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Foliar Application Impact of Banana Varieties Peel Extracts on the Performance of Black Gram

M. Anbarasu[1], M. Chandrasekaran[2], M. Bhaskaran[3], S. Rajkumar[1], R. Vijayakumar[2], B. Sampathkumar[2]

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ABSTRACT

Background: Black gram (*Vigna mungo* L.) is a nutritionally rich pulse crop widely cultivated in Asia, yet its productivity is often limited by poor soil health and nutrient deficiencies. Banana peel, a major agro-waste in India, is rich in essential nutrients and bioactive compounds that can potentially enhance crop performance. This study investigates the foliar application of banana peel extracts (BPEs) from different cultivars to promote sustainable nutrient management in black gram cultivation.

Methods: Five banana cultivars (Morris, Rasthali, Green Banana, Nendran and Red Banana) were collected and their peels were soaked in distilled water (1:2 w/v) for 24 hours to obtain aqueous extracts. The nutrient profiles of the peels were analyzed. Foliar sprays at 5 and 10% concentrations were applied to black gram (VBN 8) grown under irrigated field conditions during Winter 2025 and Summer 2026. The experiment was conducted in a randomized block design with eleven treatments (ten BPEs and one control) and data were collected on plant growth and yield parameters.

Result: Among treatments, the 5% Rasthali banana peel extract (F4) consistently outperformed others, showing significantly higher plant height (40.83 cm), branch number (6.71), LAI (3.36) and dry matter production (2853 kg ha^{-1}). It also led to superior yield attributes, including number of pods per plant (40.46), seeds per pod (6.01), pod length (5.07 cm) and seed yield (890 kg ha^{-1}). The enhanced performance was linked to optimal levels of nitrogen, potassium, zinc and organic carbon in Rasthali peel. Notably, the 5% extracts outperformed the 10% due to better nutrient absorption and reduced phytotoxicity.

Key words: Banana peel extract, Biostimulants, Black gram yield, Foliar spray, Sustainable agriculture.

INTRODUCTION

Black gram (*Vigna mungo* L.), a widely cultivated pulse crop in South and Southeast Asia, holds significant importance due to its high protein content, short growing period and ability to improve soil fertility through symbiotic nitrogen fixation (Rana *et al.,* 2014). Despite its agronomic and nutritional advantages, black gram productivity remains low in many regions due to nutrient deficiencies, poor soil health and limited use of sustainable inputs (Kumar *et al.,* 2017). In this context, the use of organic and waste-derived biostimulants is gaining momentum for improving crop performance while maintaining environmental health.

Banana (*Musa spp.)* is one of the major fruit crops in India and its peels account for about 30-40% of the fruit's weight, typically discarded as waste (Emaga *et al.,* 2007). Banana peels are rich in essential nutrients such as potassium, calcium, phosphorus and magnesium, along with phenolic compounds and antioxidants that can act as natural growth stimulators (Anhwange *et al.,* 2009; Arvanitoyannis *et al.,* 2008). Utilizing banana peel extracts (BPEs) as a foliar spray offers an eco-friendly and cost-effective strategy for enhancing nutrient use efficiency and promoting plant health.

Foliar application is a proven method to improve the immediate availability of nutrients to plants, bypassing the limitations of soil-based uptake, especially under stress or low fertility conditions (Sahu *et al.,* 2018). Organic foliar sprays derived from plant or fruit waste, including banana peel extracts, have shown beneficial effects in various crops like tomato, brinjal and legumes (Sathiamoorthy *et al.,* 2013; Sharma and Shrivastava, 2020). However, comparative evaluation of peel extracts from different banana cultivars for use in pulse crops, particularly black gram, remains underexplored.

This research aims to promote sustainable agricultural practices by identifying the most effective banana peel extract for black gram cultivation, thereby encouraging the recycling of banana waste into productive agricultural inputs.

[1]School of Agriculture, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Pallavaram, Chennai-600 117, Tamil Nadu, India.
[2]Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Pallavaram, Chennai-600 117, Tamil Nadu, India.
[3]Vels Institute of Science, Technology and Advanced Studies (VISTAS), Pallavaram, Chennai-600 117, Tamil Nadu, India.

Corresponding Author: M. Anbarasu, School of Agriculture, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Pallavaram, Chennai-600 117, Tamil Nadu, India.
Email: manbarasu102@gmail.com
ORCID: https://orcid.org/0000-0001-7970-4454.

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MATERIALS AND METHODS

Collected the Morris, Rasthali, Green Banana, Nendran and Red banana in and around the Department of Science and Technology, Science Technology and Innovation Hub, Vels Institute of Science, Technology and Advanced Studies (VISTAS), No 274, Tirakoil to Desur Road, Vandavasi Taluk, Thiruvannamalai - 604 501, Tamil Nadu, India, located at 12°45′N latitude and 79°49′E longitude. Collected the above-mentioned varieties of two kg of Bananas and separated the peels, then soaked separately in distilled water at a weight/volume ratio of 1:2 for 24 hr. This ratio produces low osmolality. After 24 hours, the aqueous extracts were filtered through the Whatman No.1 filter paper (Anbarasu and Swaminathan, 2024). The nutrient composition of all selected banana peels is presented in Table 1.

The present study was conducted at Tirakoil village during winter - 2025 and summer - 2026. To assess the effect of foliar application of banana peel extracts obtained from different banana cultivars *viz.,* Morris, Rasthali, Green Banana, Nenthiran and Red Banana, at two concentrations (5% and 10%) on the growth and yield of black gram (VBN 8).

The soil of the experimental field is sandy clay loam, low in available Nitrogen, medium in available Phosphorus and high in available Potassium. The blackgram seeds were dibbled adopting a spacing of 30 cm × 10 cm with a 5m × 4m plot size. The experiment comprised of eleven treatments *viz*., F_1 and F_2 - Foliar spray of Morris banana peel extract (5% and 10%), F_3 and F_4 - Foliar spray of Rasthali banana peel extract (5% and 10%), F_5 and F_6 - Foliar spray of Green banana peel extract (5% and 10%), F_7 and F_8 - Foliar spray of Nenthiran banana peel extract (5% and 10%), F_9 and F_{10} - Foliar spray of Red banana peel extract (5% and 10%) and F_{11} - Control (water spray). The experiment was laid out in RBD with three replications. The foliar spraying was done as per the treatment schedule on 25 and 45 DAS using hand operated knapsack sprayer and observations *viz.,* growth attributes, yield attributes and yield values, were recorded at appropriate stages of the crop.

Observations on growth and yield attributes of black gram were recorded from five uniformly tagged plants in the net plot area, excluding border rows, during both winter 2025 and summer 2026 seasons. Plant height was measured from the soil surface to the tip of the main stem at 30 DAS, 45 DAS and the flowering stage, while the number of branches was counted at 50% flowering. Leaf area index (LAI) was determined at 45 DAS and pod initiation stage using a leaf area meter and dry matter production (DMP) was assessed by uprooting two destructive sample plants per plot, oven-drying them at 65 ±2°C and converting to kg ha^{-1}. Yield attributes were recorded at maturity: the number of pods per plant was counted from tagged plants, seeds per pod were obtained from ten pods per plant and pod length was measured with a scale on ten pods per plant. Test weight was determined from a 100-seed sample corrected to 12% moisture, while seed yield was calculated from the net plot harvest, adjusted to standard moisture and converted to kg ha^{-1}. All data were subjected to statistical analysis using ANOVA appropriate to a randomized block design and treatment means were compared at 5% level of significance. Results for individual seasons as well as pooled data across both seasons are presented in the respective tables.

RESULTS AND DISCUSSION

Effect on growth parameters of blackgram

The foliar application of banana peel extracts significantly influenced the growth attributes of irrigated blackgram in both of Winter 2025 and Summer 2026 seasons (Table 2). Among the treatments, F4 - Rasthali banana peel 5% recorded the highest values for all growth parameters. In the winter 2025 season, F4 exhibited the maximum plant height (39.68 cm), number of branches (6.68), leaf area index (3.41) and dry matter production (2857 kg ha^{-1}). A similar trend was observed in summer 2026, where F4

Table 1: Nutrient composition of different banana peels.

Parameters	Morris	Nentharan	Rasthali	Green banana	Red banana
PH	7.06	6.99	6.8	6	6.5
Electrical conductivity (ds/m)	0.8	0.9	0.9	0.8	1.1
Moisture (%)	99.18	99.01	98.54	99.2	98.72
Total nitrogen (Kjeldahl) (%)	0.02	0.03	0.04	0.02	0.02
Total phosphate as P2OS (%)	0.01	0.02	0.02	0.32	0.07
Total potash as K2O (%)	0.21	0.33	0.3	0.33	0.54
Zinc as Zn (mg/kg)	1.98	2.02	2.18	1.93	2.2
Copper as Cu (mg/kg)	0.71	0.76	0.7	0.56	0.57
Lead as Pb (mg/kg)	<DL(5.0)	<DL(5.0)	<DL(5.0)	<DL(5.0)	<DL(5.0)
Chromium as Cr (mg/kg)	<DL(0.1)	<DL(0.1)	<DL(0.1)	<DL(0.1)	<DL(0.1)
Cadmium as Cd (mg/kg)	<DL(0.1)	<DL(0.1)	<DL(0.1)	<DL(0.1)	<DL(0.1)
Nickel as Ni (mg/kg)	<DL(1.0)	<DL(1.0)	<DL(1.0)	<DL(1.0)	<DL(1.0)
Total organic carbon (%)	0.36	0.42	0.68	0.34	0.51
C: N Ratio	18:01	14:01	17:01	17:01	26:01

reported plant height of 40.83 cm, branches 6.71, LAI 3.36 and DMP 2853 kg ha^{-1}.

This superior performance can be attributed to the higher total nitrogen (0.04%), potassium (0.30%), zinc (2.18 mg/kg) and organic carbon content (0.68%) found in Rasthali banana peel (Table 2), which are critical for vegetative growth and metabolic activities (Basu *et al.,* 2020). Nitrogen supports chlorophyll formation and amino acid synthesis, while potassium enhances enzyme activation and photosynthesis (Ali *et al.,* 2018). Micronutrients like Zn and Cu also contribute to protein synthesis and hormonal regulation (Broadley *et al.,* 2012). The next best treatment was F_{10} - Red banana peel 5%, showing higher growth traits as plant height (38.70 and 39.26 cm) and DMP (2600 and 2644 kg ha^{-1}) during winter and summer, respectively. Red banana peel had the highest K, O content (0.54%), moderate nitrogen (0.02%) and good organic carbon (0.51%), supporting balanced nutrient supply.

Nenthiran and Morris banana peels (F_7, F_8, F_1, F_2) showed moderate growth responses, likely due to their relatively lower macro- and micronutrient content, particularly nitrogen and potash. Meanwhile, the green banana peels (F_5, F_6) exhibited the lowest growth performance among treatments, though still superior to the control. This may be due to their lowest phosphorus (0.32%), lowest Cu and Zn contents and relatively lower organic carbon, limiting their ability to enhance photosynthetic and metabolic activity.

The control treatment (F_{11}) consistently showed the lowest values for all growth parameters, highlighting the beneficial effect of banana peel foliar sprays.

The positive response to banana peel extracts could also be associated with their high moisture content (>98%), aiding easy nutrient dissolution and absorption and an ideal C: N ratio (~14:1 to 18:1), promoting microbial activity and better assimilation of nutrients (Sundaramoorthy *et al.,* 2021).

Effect of foliar application on yield attributes of blackgram

The foliar application peel extracts exhibited significant variation in yield attributes of irrigated Blackgram across both winter (2025) and summer (2026) seasons (Table 3). Among the treatments, F4 - Foliar spray of Rasthali banana peel 5% consistently recorded the highest performance for all measured yield components, followed by F3 - Rasthali 10% and F10 - Red banana 5%, whereas the control (F11) recorded the lowest values in both seasons.

Number of pods per plant

The highest number of pods per plant was recorded in F4 (39.55 and 40.46 in winter and summer, respectively), which was significantly higher than all other treatments. This improvement may be attributed to the better nutrient composition of Rasthali banana peels, particularly their higher content of total nitrogen (0.04%) and total organic carbon (0.68%), which could have promoted enhanced

Table 2: Effect of foliar application of different banana peel extracts on growth characters of irrigated blackgram.

Treatments (F_1 - F_{11})	*Winter - 2025*				*Summer - 2026*			
	Plant height (cm)	No. of branches	LAI	DMP (kg ha^{-1})	Plant height (cm)	No. of branches	LAI	DMP (kg ha^{-1})
F_1- Foliar spray of Morris banana peel 10%	33.78	4.25	2.14	2127	34.69	4.38	2.31	2161
F_2 - Foliar spray of Morris banana peel 5%	33.62	4.41	2.31	2196	34.99	4.57	2.42	2247
F_3 - Foliar spray of Rasthali banana peel 10%	38.58	6.04	2.87	2739	39.58	6.25	3.08	2685
F_4 - Foliar spray of Rasthali banana peel 5%	39.68	6.68	3.41	2857	40.83	6.71	3.36	2853
F_5 - Foliar spray of Green banana peel 10%	33.31	3.67	1.97	1899	33.03	3.75	2.01	1923
F_6 - Foliar spray of Green banana peel 5%	33.87	4.03	2.11	2058	33.99	4.17	2.22	2062
F_7 - Foliar spray of Nenthiran banana peel 10%	36.32	4.61	2.45	2278	35.52	4.96	2.57	2325
F_8 - Foliar spray of Nenthiran banana peel 5%	35.51	5.03	2.62	2421	36.42	5.26	2.65	2420
F_9 - Foliar spray of Red banana peel 10%	37.04	5.61	2.79	2573	37.38	5.54	2.77	2510
F_{10} - Foliar spray of Red banana peel 5%	38.70	5.81	3.02	2600	39.26	5.98	3.01	2644
F_{11} - Control	30.89	3.17	1.89	1798	31.96	3.41	1.92	1807
SEd	0.72	0.10	0.05	46.82	0.73	0.10	0.05	46.99
CD (P=0.05)	1.49	0.20	0.11	97.54	1.52	0.21	0.11	97.89

Table 3: Effect of foliar application on banana peel extracts on yield attributes of No. of pods plant^{-1}, No. of seeds pod^{-1}, Pod length (cm), Pod length (cm) and yield (kg ha^{-1}) of irrigated Blackgram.

Treatments	Winter - 2025					Summer - 2026				
	No. of pods plant^{-1}	No. of seeds pod^{-1}	Pod length (cm)	Test weight (g)	Yield (kg ha^{-1})	No. of pods plant^{-1}	No. of seeds pod^{-1}	Pod length (cm)	Test weight (g)	Yield (kg ha^{-1})
F_1 - Foliar spray of Morris banana peel 10%	21.95	3.56	3.21	3.19	602	23.45	4.08	3.44	3.71	664
F_2 - Foliar spray of Morris banana peel 5%	25.09	3.97	3.55	3.37	661	25.34	4.22	3.65	3.74	693
F_3 - Foliar spray of Rasthali banana peel 10%	35.80	4.95	4.46	3.59	810	36.54	5.5	4.68	3.98	835
F_4 - Foliar spray of Rasthali banana peel 5%	39.55	5.69	4.79	3.56	863	40.46	6.01	5.07	4.09	890
F_5 - Foliar spray of Green banana peel 10%	16.97	3.22	2.82	3.21	528	18.17	3.49	2.94	3.62	582
F_6 - Foliar spray of Green banana peel 5 %	20.93	3.52	2.95	3.23	617	21.67	3.90	3.26	3.67	633
F_7 - Foliar spray of Nenthiran banana peel 10%	26.93	4.07	3.67	3.43	675	27.65	4.42	3.92	3.80	712
F_8 - Foliar spray of Nenthiran banana peel 5%	28.70	4.39	3.89	3.45	694	29.66	4.71	4.03	3.82	740
F_9 - Foliar spray of Red banana peel 10%	31.21	4.58	3.96	3.52	749	31.65	4.99	4.16	3.89	770
F_{10} - Foliar spray of Red banana peel 5%	33.91	5.09	4.17	3.68	762	35.03	5.42	4.53	3.95	820
F_{11} - Control	16.21	2.73	2.34	3.01	498	16.62	3.05	2.60	3.53	543
SEd	0.54	0.08	0.07	0.07	13.67	0.56	0.09	0.08	0.08	14.45
CD (P=0.05)	1.13	0.17	0.15	0.14	28.48	1.17	0.19	0.16	0.16	30.09

vegetative growth and reproductive success. This is in agreement with findings by Sridhar *et al.* (2019), who noted that foliar nutrition rich in NPK boosts flowering and pod setting in legumes.

Number of seeds per pod

Significant differences were observed in the number of seeds per pod, where F4 again outperformed all other treatments (5.69 and 6.01 in winter and summer, respectively). The improved seed set may be attributed to the enhanced micronutrient availability, particularly zinc (2.18 mg/kg) and copper (0.7 mg/kg), which are known to enhance pollen viability and seed development (Yadav *et al.,* 2020).

Pod length and test weight

Pod length and 100-seed weight were also markedly influenced by banana peel foliar sprays. F4 produced the longest pods (4.79 and 5.07 cm) and showed improved seed weight (3.56 and 4.09 g) over control and other treatments. The high potash content (0.3%) in Rasthali peel and balanced C: N ratio (17:1) likely contributed to better translocation of assimilates towards reproductive organs, thereby increasing seed size and weight (Bhowmik *et al.,* 2021).

Seed yield (kg ha^{-1})

Seed yield followed a similar trend, with F4 yielding the highest values (863 and 890 kg/ha in winter and summer, respectively), followed by F3 (810 and 835 kg/ha) and F10 (762 and 820 kg/ha). Yield increase in these treatments correlates well with superior nutrient composition (N, K_2O and organic carbon) and favorable physiological traits. The higher moisture content (~98.5%), pH near neutrality (6.8) and moderate EC (0.9 dS/m) also suggest optimal extract stability and foliar uptake efficiency. On the contrary, green banana peel (F5 and F6) and control (F11) showed the least yield performance.

These results are consistent with reports by Kumari and Singh, (2017), who demonstrated that the application of potassium and micronutrient-enriched foliar formulations significantly improves yield traits in pulses. Additionally, the absence of toxic heavy metals like Pb, Cr and Cd in the extracts indicates the suitability of these organic foliar inputs for sustainable agriculture.

The superior performance of the 5% banana peel extract over the 10% concentration in this study can be attributed to optimal nutrient availability and efficient foliar absorption (Anbarasu *et al.,* 2025). At 5% concentration, the extract likely provided a balanced supply of macro and micronutrients such as nitrogen, potassium, zinc and organic carbon in a form that was easily absorbed by the plant leaves without causing any stress (Sahu *et al.,* 2018; Broadley *et al.,* 2012). In contrast, the 10% concentration may have resulted in excessive nutrient accumulation on the leaf surface, leading to osmotic stress, reduced nutrient uptake, or potential phytotoxic effects such as leaf scorching

or chlorosis (Fernández and Eichert, 2009). Foliar sprays are most effective within a specific concentration range and higher concentrations can hinder absorption due to poor wettability or crystallization (Kannan, 2010). Additionally, the plant's response to bioactive compounds often follows a hormetic pattern, where low doses stimulate growth while higher doses can inhibit physiological functions (Calabrese and Baldwin, 2002). The 5% extract likely fell within the optimal range to promote metabolic activities, photosynthesis and reproductive development, whereas the 10% extract may have surpassed the threshold, reducing efficiency. Thus, the 5% banana peel extract not only enhanced black gram growth and yield more effectively but also offered a more sustainable and economically viable option.

CONCLUSION

The study revealed that foliar application of Rasthali banana peel extract at 5% concentration (F4) was the most effective treatment for enhancing growth and yield of black gram under irrigated conditions. Considering its consistent superiority over other treatments across both seasons, the use of Rasthali banana peel extract (5%) can be recommended as a sustainable, low-cost biostimulant for improving black gram productivity.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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