananas and a member of the commercial Cavendish banana Variety group. Banana plants need a large amount of fertilization elements especially potassium (Kumar and Kumar, 2008). 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 (Godoy *et al*., 2018; Mendes *et al*., 2016). 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 (Borges, 2004; Kirkby, 1987; Millik *et al*., 2018; Patel *et al*., 2017; Ram and Prasad, 1988; Tuner and Barkus, 1983). 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 under-ground water (Abo-Hamda *et al*., 2020). 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). 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, as well as to control and continues providing of the trees with their requirements of K (Bettage and Ben Moimoun, 2008; Godoy *et al*., 2018; Ng *et al*., 2016; Oliveira *et al*., 2013; Soti *et al*., 2015). Therefore, this study aimed to investigate the effect of slow-release potassium fertilizer on vegetative growth and fruiting of Grand Nain banana plants.

2. Materials and methods

2.1 Experimental site and treatments description

Thirty-six healthy uniform plants of banana Grand Nain cultivar (*Musa* spp.) grown in silty clay soil under flood irrigation system in a private orchard at Al-Badari, Assiut, Egypt. Suckers planted as distance of (3.5 × 3.5) meters apart, each hole content three suckers (1028 plants/feddan) and selected during the three successive seasons 2021 (first ratoon plants) and 2022 (second ratoon plants). The soil samples were collected from different locations in the plantation at 0-30 and 30-60 cm depths then analysed for physical and chemical properties according to Wilde *et al*. (1985) and the obtained data are shown in Table (1).

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

Characters	Values	Characters	Values
Particle size distribution		Total N (%)	0.16
Sand (%)	15.40	Available P (ppm, Olsen)	4.22
Silt (%)	50.50	Available K (ppm, ammonium acetate)	310
Clay (%)	34.10	Available S (ppm)	3.11
Texture	Silty clay	Available EDTA extractable micronutrients (ppm)	
PH (1:2.5 extract)	7.29	Zn	11.49
EC (1:2.5 extract) mmos/1cm/25ºC	0.74	Fe	9.11
O.M %	1.73	Mn	10.1
CaCo3 %	1.80	Cu	1.05

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

- A1: 1.6 kg control potassium sulphate /plant /year.
- A2: 2 kg slow-release potassium + 400 g potassium sulphate /plant /year.
- A3: 4 kg slow-release potassium + 400 g potassium sulphate / plant /year.
- A4: 8 kg slow-release potassium + 400 g potassium sulphate /plant /year.

Slow-release potassium fertilizer (15% K_2O) rates (2, 4 and 8 kg) + 400 g potassium sulphate / plant /year 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 studied seasons. Each treatment contained three replicates, and each replicate had three plants.

2.2 Data recorded

Samples of three plants of each experimental plot were taken to determine growth parameters at the end of the season as follows:

2.2.1 Vegetative growth parameters

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

1- Pseudostem height (cm) from the soil surface to emergence of the first leaf.
2- Pseudostem circumference (cm) at 20 cm above soil surface.
3- Leaf area (m^2) on the third expanded leaf from the top using the following equation: Leaf area (m^2) = Length × Width × 0.8 according to Murry (1960).
4- Leaves number per plant at bunch shooting.
5- Total assimilation area (m^2/plant) was deter-mined using the equation: Total assimilation area (m^2/plant) = leaf area × number of green leaves per plant (Ibrahim, 1993).

2.2.2 Yield and fruit physical characteristics

Bunches were harvested at the green maturity stage during the period from November to January in both seasons

which the bunch (or fruits) were suitable (when fingers full mature stage). Then to estimate the following fruit physical characteristics for each treatment as follows: Yield (ton /feddan), bunch weight (kg), hand number/bunch, hand weight (kg), finger weight (g) and finger pulp percentage as well as finger length and circumference (cm).

2.3 Experimental design and statistical analysis

All obtained data were tabulated and statistically analyzed according to Mead *et al.* (1993) by using computer program of Statistic version 9 (Analytical Software, 2008). The differences between the means were tested using L.S.D test at 5 %.

3. Results and Discussion

3.1 Vegetative growth traits

Data showed that in Table (2), all vegetable growth of Grand Nain banana plants *i.e*., pseudostem height, and pseudostem circumference were significantly affected by treatments, although a slight increase was detected in all treatments compared to control in both seasons. Whereas green pseudostem circumference was greatly affected by the studied slow-release fertilizer treatments in (2021 and 2022) seasons. The highest green pseudostem circumference (18.67 cm, 20.23 cm) were recorded by 8 kg slow-release potassium + 400 g potassium sulphate /plant /year in both seasons respectively. On the other hand, the lowest values of this parameter were scored by 2 kg slow-release potassium + 400 g potassium sulphate /plant /year, compared with control treatment 1.6 kg control potassium sulphate in both seasons, respectively. The highest green pseudostem circumference may be due to the continues of supply plants by K ions from slow-release potassium fertilizer, it activates at least (60) different enzymes such as (RuBP carboxylase enzyme) and enhances protein content in-volved in plant growth (Marschner, 1995). These findings are in accordance with those obtained by Oliveira *et al.* (2013), Soti *et al.* (2015), and Abo-Hamda *et al.* (2020).

Table (2): Effect of different slow-release potassium fertilizer rates on pseudostem height, numder of green leaves/ plant and pseudostem circumference (cm) of banana var. Grand Nain' in 2021 and 2022 seasons.

Treatments	Pseudostem height (cm)			Pseudostem circumference (cm)			Pseudostem height (cm)		
	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means
A1	303.33	311.67	307.50	73.33	74.00	73.67	12.33	14.00	13.17
A2	310.67	314.00	312.33	75.67	77.00	76.33	15.67	15.67	15.67
A3	314.00	317.00	315.50	81.00	82.00	81.50	16.33	16.33	16.33
A4	322.33	338.00	330.17	83.67	85.00	84.33	18.67	20.33	19.50
L.S.D 5 %	1.81	2.62		2.30	3.59		2.03	0.74	

3.2 leaf area (m^2), total leaf area (m^2), Finger length (cm)

Leaf area (m^2), total leaf area (m^2) and finger length (cm) of Grand Nain banana plants were positively responded to the studied treatments as shown in Table (3), the highest of total leaf area (36.47 and 41.34 m^2 /plant), and finger length (21.76 and 23.55 cm) were recorded by 8 kg slow-release potassium + 400 g potassium sulphate /plant /year 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 finger length may be due to the constant potassium supply from slow-release potassium which acted as an activator of several enzymes (Millik *et al*., 2018). The higher values of total leaf area (m^2 /plant) can be explained by the relation with the increment green leaves number /plant. The illustrated results were in agreement with Oliveira *et al*. (2013), Soti *et al*. (2015), Ng *et al*. (2016), Godoy *et al*. (2018), and Abo-Hamda *et al*. (2020).

Table (3): Effect of different slow-release potassium fertilizer rates on leaf area (m^2), total leaf area (m^2), finger length (cm) of banana var. Grand Nain' in 2021 and 2022 seasons.

Treatments	leaf area (m^2)			Total leaf area (m^2)			Finger length (cm)		
	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means
A1	1.82	1.87	1.84	22.40	26.14	73.67	16.54	18.21	17.38
A2	1.86	1.95	1.90	29.11	30.50	76.33	18.07	19.88	18.98
A3	1.87	1.95	1.91	30.50	31.90	81.50	19.24	21.03	20.14
A4	1.95	2.03	1.99	36.47	41.34	84.33	21.76	23.55	22.66
L.S.D 5 %	0.09	0.07		3.82	2.36		1.11	1.13	

3.3 Crop quality traits

3.3.1 Finger circumference (cm), finger weight (g) and finger pulp weight (g)

The data in Table (4) showed that the heaviest finger (165.24 and 182.08 g) and the highest finger circumference values (13.13 and 13.38 cm) were associated with 8 kg of slow-release potassium + 400 g potassium sulphate in both seasons. On the other hand, the lowest values were recorded by the control treatment 1.6 kg of potassium sulphate in both seasons respectively. The higher finger weight was associated with the higher finger pulp weight as in Table (4). In addition, the increased finger weight and finger circumference clearly indicated that potassium was involved in cell enlargement and that the increased finger circumference might be due to the continuous supply of potassium from (slow-release potassium) which acted as an activator for many enzymes (Millik *et al*., 2018). The results were confirmed by those obtained from Oliveira *et al*. (2013),

Ng *et al*. (2016), and Godoy *et al*. (2018). On the other hand, finger pulp weight and pulp /peel ratio were significantly affected by slow-release potassium fertilization treatments during the study as shown in Table (4), where plants fertilized with 8 kg of slow-release potassium + 400 g potassium sulphate gave significantly higher finger pulp weight (123.48 and 139.87 g). Whereas finger peel weight was not significantly affected by treatments in the two seasons respectively compared to the control treatment. On the other hand, the control treatment 1.6 kg of potassium sulphate recorded the lowest value of finger pulp weight (g) in the first season and the second season respectively. The increase in pulp /peel ratio due to increased potassium supply was mainly due to the increase in pulp weight which was a result of the pathological activity of enzymes involved in starch and protein synthesis (Patel *et al.*, 2017). These results were consistent with Oliveira *et al.* (2013), and Ng *et al.* (2016).

Table (4): Effect of different slow-release potassium fertilizer rates on finger circumference (cm), finger weight (g), finger pulp (%) and of banana var. Grand Nain in 2021 and 2022 seasons.

Treatments	Finger circumference (cm)			Finger weight (g)			Finger pulp (%)		
	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means
A1	12.38	12.56	12.48	147.10	158.16	152.63	65.13	65.35	65.24
A2	12.55	12.83	12.70	150.30	165.39	157.84	69.97	70.58	70.28
A3	12.77	13.04	12.91	156.16	174.52	165.34	72.17	72.59	72.38
A4	13.13	13.38	13.26	165.24	182.05	173.64	74.73	76.83	75.78
L.S.D 5 %	0.19	0.23		2.46	1.76		4.26	2.22	

3.3.2 Number of fingers /hand, number of hands /bunch, hand weight (kg) and bunch weight (kg)

The effect of different slow release potassium fertilizer treatments on number of hands /bunch, number of fingers /hand, hand weight (kg) and bunch weight (kg) were presented in Table (5), the data clearly indicated that, the highest number of fingers /hand (20.78 and 22.88 hands) number of hands /bunch (11.33 and 11.67 fingers) and the heaviest hand (3.05 and 3.59 kg) were recorded by treatment of 8 kg slow-release potassium + 400 g potassium sulphate /plant /year in both seasons, respectively compared with control treatment. However, the highest values of bunch weight (28.84 and 31.16 kg) were recorded by 8 kg slow-release potassium + 400 g potassium sulphate in both seasons, respectively. In reverse, the lowest values of these parameters were registered by control treatment 1.6 kg control potassium sulphate in both seasons. The highest number of hands /bunch, number of fingers /hand, hand weight and bunch 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*. (2013), Ng *et al*. (2016) and Godoy *et al*. (2018).

Table (5): Effect of different slow-release potassium fertilizer rates on number of fingers /hand, number of hands/ bunch, hand weight (kg) and bunch weight (kg) of banana var. Grand Nain' in 2021 and 2022 seasons.

Treatments	Number of fingers/hand			Number of hands/bunch			Hand weight (kg)			Bunch weight (kg)		
	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means	First season (2021)	Second season (2022)	Means
A1	14.95	16.57	15.76	10.67	11.00	10.83	2.09	2.55	2.32	21.90	22.82	22.36
A2	17.32	19.12	18.22	10.83	11.17	11.00	2.64	2.85	2.75	24.89	26.62	25.76
A3	19.04	20.81	19.92	11.00	11.33	11.17	2.92	3.02	2.97	26.42	28.18	27.30
A4	20.78	22.88	21.83	11.33	11.67	11.50	3.05	3.59	3.32	28.84	31.16	30.00
L.S.D 5 %	1.08	1.14		N.S	N.S		0.90	0.47		1.37	2.10	

3.4 Yield (ton/feddan)

Results given in Table (6), pointed out that, the highest yield (29.65 and 32.04 ton/feddan) were recorded by 8 kg slow-release potassium + 400 g potassium sulphate in the first and second seasons, respectively. In reverse, control treatment 1.6 kg control potassium sulphate scored the lowest values of these parameter 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 as shown in Table (4). Besides, the increase of yield was related to the increase in the bunch weight (Kumar and Kumar, 2008). These results are in agreement with the results obtained by Oliveira *et al*. (2013), Ng *et al*. (2016), and Godoy *et al*., 2018).

Table (6): Effect of different slow-release potassium fertilizer rates on yield (ton/feddan) of banana var. Grand Nain in 2021 and 2022 seasons.

Treatments	Yield (ton/feddan)		
	First season (2021)	Second season (2022)	Means
A1	22.52	23.46	22.99
A2	25.58	27.37	26.48
A3	27.16	28.97	28.06
A4	29.65	32.04	30.84
L.S.D 5 %	1.41	2.16	

4. Conclusion

From this study, it could be recommended that, Grand Nain banana plants fertilized with 8 kg slow-release potassium + 400 g potassium sulphate /plant /year recorded the highest values of yield (ton /feddan), also, enhanced quality of Grand Nain fruits, under the same conditions of this study in 2021 and 2022 seasons.

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