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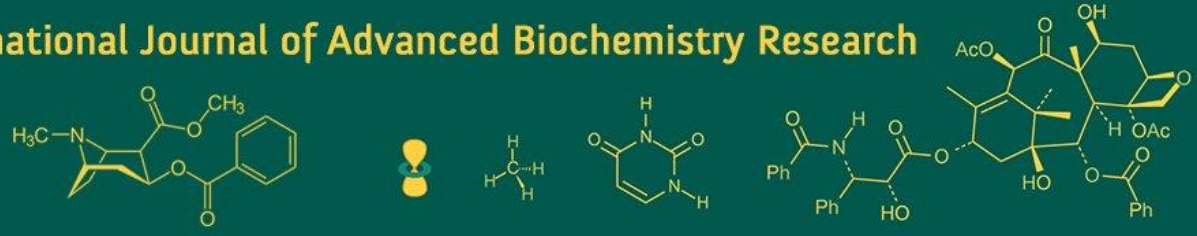

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Effect of Plant Growth Regulators (PGRs) and growing media on macropropagation of banana (*Musa* spp.) cv. Grand Naine

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Abstract
The present research entitled "Effect of Plant Growth Regulators (PGRs) and growing media on macropropagation of banana (*Musa* spp.) cv. Grand Naine" was carried out during April to August 2025 at research farm of Dr. YSRHU – Banana Research Station, Pulivendula (semi-arid southern agro-climatic zone, Andhra Pradesh). The experiment was laid out in a Factorial Completely Randomised Design (FCRD) with sixteen treatment combinations and three replications per treatment to assess the influence of plant growth regulators (PGRs) and growing media on macropropagation of banana (*Musa* spp.) cv. Grand Naine. Factor -I represents Plant Growth Regulators (T) which includes T_1 – 40 ppm BAP (6-Benzylaminopurine), T_2 – 50 ppm BAP, T_3 – 60 ppm BAP, T_4 – 250 ppm IBA, T_5 – 300 ppm IBA, T_6 – 10 ppm GA_3, T_7 – 20 ppm GA_3 and T_8 – control. Factor -II represents Growing media (G) which includes G_1 – Cocopeat and G_2 – Sawdust. Among PGRs, 60 ppm BAP (T_3) significantly accelerated initiation of primary suckers (18.95 days), secondary suckers (58.70 days) and produced the highest number of primary suckers (4.87), secondary suckers (16.72), and total suckers (21.60) per rhizome. Cocopeat outperformed sawdust in earlier sucker initiation and higher sucker counts. A significant interaction was noted for days taken for initiation of primary suckers, number of secondary suckers, and total sucker number, with (T_3G_1) 60 ppm BAP + cocopeat yielding optimal results. The findings demonstrated that BAP's efficacy in overcoming apical dominance, facilitating bud break, and improving sucker proliferation. This has promising implications for cost-effective banana macropropagation in semi-arid regions.

Keywords: Banana macropropagation, Grand Naine, BAP (6-Benzylaminopurine), growing media

Introduction
Banana (*Musa* spp.), belonging to the family Musaceae with a chromosome number of 2n = 22, originated in the Indo-Malayan (Southeast Asia) region. The name "banana" is derived from the Arabic word *banana*, meaning "finger." It is also known by various names such as "Adam's fig," "Kalpataru," "Tree of Wisdom," and "Apple of Paradise." In India, it is often referred to as the "Fruit of the Wise Men" (Bose, 2001) [2]. Bananas can be consumed raw, dried, fried, or baked. They are rich in vitamin C, vitamin B6, manganese, dietary fiber, and potassium (358 mg/100 g) (Zhang *et al*., 2005) [15]. Bananas serve as a convenient source of essential nutrients. They can also be processed into value-added products like banana puree, chips, flour, wine, and vinegar. Even banana peels are used to make vinegar (Emaga *et al*., 2007) [5].

Banana is a widely consumed fruit and a staple food in many African countries (Olufemi, 2024). Globally, Grand Naine and Dwarf Cavendish cultivars make up nearly 47% of banana production (Voora *et al*., 2023) [14]. Grand Naine (AAA) is the dominant cultivar worldwide, valued for its high yield, export quality, and resistance to Fusarium wilt (Race-1). In India, it is the single largest ruling cultivar over the native cultivars.

Banana production faces several challenges, with quality planting material being the foremost constraint (Singh *et al*., 2011) [11]. Conventional propagation by sucker separation is slow due to apical dominance and often spreads pests and diseases (Kilwinger *et al*., 2020) [7]. Tissue culture produces disease-free plants but is costly, technically demanding, and limited by climate conditions, restricting its use among small-scale farmers. Macropropagation offers a low-cost, simple alternative by suppressing apical dominance

to stimulate lateral bud growth (Uma *et al*., 2008) [13]. This hybrid approach combines benefits of conventional and tissue culture methods, enabling farmers to rapidly multiply healthy suckers and improve banana productivity (Challam *et al*., 2023; Staver *et al*., 2010) [3, 12].

Materials and Methods

The study on the "Effect of Plant Growth Regulators (PGRs) and growing media on macropropagation of banana (*Musa* spp.) cv. Grand Naine" was conducted from April to August 2025 at research farm of Banana Research Station, Pulivendula, Andhra Pradesh (14°25' N, 78°13' E; 272 m altitude), located in the semi-arid southern agro-climatic zone.

Healthy, disease-free sword suckers of cv. Grand Naine, weighing 1.5 kg, were collected from farmers' fields. The rhizomes were pared by removing roots and superficial layers to eliminate burrowing nematodes. Primary decortication involved detopping above the rhizome-aerial shoot junction, followed by primary decapitation by removal of the apical meristem (2 cm diameter and depth) to suppress apical dominance. The rhizome surface was incised with 6-8 cross-wise cuts (2 cm deep) for moisture drainage. Surface sterilization was done by immersing rhizomes in 1% sodium hypochlorite for 15–20 minutes, followed by shade drying for 30 minutes. Rhizomes were treated with plant growth regulators according to experimental treatments and planted in growing media with 2–3 cm coverage. The substrate consisted of cocopeat (soaked overnight) and sawdust (moistened and decomposed for 2–3 weeks), mixed uniformly with biofertilizers Arbuscular Mycorrhizal Fungi (AMF) and *Bacillus subtilis* each applied at 30 g per 2 kg substrate. Two kilograms of substrate were filled in 9" × 10" polybags for planting. Regular irrigation was provided every 2–3 days to maintain moisture without waterlogging. At the three leaf stage (15–20 cm height, 2.5 cm stem girth), secondary decortication was performed by cutting 2 cm above the collar, followed by secondary decapitation of primary shoots with removal of apical meristem and 4–6 criss-cross incisions (1 cm deep). Rhizomes were again covered with media (2 cm depth). After 25–30 days, secondary shoots developed, and plantlets at 3–4 leaf stage (25–30 cm height) were separated with roots and rhizome pieces, then transferred to fresh polybags for hardening.

The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with two factors: Factor -I represents Plant Growth Regulators (T) which includes T_1 – 40 ppm BAP (6-Benzylaminopurine), T_2 – 50 ppm BAP, T_3 – 60 ppm BAP, T_4 – 250 ppm IBA, T_5 – 300 ppm IBA, T_6 – 10 ppm GA_3, T_7 – 20 ppm GA_3 and T_8 – control. Factor -II represents Growing media (G) which includes G_1 – Cocopeat and G_2 – Sawdust. Plant Growth Regulators (8 treatments) and Growing Media (2 treatments), resulting in sixteen treatment combinations and three replications per treatment.

The key morphometric parameters recorded during the study included: days taken for initiation of primary suckers, days taken for initiation of secondary suckers, number of primary suckers per rhizome, number of secondary suckers per rhizome, and the total number of suckers produced per rhizome.

Results and Discussion

The data pertaining to the number of days taken for the initiation of primary suckers and secondary suckers as influenced by plant growth regulators (PGRs) and growing media through macropropagation of banana (*Musa* spp.) cv. Grand Naine, are presented in Table 1.

The initiation of primary suckers in banana cv. Grand Naine was significantly influenced by plant growth regulators (PGRs), growing media, and their interaction. Among PGRs, (T_3) 60 ppm BAP resulted in the early initiation of primary suckers, taken 18.95 days, statistically on par with (T_2) 50 ppm BAP and (T_1) 40 ppm BAP which recorded 19.08 days and 19.21 days respectively, while the control (T_8) recorded the maximum duration of 25.57 days. Cocopeat (G_1) as a growing medium resulted in earlier initiation (20.73 days) compared to sawdust (G_2) at 22.57 days. The combination (T_3G_1) recorded the minimum time (18.00 days), which was statistically on par with (T_2G_1) 18.69 days, (T_2G_2) 19.47 days, and (T_3G_2) 19.90 days. The maximum number of days was recorded in (T_8G_2) 26.14 days. The effectiveness of BAP in promoting early sucker emergence may be attributed to its role in suppressing apical dominance and stimulating lateral bud growth, as supported by earlier studies (Faturoti *et al*., 2002; Uma *et al*., 2008 and Challam *et al*., 2023) [6, 13, 3].

The initiation of secondary suckers in banana cv. Grand Naine was significantly influenced by PGR treatments and growing media. Application of 60 ppm BAP (T_3) led to the earliest initiation (58.70 days), which was on par with (T_2) 50 ppm BAP and (T_1) 40 ppm BAP, which recorded 59.50 days and 60.25 days, respectively. While the control (T_8) recorded the longest duration (70.48 days). Cocopeat (G_1) promoted earlier initiation (62.70 days) than sawdust (G_2) at 65.37 days. The interaction effect was non-significant. BAP proved effective due to its cytokinin action, enhancing cell division, breaking bud dormancy, and promoting nutrient translocation. Similar findings were reported by Uma *et al*. (2008) [13] and Challam *et al*. (2023) [3].

Table 1: Days taken for initiation of primary and secondary suckers as influenced by PGRs and growing media through macropropagation of banana cv. Grand Naine.

PGRs (T)	Days taken for initiation of primary suckers			Days taken for initiation of secondary suckers		
	Growing media (G)					
	G1	G2	Mean	G1	G2	Mean
T1	19.05	19.37	19.21	59.09	61.40	60.25
T2	18.69	19.47	19.08	58.73	60.27	59.50
T3	18.00	19.90	18.95	57.40	60.00	58.70
T4	20.80	22.47	21.64	65.16	67.40	66.28
T5	20.67	21.60	21.13	61.07	62.53	61.80
T6	23.33	25.87	24.60	66.75	70.48	68.62
T7	20.27	25.73	23.00	65.23	68.12	66.68
T8	25.00	26.14	25.57	68.21	72.75	70.48

Mean	20.73	22.57		62.70	65.37	
Factors	SE (m) ±		C.D. at 5%	SE (m) ±		C.D. at 5%
Factor (T)	0.209		0.606	0.65		1.87
Factor (G)	0.105		0.303	0.32		0.94
T X G	0.296		0.857	0.91		NS

The data pertaining to the number of primary suckers and secondary suckers produced per rhizome, as influenced by plant growth regulators and growing media through macropropagation of banana (*Musa* spp.) cv. Grand Naine, are presented in Table 2.

PGR treatments significantly influenced the number of primary suckers per rhizome in banana. Treatment (T_3) 60 ppm BAP produced the highest mean number of primary suckers (4.87), which was statistically on par with (T_5) 300 ppm IBA with 4.69 suckers per rhizome, while the control (T_8) recorded the lowest (1.79) number of primary suckers. Among growing media, cocopeat (G_1) resulted in significantly more suckers (3.67) than sawdust (G_2) at 3.31. The interaction between PGRs and media was non-significant. These results align with Sajith *et al*. (2014) [10] and Singh, (2011) [11].

Treatment (T_3) 60 ppm BAP produced the highest mean number of secondary suckers 16.72, which was on par with (T_5) 300 ppm IBA at 16.50, while the control (T_8) had the lowest (9.69). Cocopeat (G_1) supported more suckers (13.99) than sawdust (G_2) at 13.24. A significant interaction showed that (T_3G_1) produced the maximum number of secondary suckers 17.42, which was on par with (T_5G_1), which recorded 17.25 suckers, whereas (T_8G_2) recorded the least (9.40). These results align with previous studies by Kindimba and Msogoya (2014) [8] and Dayarani *et al*. (2013) [4].

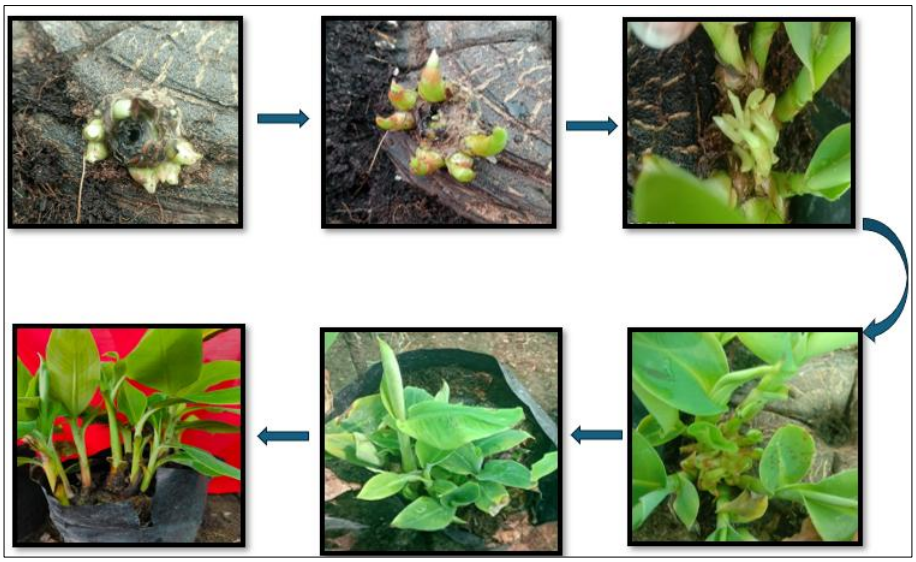

Plate 1: Bud sprouting to shoot emergence in T_3G_1 rhizomes of banana cv. Grand Naine

Table 2: Number of primary and secondary suckers per rhizome as influenced by PGRs and growing media through macropropagation of banana cv. Grand Naine

PGRs (T)	Number of primary suckers			Number of secondary suckers		
	Growing media (G)					
	G1	G2	Mean	G1	G2	Mean
T1	4.24	4.05	4.14	14.63	14.40	14.52
T2	4.46	4.37	4.42	15.04	14.94	14.99
T3	4.90	4.85	4.87	17.42	16.03	16.72
T4	4.03	3.47	3.75	14.17	14.07	14.12
T5	4.87	4.51	4.69	17.25	15.74	16.50
T6	2.43	1.53	1.98	11.37	10.57	10.97
T7	2.47	2.03	2.25	12.03	10.74	11.39
T8	1.93	1.66	1.79	9.97	9.40	9.69
Mean	3.67	3.31		13.99	13.24	
Factors	SE (m) ±		C.D. at 5%	SE (m) ±		C.D. at 5%
Factor (T)	0.12		0.35	0.14		0.42
Factor (G)	0.06		0.18	0.07		0.21
T X G	0.17		NS	0.20		0.59

The data on the total number of suckers produced per rhizome, as influenced by various plant growth regulators (PGRs) and growing media under macropropagation of banana (*Musa* spp.) cv. Grand Naine, are presented in Table 3.

PGR treatments significantly influenced the total number of suckers per banana rhizome, with (T_3) 60 ppm BAP producing the highest mean (21.60), which was on par with (T_5) 300 ppm IBA at 21.19, while the control (T_8) had the lowest (11.48). Cocopeat (G_1) supported more suckers

(17.65) than sawdust (G_2) at 16.54. A significant interaction showed T_3G_1 (22.32) which was statistically on par with T_5G_1 (22.12) combinations yielded the most suckers, whereas T_8G_2 had the least (11.06). BAP's effectiveness is attributed to its cytokinin activity that suppresses apical dominance and promotes axillary bud development, consistent with findings by Dayarani *et al*. (2015) [4].

Table 3: Total number of suckers per rhizome as influenced by PGRs and growing media through macropropagation of banana cv. Grand Naine.

PGRs (T)	Growing Media (G)		
	G1	G2	Mean
T1	18.87	18.45	18.66
T2	19.49	19.31	19.40
T3	22.32	20.88	21.60
T4	18.20	17.54	17.87
T5	22.12	20.25	21.19
T6	13.80	12.11	12.95
T7	14.50	12.77	13.63
T8	11.90	11.06	11.48
Mean	17.65	16.54	
Factors	SE (m) ±		C.D. at 5%
Factor (T)	0.21		0.60
Factor (G)	0.10		0.30
T X G	0.29		0.85

Conclusion

The study revealed that 60 ppm BAP significantly improved all key parameters in macropropagation of banana cv. Grand Naine, including early initiation of primary suckers (18.95 days) and secondary suckers (58.70 days), and increased the number of primary suckers (4.87), secondary suckers (16.72), and total suckers per rhizome (21.60). Cocopeat outperformed sawdust as a growing medium across all parameters. BAP's effectiveness is attributed to its cytokinin activity that promotes axillary bud growth and breaks apical dominance, aligning with earlier studies. Therefore it can be concluded that the combination of cocopeat as the growing media and BAP concentration of 60 ppm is suitable for the successful macropropagation of banana cv. Grand Naine in semi- arid region of Andhra Pradesh.

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