

Evaluation of Banana (*Musa spp. L.*) Cultivars for Growth, Yield and Fruit Quality in Terai Region of West Bengal

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ABSTRACT

The experiment was conducted to study the growth, yield and fruit quality of fifteen banana cultivars in terai zone of West Bengal. The cultivars under observation were Malbhog, Amrit Sagar, Monthan, Manohar, Lal Kela, Dwarf Cavendish, Pisang Awak, Manua, FHIA-01, CO-1, Agniswar, Chini Champa, Hill Banana, Rajapuri and Grand Naine. The study revealed that the growth, yield, and fruit quality varied significantly among the banana cultivars under observation. Amrit Sagar recorded the highest plant height (4.12 m), whereas maximum number of leaves per plant was noted in Monthan (15.0) at the time of shooting. The banana cultivar Malbhog produces the lowest number of suckers per plant (7.83). The maximum number of hands per bunch (13.67), finger length (15.82 cm) and yield per plant (20.51 kg) were recorded in the cultivar Grand Naine. Monthan cultivar of banana produces the maximum weight of hand (1.62 kg) as well as fingers (150.83 g). Pisang Awak resulted the maximum number of fingers per hand (11.44). The highest total soluble solid was recorded in Pisang Awak (27.00 °Brix) followed by Lal Kela (24.67 °Brix). Banana fingers with lowest acidity was found in the cultivar Hill Banana (0.24 %). The maximum reducing sugar (13.13%), non-reducing sugar (7.32%) and total sugar (19.48%) were recorded in the cultivar Agniswar, Amrit Sagar and Chini Champa, respectively. The fingers of Grand Naine had the highest ascorbic acid content (11.68 mg 100 g pulp⁻¹). On the basis of yield, the cultivar Grand Naine may be recommended for commercial cultivation of banana in terai zone of West Bengal.

Keywords: Banana, Growth, Yield, Quality

ARTICLE INFO

Received on	:	14/04/2026
Accepted on	:	12/06/2026
Published online	:	30/06/2026



INTRODUCTION

Banana (*Musa spp. L.*) belongs to the family Musaceae and is one of the most important fruit cultivated in the tropical and subtropical regions of the world. It serves as a staple food for millions of people. Banana ranks fourth in terms of gross value production, next to rice, wheat and maize in the world (Kumbirai et al., 2022). It is an exceptionally nutritious fruit containing a huge amount of carbohydrates and a fair quantity of protein, minerals and essential vitamins (Shinde et al., 2025; Jeet et al., 2015). Banana is very suitable for children suffering from malnutrition. The mild laxative property of banana helps to relieve constipation. Bananas are also used to cure ulcers, diarrhoea, bronchitis and dysentery. No part of the banana plant is being wasted. Since, the uses of bananas are ranging from food, fibre and fertilizers (Shinde et al., 2025). Apart from used as a fruit, the male flower and central core of the pseudostem are also consumed as vegetables in different parts of the country. High quality papers are prepared from banana fibres. The banana pseudostem sap is a valuable source of plant essential elements and is a rich source of potassium (K) that can be utilized as liquid organic fertilizer

(Chakraborty et al., 2021). Hence, banana plant is called as Kalpatharu in India (Tak et al., 2015). India is the largest producer of banana in the world. As per FAOSTAT (2024), India occupies almost 16.0 % of the total global area of production and shares more than 26.0 % of global banana production. There is a consistent market demand for banana throughout the year. Hence, banana farming plays a pivotal role in sustaining the economic stability of the banana growers.

This fruit crop is highly adaptable to diverse agro-climatic zones and cultivated almost all the states in India. West Bengal is one of the leading banana producing states of the nation with varied physiographic and climatic conditions. The major banana varieties cultivated in the state West Bengal are Malbhog, Grand Naine, Kanthali, Amrit Sagar, Chini Champa, and Monthan (Apoorva et al., 2026). The terai zone of West Bengal is characterized by unique soil composition and rainfall patterns that offer immense scope for commercial banana cultivation (Deb et al., 2025). Despite several

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opportunities, farmers of this region are facing several challenges regarding banana cultivation. One of the major issues includes reliance on one or few banana cultivars for a long period of time that resulted in poor productivity and is often encountered with devastating diseases and pest attacks (Deb et al., 2025). Such cultivars fail to meet the ever-increasing demand of the banana growers. Hence, the introduction of new cultivars is necessary to boost the banana production in this region. Therefore, the study aimed to select promising banana cultivars for the growers of this region by assessing growth, yield and quality performance.

MATERIALS AND METHODS

This experiment was carried out at the instructional farm of Department of Pomology and Post-Harvest Technology, Uttar Banga Krishi Vishwavidyalaya, Pundibari, Cooch Behar, West Bengal, during the 2023-24 growing seasons. The area is situated at 26°19'86" N latitude and 89°23'53" E longitude roughly at an elevation of 80.0 meter above mean sea level experiencing summer temperatures between 21°C and 34 °C, winter temperatures between 9 °C and 21°C, and a substantial annual rainfall of 1300 mm, most of which falls during the monsoon season from mid-June to early September, with some precipitation continuing till mid-November. The soil of the experimental site was identified as silty clay loam of Mollisol order and having pH 5.2 and organic C 0.72 %. The available N, P and K of the experimental soil were 218.7, 14.08 and 152.6 kg ha⁻¹, respectively. The experimental field underwent land preparation before planting, which included manual bed preparation, clod-breaking with a power tiller, weeding, levelling and ploughing. Uniform, and disease-free sword suckers (1.5-2.0 kg) of each cultivar (Malbhog, Amrit Sagar, Monthan, Manohar, Lal Kela, Dwarf Cavendish, Pisang Awak, Manua, FHIA-01, CO-1, Agniswar, Chini Champa, Hill Banana, Rajapuri and Grand Naine) were planted in three replications at spacing of 2.0 m between rows and 1.5 m between plants during the rainy season, after being treated with 5.0% Bavistin. Nutrient management for each banana plant included the application of 10 kg farm yard manure (FYM) and a total of 250 g N, 50 g P, and 300 g K. The entire FYM and P doses, along with 40 % of N and 25 % of K, were incorporated at the time of planting. The remaining N and K were subsequently applied in three equal split doses at four, six, and eight-months post-planting. Urea, single super phosphate (SSP), and muriate of potash (MOP) was used as respective source of N, P and K. Plant protection measures included the application of carbendazim at 10 kg ha⁻¹ for fungal control and imidacloprid at 2 ml L⁻¹ (10 l/ha) for insect and pest management. Supplemental irrigation was carried out at 15-day intervals during summer and 21-day intervals during winter using the furrow method. Intercultural operations encompassed propping with strong bamboos to support plants against wind damage, denavelling to ensure

proper fruit development, desuckering to maintain two sword suckers per hill and minimize nutrient competition, and regular leaf pruning of dried or damaged leaves. The plant growth parameters were recorded at the time of shooting. The fruit bunches were harvested when the ridges of banana fingers changed from angular to roundish. The total soluble solid (TSS) of the fruit was measured with hand refractometer. Titratable acidity, ascorbic acid and sugar content of the fruit pulp were determined following the method described by AOAC (2004). The data were analysed for the variance and the least significant differences were calculated to compare the significant effect at $p \leq 0.05$.

RESULTS AND DISCUSSION

The comparative evaluation of fifteen banana cultivars in the terai zone of West Bengal revealed prominent morphological diversity in plant growth characteristics. However, the pseudostem girth and leaf breadth were found to be statistically similar within the banana cultivars (Table 1). Banana plant with the tallest stature was recorded in Amrit Sagar (4.12 m). In contrast, Grand Naine had the shortest plants among the group (3.17 m). The pseudostem girth was recorded maximum in Manohar and Pisang Awak (68.50 cm) suggesting their suitability for supporting substantial fruit bunches. Agniswar (62.00 cm) and FHIA-01 (62.33 cm) displayed comparatively less robust stems. Pseudostem girth is considered as a key indicator of structural resilience. The pronounced plant vigor registered in Amrit Sagar and Manohar is likely attributed to their robust genetic makeup. Meanwhile, the compact stature of the Grand Naine cultivar indicated the influence of dwarfing genes and low endogenous gibberellin production (Tong et al., 2024). Similar variations in plant height and pseudostem girth were also reported by Tak et al. (2015). The banana cultivar 'Monthan' had the highest number of leaves per plant (15.0) during shooting. Efficient nutrient partitioning might have been responsible for more foliage development in this banana cultivar. The lowest leaf count during shooting was noted in Agniswar (9.0). The number of functional leaves required for proper fruit development and bunch maturation in banana was reported to be 9-12 per plant (Mattos et al., 2010). All the tested banana cultivars ranged 9-15 functional leaves at shooting in this zone and were found to be suitable for commercial farming. Leaf dimensions also varied across the banana cultivars. The longest leaves (2.42 m) were recorded in the cultivar Amrit Sagar, and Lal Kela registered with the shortest leaves (1.47 m). The length of banana leaves might be governed genetically and varied within the genotypes (Sagar et al., 2014). Leaf breadth remained statistically uniform (66.47–73.82 cm) across all the cultivars, which might be due to greater environmental influence on this characteristic than genetic factors. The results are consistent with previous findings for different banana genotypes (Sagar et al., 2014;

Paul et al., 2023). Dwarf Cavendish and Hill Banana exhibited the highest sucker production (9.67 suckers per plant) ability that might be due to strong rhizome development. On the other hand, Malbhog (7.83) and Lal Kela (7.92) produced fewer number of suckers, which might limit for ratoon crop production. These observed growth differences primarily reflect complex genotype-environment interactions (Apoorva et al., 2026). Banana cultivars such as Amrit Sagar demonstrated optimal adaptation through robust vegetative growth. However, other banana cultivars like Grand Naine had specialized features such as dwarfism that indicated adaptive advantages against wind damage (Tong et al., 2024).

Table 1: Growth performance of banana cultivars in terai zone of West Bengal

Banana Cultivars	Plant height (m)	Pseudostem girth (cm)	Number of leaves/ plant	Leaf length (m)	Leaf breath (m)	Number of suckers/plant
Malbhog	3.52	65.50	11.50	1.52	71.53	7.83
Amrit Sagar	4.12	66.33	11.00	2.42	71.54	8.40
Monthan	4.02	67.67	15.00	1.72	68.58	9.40
Manohar	3.60	68.50	11.83	1.81	73.82	9.08
Lal Kela	3.40	63.67	11.67	1.47	71.10	7.92
Dwarf Cavendish	3.59	67.33	11.50	1.83	71.02	9.67
Pisang Awak	3.44	68.50	11.00	1.80	66.47	8.51
Manua	3.66	65.83	12.17	1.71	71.53	8.67
FHIA-01	3.62	62.33	11.83	1.56	71.96	8.50
CO-1	3.71	63.67	12.67	1.70	69.22	8.67
Agniswar	3.47	62.00	9.00	2.07	73.33	8.50
Chini Champa	3.64	64.50	13.33	1.75	70.82	9.10
Hill Banana	3.30	68.83	12.00	1.58	68.31	9.67
Rajapuri	3.47	66.17	11.00	1.58	72.07	9.00
Grand Naine	3.17	62.83	11.67	1.60	72.83	8.33
CD _{0.05}	0.42	NS	2.61	0.42	NS	1.02
CV (%)	6.96	6.16	13.20	14.35	5.54	6.98

Significant variation on yield characters was displayed by the tested banana cultivars in the *terai* zone of West Bengal (Table 2). The highest yield per plant (20.51 kg) was registered in Grand Naine banana. The next best yield per plant was recorded in Monthan (18.03 kg/plant) followed by FHIA-01 (17.43 kg plant⁻¹). In contrast, Manohar (11.75 kg plant⁻¹) and CO-1 (11.05 kg plant⁻¹) produced the lowest yields in this region. The highest yield of Grand Naine might be linked to its advantageous bunch architecture, specifically its maximum number of hands per bunch (13.67) and substantial finger weight (120.76 g) (Tak et al., 2015). These traits reflect higher sink strength and effective allocation of carbohydrates to developing fruits. The high yield of Monthan is likely to be associated with its heavy finger weight (150.83 g). The FHIA-01 had the longest finger (16.52 cm), resulting in high yield, indicating efficient resource utilization and balanced

vegetative and reproductive growth. The results are consistent with previous published reports from different locations (Sagar et al., 2014; Paul et al., 2023). The highest number of fingers per hand (11.44) was recorded in Pisang Awak but finally resulted a moderate yield (12.54 kg plant⁻¹), suggesting possible limitation in photosynthetic efficiency, potentially due to insufficient number of leaves (Table 1). The lowest yield per plant was noted in CO-1 (11.05 kg plant⁻¹). Dwarf Cavendish, though smaller in stature, registered a respectable yield (14.01 kg plant⁻¹). Environmental factors, notably the heavy rainfall and high humid conditions in the *terai* zone, lead to excessive loss of soil nutrients through leaching and increasing the pathogenic fungal pressure on certain cultivars that indirectly influencing the plant health and resulting in low yield of certain banana cultivars (Deb et al., 2025).

Table 2: Yield performance of banana cultivars in terai zone of West Bengal

Banana Cultivars	Number of hands/ bunch	Weight of hand (kg)	Number of fingers/ hand	Finger weight (g)	Finger length (cm)	Yield/ plant (kg)
Malbhog	10.83	1.35	10.63	96.11	13.12	15.40
Amrit Sagar	9.83	1.47	8.86	111.90	12.75	15.52
Monthan	10.00	1.62	9.43	150.83	15.12	18.03
Manohar	9.33	1.10	9.36	95.10	12.73	11.75
Lal Kela	8.00	1.30	9.88	96.20	14.33	11.85
Dwarf Cavendish	9.83	1.27	9.68	100.97	15.07	14.01
Pisang Awak	9.50	1.49	11.44	105.08	14.17	12.54
Manua	10.00	1.10	10.43	90.00	12.63	12.39
FHIA-01	10.00	1.57	10.77	118.33	16.52	17.43
CO-1	9.50	1.05	8.92	92.43	13.32	11.05
Agniswar	10.67	1.12	10.18	95.93	13.33	13.00
Chini Champa	10.00	1.14	9.85	82.50	13.80	12.67
Hill Banana	8.83	1.24	10.28	97.50	14.48	12.22
Rajapuri	10.33	1.30	8.55	115.92	13.82	15.07
Grand Naine	13.67	1.43	10.27	120.76	15.82	20.51
CD _{0.05}	1.74	0.19	1.35	5.86	2.09	2.35
CV (%)	10.38	8.74	8.17	3.35	8.87	9.87

The biochemical profiling of the banana cultivars uncovered notable differences in fruit quality characteristics (Table 3). The highest total soluble solid (TSS) of the banana pulp was recorded in the cultivar Pisang Awak (27 °Brix) followed by Lal Kela (24.67 °Brix). These elevated TSS levels in these cultivars may be attributed to a high level of enzymatic metabolism of starch during ripening (Cordenunsi-Lyenko *et al.*, 2019). In contrast, FHIA-01 exhibited notably low TSS (14.17 °Brix). Grand Naine distinguished itself with the highest acidity (0.83%) and ascorbic acid content (11.68 mg/100g). The pronounced acidity, might be due to the predominance of malic, citric and oxalic acid in this cultivar (Bugaud *et al.*, 2013). The lowest acidity was noted in Hill Banana (0.24%). Monthan displayed an interesting combination: moderate sweetness (16.22 °Brix) alongside elevated vitamin C (11.33 mg 100 g⁻¹). Analysis of the reducing sugar content of the banana fruit pulp revealed that Agniswar

(13.13%) and Pisang Awak (12.90 %) effectively convert complex carbohydrates during ripening. The lower reducing sugars (8.06 %) and low TSS (18.83 °Brix) of Manua might reflected an incomplete starch breakdown in this cultivar. However, high TSS and low reducing sugar Hill Banana, CO-1 Dwarf Cavendish banana indicated increased conversion of starch to sugar, with reducing sugars serving as substrates for the banana's respiration process (Watharkar *et al.*, 2021). The total sugar content was the highest in the cultivar Chini Champa (19.48 %). However, the highest nonreducing sugar was registered in the cultivar Amrit Sagar (7.32 %). A huge variation in ascorbic acid content (6.30 to 11.68 mg/100g) of the banana cultivars highlights genetic differences in the efficiency of the L-galactose pathway for vitamin C biosynthesis among the cultivars. These quality traits are modulated by both cultivar-specific gene expression and the microclimate of the *terai* zone.

Table 3: Fruit quality of banana cultivars in *terai* zone of West Bengal

Banana Cultivars	TSS (°Brix)	Acidity (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Ascorbic acid (mg 100 g/ plup)
Malbhog	24.00	0.56	12.58	5.42	18.00	6.30
Amrit Sagar	22.33	0.47	11.43	7.32	18.75	7.43

Banana Cultivars	TSS (°Brix)	Acidity (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Ascorbic acid (mg 100 g/ plup)
Monthan	16.22	0.42	10.03	4.75	14.79	11.33
Manohar	21.30	0.35	8.98	4.05	13.02	6.81
Lal Kela	24.67	0.27	12.24	5.39	17.63	9.05
Dwarf Cavendish	23.67	0.50	8.82	4.86	13.68	7.91
Pisang Awak	27.00	0.39	12.90	5.21	18.11	7.57
Manua	18.83	0.26	8.06	5.38	13.44	10.26
FHIA-01	14.17	0.39	10.13	3.93	14.06	10.77
CO-1	24.50	0.35	8.53	4.88	13.41	6.58
Agniswar	22.33	0.26	13.13	4.20	17.33	8.47
Chini Champa	22.40	0.42	12.48	7.00	19.48	8.95
Hill Banana	20.83	0.24	8.30	4.18	12.48	8.44
Rajapuri	23.43	0.43	9.61	5.59	15.20	7.22
Grand Naine	21.67	0.83	9.03	5.38	14.41	11.68
CD _{0.05}	2.53	0.07	0.96	0.93	1.52	0.95
CV (%)	6.90	9.97	5.51	10.8	5.82	6.64

CONCLUSION

Banana is one of the major commercial fruit crop cultivated in *terai* zone of West Bengal. To increase the farmers income and ensure food security, some promising high-yielding banana cultivars are required to be introduced in this region, along with the cultivated varieties like Malbhog, Amrit Sagar, Chini Champa and Monthan. Based on the findings, the best performing cultivar in respect of yield was 'Grand Naine'. The other cultivars exhibited better yield in *terai* zone of West Bengal were Monthan (18.03 kg plant⁻¹), Amrit Sagar (15.52 kg plant⁻¹) and Malbhog (15.40 kg plant⁻¹). However, the disease and pest reactions, post-harvest handling practices and social aspects needed to be studied before popularizing a new cultivar in this region.

REFERENCES

- AOAC. 2004. Official methods of analysis. In: Hortwitz W (ed). Assoc. Off. Anal. Chem., 13th ed. North Fredrick Avenue, Gaithersburg.
- Apoorva N D, Sah A K, Samanta D, Chakraborty B, Chakraborty A, Bhowmick N, Sahana N, Das A, Sherpa Z W and Singh A. 2026. Analysis of genetic diversity of banana cultivars using simple sequence repeat markers. *Plant Cell Biotechnol. Mol. Biol.* 27(3-4):261-268.
- Bugaud C, Etienne A, Mbéguie-A-Mbéguie D, Cazevielle P and Lobit P. 2013. Modelling pH and titratable acidity in banana fruit based on acid and mineral composition. *Acta Hort.* 1012: 1223–1228.
- Chakraborty B, Sarkar M, Aklade S A and Patil H E. 2021. Foliar application of banana pseudostem sap based liquid organic fertilizer enhances growth, yield and quality of strawberry (*Fragaria × ananassa* Duch.). *Vegetos* 34(4): 847–856.
- Cordenunsi-Lysenko B R, Nascimento J R O, Castro-Alves V C, Purgatto E, Fabi J P and Peroni-Okyta F H G. 2019. The starch is (not) just another brick in the wall: The primary metabolism of sugars during banana ripening. *Front. Plant Sci.* 10: 391.
- Deb P, Suresh C P and Deb P. 2025. Elimination of hard lumps in Malbhog banana (*Musa AAB*) by application of growth regulators and micronutrients. *Indian J. Ecol.* 52(1): 177–183.
- FAOSTAT. 2024. Food and Agriculture Data. Food and Agriculture Organization of the United Nations (FAO). <https://www.fao.org/faostat/en/#compare> (accessed on 9 Feb 2026)
- Jeet P, Immanuel G and Prakash O. 2015. Effects of blanching on the dehydration characteristics of unripe banana slices dried at different temperature. *Agricultural Engineering International: CIGR Journal* 17(2): 168-175.
- Kumbirai B, Zedias C and Upenyu M. 2022. Banana production in Zimbabwe: An analysis from a biotechnological perspective. *Int. J. Multidiscip. Res. Dev.* 9(7): 28–36.

- Mattos L A, Amorim E P, Amorim V B D O, Cohen K D O and Ledo C A D S. 2010. Agronomical and molecular characterization of banana germplasm. *Pesq. Agropec. Bras.* 45(2): 146–154.
- Paul R, Mondal T, Bauri F K, Mahato S and Mohanta R. 2023. Performance of AAB genomic group of banana under Gangetic Plain of West Bengal. *J. Crop Weed* 19(2): 72–77.
- Sagar B S, Raju B, Hipparagi K, Patil S N and Sahithya B R. 2014. Evaluation of banana genotypes for growth and yield under northern dry zone of Karnataka. *Bioscan* 9: 1773–1775.
- Shinde N, Pawar V, Jiwtole S, Joshi M and Rayyan A. 2025. Banana: A comprehensive review of its nutritional value, medicinal potential, antimicrobial properties and by-product utilization. *Int. J. Agric. Food Sci.* 7(11):94–101.
- Tak M K, Kumar V, Attar S, Revale A K and Patel R. 2015. Correlation of banana cv. Grand Naine with growth and yield aspect. *J. Plant Dev. Sci.* 7(1): 1–6.
- Tong N, Zhang C, Xu X, Zhang Z, Li J, Liu Z, Chen Y, Zhang Z, Huang Y, Lin Y and Lai Z. 2024. Genome-wide identification and expression analysis of DWARF53 gene in response to GA and SL related to plant height in banana. *Plants* 13(3): 458. <https://doi.org/10.3390/plants13030458>
- Watharkar R B, Chakraborty S, Srivastav P P and Srivastava B. 2021. Physicochemical and mechanical properties during storage-cum maturity stages of raw harvested wild banana (*Musa balbisiana* BB). *J. Food Meas. Charact.* 15(4):3336–3349.