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Impact of Dehanding and Growth Regulators Spray on Yield Characteristics of Banana cv. Grand Naine

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ABSTRACT

The experiment was conducted during August, 2023–May, 2024 at Banana Research Station, Pulivendula, Andhra Pradesh, India to study the effect of dehanding and growth regulators spray on yield characteristics of Banana cv. Grand Naine. The experiment consists of four dehanding treatments (D_1: 8 hands after dehanding, D_2: 9 hands after dehanding, D_3: 10 hands after dehanding, D_4: no dehanding) and three growth regulator sprays (T_1: GA_3 50 ppm+CPPU 4 ppm, T_2: GA_3 100 ppm+CPPU 4 ppm, T_3: water spray). The results showed that maximum finger length (21.23 cm), girth (11.84 cm), diameter (4.08 cm), finger weight (182.20 g) and hand weight (2.34 kg) were recorded in bunches retained with 8 hands after dehanding. Bunches retained with 10 hands after dehanding produced the highest bunch weight (23.57 kg) and maximum yield ha^{-1} (78.55 t ha^{-1}). The application of GA_3 50 ppm+CPPU 4 ppm recorded maximum finger length (20.40 cm), girth (10.97 cm), diameter (3.10 cm), finger weight (176.80 g), hand weight (2.20 kg), bunch weight (22.73 kg) and yield ha^{-1} (75.77 tons). The interaction of retaining 8 hands $bunch^{-1}$ after dehanding and bunch spray with GA_3 50 ppm+CPPU 4 ppm resulted in maximum finger length (22.61 cm), girth (12.58 cm), diameter (4.36 cm), finger weight (192.60 g), hand weight (2.54 kg). Maximum bunch weight (24.32 kg) and total yield ha^{-1} (81.05 tons) was found in combination of retaining 10 hands $bunch^{-1}$ after dehanding with bunch spray of GA_3 50 ppm+CPPU 4 ppm.

KEYWORDS: Grand naine, dehanding, GA_3, CPPU, banana, bunch weight

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

In India, bananas rank first in production and third in area among all fruit crops. It is the world's largest banana producer, contributing 19.37% of global banana output. In 2023–24, approximately 993 thousand hectares were dedicated to banana cultivation in India, yielding an estimated 37,378 thousand metric tons nationwide. Although India is the largest banana exporter, it exports only 0.3% of its total production. In 2022–23, Indian banana exports were valued at USD 176 million, or approximately 1,472 crore rupees (Anonymous, 2022–23). Major banana producers include China, the Philippines, Ecuador, Indonesia, Brazil, Mexico, Guatemala, and Colombia. Global banana exports are valued at approximately US$13.8 billion, with 20.07 million tonnes traded worldwide, and the Grand Naine variety alone represents over 90% of this global trade (Selvarajan et al., 2022).

Dry matter content is closely linked to water and photosynthate production. Changes in fruit load are known to affect the supply of carbohydrates available for fruit growth and dry matter content (Aly et al., 2018, Anjum et al., 2020). In many fruit trees, pruning or thinning out fruits improves their colour, taste, and appearance, reduces the risk of branches breaking, and boosts the tree's overall health. The timing and extent of thinning are crucial for improving fruit growth and size. Thinning earlier and more intensely results in larger fruits at harvest (Upreti et al., 2019, Zhang et al., 2024). When too many fruits grow on a plant, they compete for nutrients and energy, which limits their size. To prevent this, some fruits are removed (Simpson et al., 2021). Thinning may boost the activity of genes that produce auxin and GA, leading to more IAA and GA_3, which help with cell division and growth (Cong et al., 2022, Wagle et al., 2022). The larger average fruit size and weight may be due to the removal of smaller, lateral fruits during thinning (Thakur and Chandel, 2004, Villagra et al., 2024).

In banana removing the male bud and some smaller hands from banana bunches shortly after flowering, can help increase the size and quality of the remaining fruits (Rodriguez et al., 1988). In banana optimal growth conditions for bunch trimming is early fruit pruning, i.e. before the end of cell division, improves the dry weight of fruit more than late fruit pruning (Sarkar et al., 2015). In banana bunches, the smaller hands at the bottom often don't grow to a sellable size. These hands also consume energy and dry matter that could go to the larger hands. Removing them ensures the remaining hands grow bigger and better (Wankhade et al., 2023).

The increase in size of fruit may result from cell enlargement, driven by the synthesis of enzymes that weaken the cell wall, allowing for cell elongation. GA_3 play a role in inducing the synthesis of specific DNA-dependent mRNA and enzymatic proteins, which enhance cell plasticity and extension, ultimately leading to cell enlargement (Thakur et al., 2015, Talat et al., 2020, Sharma et al., 2020, Thakur et al., 2023).

Forchlorfenuron (CPPU), is a synthetic cytokinin with a phenyl urea structure (Arima et al., 1995). CPPU has been shown to effectively increase fruit size in various fruit crops. The enhancement of fruit size by CPPU is attributed to its ability to stimulate cell division in the early phases of fruit development and promote cell enlargement in the later stages (Susila et al., 2013).

The use of chemical and plant bio-regulators enhances the production of photosynthates and their movement to the fruits, which could contribute to the increased fruit size. (Bal et al., 1984, Bhati and Yadav, 2003, Sharma and Tiwari, 2015, Thakur et al., 2017). The study was aimed to investigate the effect of dehanding and application of growth regulators in Banana cv. Grand Naine on yield and fruit quality.

2. MATERIALS AND METHODS

2.1. Experimental design

The experiment was conducted during August, 2023–May, 2024 at Banana Research Station in Pulivendula, Andhra Pradesh, India (14°27'57.7"N, 78°12'54.8"E). Tissue culture plants of the Grand Naine banana variety were planted at a spacing of 1.8×1.8 m^2 using a Factorial Randomized Block Design. The experiment consists of four dehanding treatments (D_1: 8 hands after dehanding, D_2: 9 hands after dehanding, D_3: 10 hands after dehanding, D_4: no dehanding) and three growth regulator sprays (T_1: GA_3 50 ppm+CPPU 4 ppm, T_2: GA_3 100 ppm+CPPU 4 ppm, T_3: water spray). All plants received uniform fertilizer application and care throughout the experiment. In this experiment, growth regulators GA_3 at concentrations of 50 ppm and 100 ppm, along with CPPU at 4 ppm, were sprayed on the banana bunches immediately after the opening of last hand and 15 days later (second application). Dehanding, or bunch trimming, involved removing the smaller, lower-value hands to enhance nutrient allocation to the remaining fruits, thereby improving growth and export quality. Dehanding was done one week after the opening of last hand, using a knife or sickle. Data were collected on bunch weight, hand weight, no. of fingers $bunch^{-1}$, no. of fingers $hand^{-1}$, finger length, girth, diameter, finger weight, and yield ha^{-1} after harvesting.

2.2. Statistical analysis

The yield data were analysed using the methods outlined by Panse and Sukhatme (1978) for a Factorial Randomized Block Design (FRBD). The analysis of variance was

performed, and the F value was used to determine significance at the 5% level.

3. RESULTS AND DISCUSSION

The different dehanding treatments and growth regulator sprays on bunches in banana showed significant differences in respect of bunch weight, hand weight, fruit weight, no. of fruits bunch^{-1}, length of the fruit, girth of the fruit and yield hectare^{-1} (Table 1).

Bunches retained with ten hands after dehanding produced significantly maximum bunch weight (23.57 kg), Among growth regulator treatments, the highest bunch weight of 22.73 kg was observed in bunches sprayed with GA_3 50 ppm+CPPU 4 ppm , Bunches sprayed with water produced the lowest weight (20.26 kg), Regarding interactions, bunches retained with ten hands and sprayed with GA_3 50 ppm+CPPU 4 ppm recorded the maximum bunch weight of 24.32 kg, Increased bunch weight is often attributed to growth regulator sprays, which enhance photosynthesis, improve nutrient mobilization, and support the accumulation of quality components. Trimming optimizes nutrient use, directing resources to the remaining fruits rather than

Table 1: The effect of dehanding and bunch spray of GA_3 and CPPU on yield of banana cv. grand naine

Treatments	Bunch weight (kg)	Hand weight (kg)	Number of fingers bunch^{-1}	Number of fingers hand^{-1}	Finger length (cm)	Finger girth (cm)	Finger diameter (cm)	Finger weight (g)	Yield (t ha^{-1})
Dehanding (D)									
D_1	21.58	2.34	163.57	25.60	21.23	12.81	4.08	182.20	71.94
D_2	22.24	2.13	168.07	24.98	20.34	11.42	3.64	175.43	74.12
D_3	23.57	1.87	174.57	24.84	18.07	10.28	3.27	164.10	78.55
D_4	19.09	1.72	159.11	24.69	16.59	9.74	3.10	147.95	63.63
SEm±	0.12	0.02	0.20	0.36	0.09	0.10	0.031	0.40	0.39
CD (p=0.05)	0.35	0.06	0.56	NS	0.28	0.28	0.09	1.04	1.15
Growth regulators (T)									
T_1	22.73	2.20	166.54	25.15	20.40	11.77	3.75	176.80	75.77
T_2	21.86	2.04	166.33	25.09	19.18	11.18	3.56	166.90	72.86
T_3	20.26	1.80	166.12	24.86	17.60	10.23	3.26	158.60	67.55
SEm±	0.10	0.02	0.20	0.31	0.08	0.08	0.027	0.30	0.34
CD (p=0.05)	0.30	0.05	NS	NS	0.24	0.24	0.08	0.90	1.01
Interaction D×T									
D_1T_1	22.47	2.54	164.00	25.84	22.61	13.68	4.36	192.60	74.90
D_1T_2	21.83	2.39	163.38	25.43	21.28	13.10	4.17	182.20	72.78
D_1T_3	20.44	2.08	163.32	25.54	19.80	11.64	3.71	171.80	68.13
D_2T_1	23.07	2.35	167.90	24.85	21.79	12.21	3.90	180.20	76.90
D_2T_2	22.81	2.21	168.32	24.93	20.81	11.48	3.65	176.10	76.02
D_2T_3	20.83	1.82	168.00	25.16	18.42	10.56	3.36	170.00	69.44
D_3T_1	24.32	1.98	175.00	24.76	19.45	11.03	3.51	177.30	81.05
D_3T_2	23.87	1.88	174.44	25.09	17.93	10.30	3.28	161.50	79.57
D_3T_3	22.51	1.76	174.26	24.67	16.84	9.51	3.03	153.50	75.03
D_4T_1	21.07	1.91	159.26	25.13	17.73	10.17	3.24	157.00	70.23
D_4T_2	18.92	1.69	159.18	24.90	16.71	9.85	3.14	147.90	63.08
D_4T_3	17.27	1.56	158.90	24.06	15.34	9.20	2.93	138.90	57.58
SE (m)	0.20	0.03	0.30	0.62	0.16	0.17	0.053	0.60	0.68
CD (p=0.05)	0.64	0.11	NS	NS	0.51	0.52	0.16	1.82	2.06

D_1: 8 hands after dehanding; D_2: 9 hands after dehanding; D_3: 10 hands after dehanding; D_4: no dehanding; T_1: GA_3 50 ppm+CPPU 4 ppm; T_2: GA_3 100 ppm+CPPU 4 ppm; T_3: Water spray

unneeded parts of the bunch These effects contribute to improved physical attributes, such as increased fruit weight and size, ultimately resulting in higher yields. These findings were in line with results by Singh et al. (2017) in mango, Chaturvedi et al. (2005) in strawberry, Badal and Tripathi (2021) in guava, and Gupta et al. (2022). Baiyeri et al. (2010) suggested that pruning improves fruit quality by reducing the number of fruits, allowing more nutrients to concentrate on the remaining ones. The growth of banana fruits depends on the changing balance between sources (like leaves) and sinks (like fruits) during development. Studies show that adjusting the source to sink balance affects fruit growth differently, possibly due to variations in fruit age when treatment is applied (Jullien et al., 2001a).

Retention of eight hands bunch^{-1} after dehanding produced the maximum hand weight (2.34 kg), finger length (21.23 cm), girth (12.81 cm), diameter (4.08 cm), and fruit weight (182.20 g). Among growth regulator treatments, bunch spray of GA_3 50 ppm+CPPU 4 ppm resulted in the highest hand weight of (2.20 kg) finger length (20.40 cm), girth (11.77 cm), diameter (3.75 cm) and fruit weight (176.80 g). The highest mean no. of fingers bunch^{-1} (174.57) was observed when ten hands bunch^{-1} were retained after dehanding. However, growth regulator sprays alone, as well as the interaction between dehanding and growth regulator sprays, with reference to No. of fingers bunch^{-1} were non-significant. With regard to interaction effects the treatment combination of retention of eight hands bunch^{-1} after dehanding and bunch spray of GA_3 50 ppm+CPPU 4 ppm showed maximum hand weight (2.54 kg) maximum finger length (22.61 cm), girth (13.68 cm), diameter (4.36 cm) and weight (192.60 g). The number of fruits on a plant plays a significant role in determining fruit size variations (Park and Park, 1997). The increase in finger length, girth and weight after removing the terminal hands is likely due to the redistribution of dry matter among the remaining hands of the bunch, which aids in increasing their size.

In commercial fruit production, thinning is often practiced to enhance fruit size, as it leaves only the larger fruits on the plant and reduces competition for water, nutrients, and carbohydrates among the remaining fruits. Thinning treatments promoted faster fruit growth and expansion than the control, leading to larger fruits. Studies by Ulger et al. (2004) and Kumar (2014) indicate that fruit growth and size are influenced by the plant's endogenous hormone levels. Research has shown that cell division and growth in fruits are closely linked to these hormonal changes (Zhang et al., 1994; Pozo, 2001). Bunches treated with GA_3 50 ppm+CPPU 4 ppm showed the highest finger length, girth, and weight compared to those sprayed with GA_3 100 ppm+CPPU 4 ppm, or water alone. This increase in fruit size may be due to cell enlargement, driven by enzymes that weaken the cell wall, facilitating cell elongation. GA_3 contributes for promoting the synthesis of specific DNA-dependent mRNA and enzymes, enhancing cell plasticity and extension, which ultimately leads to cell enlargement (Teale et al., 2006; Mesejo et al., 2016). These results align with the findings of Jaykumar et al. (2010). Forchlorfenuron (CPPU), a synthetic cytokinin having phenyl urea structure (Arima et al., 1995), effectively increase fruit size across various fruit crops. CPPU enhances fruit size by stimulating cell division in the early stages of fruit development and promoting enlargement of cell in later stages. The use of these chemical and plant growth regulators also boosts the production and movement of photosynthates to the fruits, which likely contributed to the increased fruit size observed in this study. The yield ha^{-1} was significantly impacted by dehanding, growth regulators, and their interactions. Results showed that banana bunches retaining ten hands after dehanding (D_3) produced the highest yield of 78.55 t ha^{-1}, while the lowest yield of 63.63 t ha^{-1} was observed in the control (D_4). Among the treatments, bunches sprayed with GA3 50 ppm and CPPU 4 ppm (T_1) yielded 75.77 t ha^{-1}, while the minimum yield of 67.55 t ha^{-1} was recorded for bunches sprayed with water (T_3). Regarding interactions, the highest yield of 81.05 t ha^{-1} was achieved by the combination (D_3T_1), where bunches retained ten hands after dehanding and were sprayed with GA_3 50 ppm+CPPU 4 ppm. The lowest yield of 57.58 t ha^{-1} was recorded in bunches with no dehanding and water spray (D_4T_3).

Retaining eight hands bunch^{-1} after dehanding and spraying with GA_3 50 ppm+CPPU 4 ppm (D_1T_1) resulted in larger fruit sizes, although the overall yield decreased due to fewer fruits bunch^{-1} and maximum yield was recorded in the bunches retained with a greater number of hands. The decrease in yield after thinning in kiwi occurs because thinning reduces the total no. of fruits on the vine (Xiloyannis et al., 1997; Park and Park, 1997). Fruit yields were much lower in trees that were heavily thinned, with 30–46% of the crop removed.

4. CONCLUSION

The use of GA_3 and CPPU significantly increased yield attributes in banana. Retaining 8 hands bunch^{-1} along with GA_3 50 ppm+CPPU 4 ppm spray (D_1T_1) showed maximum fruit length, girth, diameter, weight, hand weight whereas (D_3T_1) bunches with ten hands and GA_3 50 ppm+CPPU 4 ppm bunch spray showed maximum bunch weight, yield ha^{-1}. The combination of retaining 8 hands bunch^{-1} after dehanding and spray with GA_3 50 ppm+CPPU 4 ppm enhanced yield attributes when compared with other treatments.

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