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Influence of growth regulator sprays on morphological, physiological, yield, and fruit quality traits of Grande Naine Bananas (*Musa cavendishii*) under Upper Egypt conditions

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Abstract

This study was conducted during the 2020 and 2021 growing seasons to evaluate the effects of spraying various growth regulators (Volex 250 ppm, Cytoking 250 ppm, Cytokinin 250 ppm, and Gibberellin 250 ppm) on the morphological, physiological, and yield characteristics, as well as the fruit quality of Grande Naine banana plants (*Musa cavendishii*) grown in Sohag, Egypt. The results showed significant improvements in pseudostem height, circumference, and the number of leaves per plant in treated plants compared to the control. The most notable increases in yield components, including the number of fingers and hands per bunch, hand weight, and bunch weight, were recorded in plants treated with Cytokinin 250 ppm, which showed statistically significant improvements over the control ($p < 0.05$). In terms of fruit quality, treatments with Volex and Cytoking at 250 ppm resulted in higher total soluble solids (TSS) and TSS/acid ratio, while lowering fruit acidity compared to untreated plants. Based on these findings, we recommend the use of Cytokinin 250 ppm to enhance banana yield and fruit quality under the environmental conditions of Upper Egypt.

Keywords: *Musa sp.*, growth regulators, morphological traits, physiological traits, yield, fruit quality.

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1. Introduction

Banana (*Musa spp.*) is a monocotyledonous plant classified in the Musaceae family, which includes two genera: *Musa* and *Enset*. The genus *Musa* produces edible bananas and includes two significant species, *Musa sapientum* and *Musa cavendishii* (Purseglove, 1972; Stover and Simmonds, 1987). Bananas are among the most important fruit crops in tropical and subtropical regions due to their high nutritional value, providing sugars, vitamins, and minerals. Banana plants are herbaceous, growing between 2 to 9 meters in cultivated varieties, and up to 15 meters in some wild species. The plant consists of an underground stem, or corm, which supports the pseudostem, leaves, and inflorescence. The pseudostem is made of tightly rolled leaf sheaths that form a firm cylindrical structure. Bananas are monocarpic, meaning each shoot flowers and fruits only once before dying. New shoots, called suckers, perpetuate the plant's life cycle (Purseglove, 1972; Stover and Simmonds, 1987). In Egypt, bananas are a popular and valuable fruit crop. As of 2020, the total cultivated area for bananas was about 74,112 feddans, with a fruiting area of 72,812 feddans, producing approximately 1,347,000 tons of bananas (Ministry of Agriculture A.R.E., 2020). The productivity of banana cultivation is vital for both local consumption and market pricing. Growth regulators play a crucial role in enhancing banana productivity, particularly by increasing the weight of bunches and individual fruits. This, in turn, improves both the marketable yield and the economic return for farmers (Khodair and

Radwan, 2018). The aim of this study was to evaluate the effect of different growth regulators on the morphological and physiological traits, yield components, and fruit quality of Grande Naine bananas grown under the environmental conditions of Sohag, Egypt. By applying specific growth regulators, we seek to identify optimal treatments for improving banana yield and fruit quality in this region.

2. Materials and methods

This study was conducted during the 2020 and 2021 growing seasons on second and third ratoon plants of Grande Naine bananas (*Musa cavendishii*) at a private farm in Alkhiam village, Sohag governorate, Egypt. All banana plants were of similar age and growth, and received standard agricultural practices, including fertilization and irrigation. The study aimed to investigate the effects of different growth regulators on the plants' morphological, physiological, and yield characteristics, as well as fruit quality. The experiment consisted of five treatments, including a control group (sprayed with water) and four growth regulator treatments:

- Volex 250 ppm (Cytokinin 4%, Auxin 4%),
- Cytoking 250 ppm (Cytokinin 4%, Auxin 4%),
- Cytokinin 250 ppm.
- Gibberellin 250 ppm.

Banana plants were spaced 3.5×3.5 meters apart under loamy soil conditions

and irrigated using the flood system. Growth regulators were applied as foliar sprays four times during each growing season: mid-March, mid-April, mid-May, and mid-June (Ashraf *et al.*, 2018). Each treatment was replicated three times with five plants per replicate. The second ratoon plants were selected in the first week of April 2019, and the third ratoon plants in the same week of April 2020.

2.2 Measurements

2.2.1 Morphological characteristics

Number of leaves per plant was recorded throughout the plants' life span. Pseudostem height (cm) was measured from ground level to the neck of the inflorescence using a measuring tape, and pseudostem circumference (cm) was recorded at the base, middle, and top of the pseudostem, with the average value calculated (Ashraf *et al.*, 2018).

2.2.2 Physiological characteristics (Flowering indices)

Time of inflorescence emergence (days) was calculated as the number of days from the first treatment on March 15 until the date of inflorescence emergence. Number of bracts per inflorescence and number of hands per bunch were recorded after the complete opening of the inflorescence.

2.2.3 Yield characteristics

Number of fingers per bunch was

calculated by multiplying the mean number of fingers per hand by the number of hands per bunch. Bunch weight (kg) was measured by cutting the stalk above the first hand and weighing the bunch immediately. The second hand of each bunch was also weighed (Alvarez *et al.*, 2001).

2.2.4 Fruit quality

Total soluble solids (TSS%) were measured using a hand refractometer at the ripe stage. Total acidity (%) was determined by titrating with 0.1 N sodium hydroxide using phenolphthalein as an indicator (A.O.A.C., 1995). TSS/acid ratio was calculated by dividing the TSS value by the acidity percentage.

2.3 Experimental design

The experiment followed a randomized complete block design (RCBD) with five replicates. Data collected were subjected to analysis of variance (ANOVA), and significant differences among means were determined according to the method described by Gomez and Gomez (1984).

2.4 Statistical analysis

All collected data were analyzed using ANOVA, and significant differences between treatments were assessed using the least significant difference (LSD) test at the 5% level of significance (Gomez and Gomez, 1984).

3. Results and Discussion

3.1 Morphological characteristics

The application of growth regulators significantly impacted the morphological traits of the Grande Naine banana plants during both the 2020 and 2021 seasons. As shown in Table (1), plants treated with Volex at 250 ppm recorded the highest pseudostem height (316 cm in 2020 and 310 cm in 2021) and pseudostem circumference (79 cm in 2020 and 86 cm in 2021), followed closely by Cytokinin at 250 ppm. The control group had the lowest values, with pseudostem heights of 267 cm (2020) and 269 cm (2021) and pseudostem circumferences of 70 cm (2020) and 74 cm (2021). These results are consistent with findings by Amin *et al.* (2016) and Dahab *et al.* (2018), who observed that the use of growth regulators promoted better vegetative growth in banana plants by enhancing cell division

and elongation.

3.2 Physiological characteristics (Flowering indices)

Table (2) highlights the effects of growth regulators on flowering indices. The time to inflorescence emergence and harvesting was shortened by treatments, particularly with Volex at 250 ppm, which recorded the lowest number of days from treatment to harvest (234 days in 2020 and 254 days in 2021) compared to the control (243 days in 2020 and 276 days in 2021). There was also an increase in the number of bracts per inflorescence, with plants treated with Cytoking at 250 ppm and Volex at 250 ppm showing the highest numbers. These results align with those reported by Hassan *et al.* (2009) and Tekle *et al.* (2014), who noted similar effects of growth regulators on the early emergence of inflorescences and enhanced floral development.

Table (1): Morphological characteristics as affected by spraying growth regulators on Grande Naine Banana plants during 2020 and 2021 seasons.

Treatment	Pseudostem height (cm)		Pseudostem circumference (cm)		Number of leaves (per plant)	
	2020	2021	2020	2021	2020	2021
Control	267	269	70	74	32	30
Volex 250 ppm	316	310	79	86	32	35
Cytoking 250 ppm	301	302	77	80	30	35
Cytokinin 250 ppm	310	309	77	81	30	35
Gibberellin 250 ppm	279	294	72	79	30	35
LSD at 5%	18.4	12.4	6.04	7.6	n.s	3.8

Table (2): Physiological characteristics (Flowering indices) as affected by spraying growth regulators on Grande Naine Banana plants during 2020 and 2021 seasons.

Treatment	Time of inflorescence emergence (days)		Number of Bracts per inflorescence		Time of harvesting (days)	
	2020	2021	2020	2021	2020	2021
Control	139	144	10	9	243	276
Volex 250 ppm	123	136	12	11	234	254
Cytoking 250 ppm	131	141	12	12	244	257
Cytokinin 250 ppm	123	140	11	12	233	262
Gibberellin 250 ppm	126	143	11	10	233	262
LSD at 5%	n.s.	n.s	1.31	1.06	n.s	n.s

3.3 Yield characteristics

The yield data presented in Tables (3) and (4) indicate a significant increase in the number of fingers and hands per bunch, hand weight, and bunch weight in treated plants compared to the control. Volex at 250 ppm recorded the highest bunch weight (36 kg in both seasons), followed

by Cytoking at 250 ppm (33 kg in both seasons). The control group had the lowest bunch weight (25 kg in 2020 and 21 kg in 2021). These findings are in agreement with Ebeed and Saleh (2008) and Khodair and Radwan (2018), who reported that growth regulators significantly enhance yield components, especially the weight of the bunch and individual hands.

Table (3): Yield and its components (number of fingers and hands per bunch) as affected by spraying growth regulators on Grande Naine banana plants during 2020 and 2021 seasons.

Treatment	Number of fingers per bunch		Number of hands per bunch	
	2020	2021	2020	2021
Control	208	209	10	9
Volex 250 ppm	239	237	12	11
Cytoking 250 ppm	242	226	12	12
Cytokinin 250 ppm	248	234	11	12
Gibberellin 250 ppm	230	230	11	10
LSD at 5%	20.25	17.74	1.31	1.06

Table (4): Yield and its components (hand and bunch weight in kg) as affected by spraying growth regulators on Grande Naine Banana plants during 2020 and 2021 seasons.

Treatment	Hand weight (kg)		Bunch weight (kg)	
	2020	2021	2020	2021
Control	2.47	2.50	25	21
Volex 250 ppm	3.20	2.90	36	36
Cytoking 250 ppm	3.03	2.70	33	33
Cytokinin 250 ppm	3.03	2.63	35	35
Gibberellin 250 ppm	2.97	2.50	29	29
LSD at 5%	0.33	0.28	4.01	3.23

3.4 Fruit quality

Table (5) shows the effect of growth regulators on fruit quality. Treatments with Cytoking and Cytokinin at 250 ppm improved the total soluble solids (TSS) content and TSS/acid ratio, while reducing acidity levels compared to the control. The maximum TSS/acid ratio was

recorded in plants sprayed with Cytoking at 250 ppm (26.40 in 2020 and 37.62 in 2021), indicating better fruit sweetness and overall quality. These results align with those of Hassan et al. (2009) and Khodair and Radwan (2018), who also observed improvements in fruit quality attributes with the application of growth regulators.

Table (5): Quality (TSS, acidity, and TSS/acid ratio) as affected by spraying growth regulators on Grande Naine banana plants during 2020 and 2021 seasons.

Treatment	TSS (%)		Acidity (%)		TSS/Acidity ratio	
	2020	2021	2020	2021	2020	2021
Control	13.5	14.8	0.641	0.620	21.06	23.89
Volex 250 ppm	15.9	15.6	0.819	0.823	19.41	18.96
Cytoking 250 ppm	15.6	15.8	0.590	0.428	26.40	37.62
Cytokinin 250 ppm	15.3	15.4	0.486	0.521	31.81	27.56
Gibberellin 250 ppm	12.3	13.0	0.610	0.548	20.16	23.72
LSD at 5%	0.72	0.59	0.022	0.033	3.11	3.57

4. Conclusion

The use of growth regulators, particularly Cytokinin and Volex at 250 ppm, significantly improved the morphological, physiological, yield, and fruit quality characteristics of Grande Naine banana plants. These treatments are recommended for enhancing banana productivity and fruit quality under the environmental conditions of Upper Egypt.

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