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Bio Stimulant Potential of Different Banana Peel Aqueous Extracts on Black Gram (*Vigna mungo*)

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ABSTRACT

Background: Banana peel, a major by-product of banana consumption, is rich in plant nutrients and bioactive compounds with potential applications as a natural bio-stimulant in agriculture. Black gram (*Vigna mungo*) is an important pulse crop and its growth could be positively influenced by organic inputs. This study investigates the effects of aqueous extracts of various banana peel varieties on black gram germination and seedling development.

Methods: Peels from five banana cultivars (Morris, Rasthali, Green, Nendran and Red banana) were soaked in distilled water (1:2 w/v) for 24 hours to prepare 5% and 10% aqueous extracts. These were tested alongside distilled water as a control in a seed germination assay using the paper towel method. Eleven treatments, each with three replicates, were evaluated for parameters including germination rate, root and shoot length, total seedling length, leaf number, fresh and dry weights and vigor indices I and II. response Index (RI) was used to assess treatment effectiveness relative to control.

Result: Overall, 5% peel extracts had a more favorable impact on seedling growth than 10% extracts. F2 (Morris 5%) and F4 (Rasthali 5%) showed the highest values in root length (7.90 cm), shoot length (21.12 cm), total length (28.10 cm) and vigor index-I (2248). F6 (Green 5%) exhibited the highest dry weight (0.33 g) and vigor index-II (26.48). Among 10% extracts, F7 (Nendran 10%) had the highest fresh, dry weights and highest vigor index-II (27.36). Most treatments had a positive Response Index, supporting the stimulatory potential of banana peel extracts on the growth of black gram.

Key words: Banana peel aqueous extracts, Black gram, Germination %, Vigour indices.

INTRODUCTION

Bananas are one of the most widely cultivated and consumed fruit crops in tropical and subtropical regions. With an average global consumption of 12 kilograms per person, it ranks as the fourth most important food crop after rice, wheat and maize. Over the past two decades, global banana production has shown steady growth, rising from approximately 70 million tonnes in 1999 to around 117 million tonnes in 2019.

Belonging to the Musaceae family, banana plants are classified under three genera: Musa, Ensette and Musella, with the genus Musa comprising the most cultivated species. Nearly all banana cultivars originate from two primary diploid species: *Musa acuminata* (A genome) and *Musa balbisiana* (B genome). Cultivars derived from *Musa balbisiana* are typically starchy and known as plantains, while those from *Musa acuminata* are sweeter and commonly consumed as dessert bananas.

As a globally significant crop, banana cultivation and processing generate large quantities of agricultural residues after each harvest, especially during the extraction of banana pulp. These residues include leaves, pseudostems, stalks and inflorescences; however, banana peels alone account for 35% to 50% of the total fruit mass (Gomes *et al.*, 2022). Despite their volume, banana peels are often discarded untreated into the environment. They are occasionally repurposed as organic fertilizer or animal feed due to their low tannin and high fiber content (Pereira and Maraschin, 2015). Most are left to decompose, contributing to environmental pollution. Globally, around 36 million tons of banana peel are produced annually, much of which ends up in landfills or domestic waste. The anaerobic decomposition of this biomass generates foul odors and harmful gases, disrupting air quality and contributing to ecological imbalance.

Banana peels are nutrient-rich and offer significant benefits, especially for plant growth and composting applications. They are an excellent source of potassium a crucial element for plant health and also contain moderate levels of phosphorus, calcium and magnesium. Moreover, they supply essential trace minerals such as iron, manganese, zinc and copper (Fidrianny and Insanu, 2014).

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In addition to their mineral content, banana peels contain valuable plant compounds including polyphenols, flavonoids, lutein (an antioxidant) and tryptophan, an amino acid associated with serotonin synthesis. Naturally slightly alkaline, banana peels decompose rapidly, making them an efficient and sustainable organic amendment for soil or compost enrichment (Zhang *et al.*, 2020).

Recognizing their nutritional potential, the agricultural sector stands to benefit from transforming banana peels into a value-added product. Motivated by this prospect, the current study was undertaken to evaluate the effect of aqueous banana peel extracts on the growth performance of black gram (*Vigna mungo*).

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), Thiruvannamalai, Tamil Nadu, India located at 12°45′N latitude and 79°49′E longitude. Collected the above-mentioned varieties of two kg Bananas and separated the peels then soaked separately in distilled water at a weight/volume ratio of 1:2 for 24 hrs. 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 experiment was conducted during the winter period of 2025.

The banana peels used for extract preparation were collected at the mature green stage of fruit development just before the onset of ripening to ensure consistency in biochemical composition and to avoid variability associated with ripening-related metabolic changes. To prepare the aqueous extract, the fresh banana peels were thoroughly washed under running tap water followed by distilled water to remove any surface contaminants, including dirt and microbial spores. The cleaned peels were then shade-dried at room temperature to reduce moisture content, which helps minimize microbial growth. The aqueous extracts were filtered and tested for effects of germination and seedling growth of Black gram (*Vigna mungo*) (L.) Hepper. (VBN 10). The treatments include aqueous extracts of F1 - Morris Banana Peel 10%, F2 - Morris Banana Peel 5 %, F3 - Rasthali Banana Peel 10%, F4 - Rasthali Banana Peel 5%, F5 - Green Banana Peel 10%, F6 - Green Banana Peel 5%, F7 - Nendran Banana Peel10 %, F8 - Nendran Banana Peel 5%, F9- Red Banana Peel 10%, F10 - Red Banana Peel 5% and F11 - Distilled water thus making to 11 treatments, each replicated three times.

A single sheet of paper towel was laid flat on a clean surface and evenly moistened using a spray mister. One side of the towel was folded in one-inch increments to create a flap. A total of 10 seeds were then placed in rows along the folded edge. The seeds were covered with the remaining portion of the towel.

The entire setup was sandwiched between germination paper (on the inside) and lamination sheets (on the outside) to help retain moisture. The towel, with seeds enclosed, was gently rolled and secured using a rubber band to ensure grip and maintain structure. The roll was then placed in a transparent container to maintain humidity. This container was kept in an area with a relatively stable temperature and labeled according to the treatment applied (Yaklich, 1985).

After the designated germination period, the towels were carefully unrolled to avoid damaging the fragile seedlings. Seedlings that developed shoots longer than 1½ inches and had at least one strong root had been counted as successfully germinated. These results were used to assess the effect of the aqueous extract treatment (Fig 1).

The container was added with the aqueous extracts frequently to avoid drying up. Distilled water was served as a control (Anbarasu *et al.*, 2024). The germination (%), root length (cm), shoot length (cm), total length (cm), no of leaves, fresh weight (g), dry weight (g), vigour index-I {Standard germination (%) × seedling length (cm)} and vigour index-II {Standard germination (%) × seedling dry weight (g)} by Abdul-Baki and Anderson, (1973) of black gram were recorded after ten days. The magnitude of

Fig 1: Wet paper roll towel of different banana peel aqueous extracts on black gram.

inhibition versus simulation in the bioassay was compared through the Response Index (RI) (Richardson and Williamson, 1988) is determined as follows,

if T > C, RI = 1 - (C/T)
if T = C, then RI = 0
if T < C, then RI = (T/C) -1

Where,
T = Treatment mean.
C = Control mean.

A negative RI reflects the proportional disparity in the output of the test crop in the treatment relative to the output in the control. The results were subjected to an analysis of variance (Ayeni *et al.*, 1997) and mean RI values were tested for standard error.

Statistical analysis

The results for each characterization data were obtained from the mean procedure of three replicates and statistical analysis was performed in a complete randomization design. The data on various parameters studied during the investigation were statistically analyzed by applying the technique of standard error deviation (±), as suggested by Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

Germination and plant growth of black gram were influenced by various varieties of banana peel aqueous extracts and percentages used and the effect showed mixed results. Even though, the five percent had the highest influence for all the parameters than that of ten percent aqueous extracts by overall growth influence.

For 5% aqueous extract effects

The germination there is no significant effect whereas, the five percent of F2 - Morris Banana Peel 5% has the highest Root Length of 7.90±1.08 cm, total length of plants is 28.10±3.46 cm and Vigour index-I is 2248±276. The F4 - Rasthali Banana Peel 5% has the highest shoot length of 21.12±1.36 cm, the Number of leaves produced is 2.00±0.02 and on par with F10 - Red Banana Peel 5% is 2.00±0.02, Fresh weight 0.41±0.03 g and on par with F8 - Nendran Banana Peel 5% is 0.41±0.04.

The F6 - Green Banana Peel 5 % has the highest dry weight plant is 0.33±0.10 g followed by F8 - Nendran Banana Peel 5% and F10 - Red Banana Peel 5%. The highest significance of Vigour index-II is 26.48±7.60 compared with F11 - Normal Water.

For 10% aqueous extract effects

The germination there is no significant effect whereas, the ten percent of F7 - Nendran Banana Peel 10% has the highest root length 6.55±0.52 cm, total leaves produced 2.00±0.02, fresh Weight 0.43±0.02 g, dry weight 0.33±0.06 g and the Vigour index-II is 27.36±5.40. F9- Red Banana Peel 10 % has the highest shoot length of 19.70±3.02 cm and total Length (cm) of 24.70±3.93. The Vigour index-I is

Table 1: Effect of different varieties of Banana peel aqueous extracts on germination and seedling growth of black gram.

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)	Total length (cm)	No. of leaves	Fresh weight (g)	Dry weight (g)	Vigor index-I	Vigor index-II
F1 - Morris banana peel 10%	80±0.02	5.52±1.18	17.20±3.24	22.72±4.33	1.60±0.27	0.30±0.10	0.22±0.02	1809±346	24.32±7.99
F2 - Morris banana peel 5%	80±0.02	7.90±1.08	20.20±2.48	28.10±3.46	1.80±0.20	0.31±0.03	0.25±0.05	2248±276	17.36±4.38
F3 - Rasthali banana peel 10%	90±0.01	5.25±0.72	16.74±2.28	21.99±3.00	1.80±0.20	0.35±0.46	0.25±0.05	1947±269	22.05±4.64
F4 - Rasthali banana peel 5%	80±0.02	5.98±0.39	21.12±1.36	27.10±1.95	2.00±0.02	0.41±0.03	0.28±0.02	2124±155	15.20±1.39
F5 - Green banana peel 10%	90±0.01	5.25±0.83	18.05±2.13	23.30±2.92	1.80±0.20	0.37±0.02	0.18±0.01	2106±262	16.29±0.86
F6 - Green banana peel 5%	80±0.02	6.05±0.95	11.75±2.45	17.80±3.33	1.90±0.20	0.39±0.02	0.33±0.10	1424±266	26.48±7.60
F7 - Nendran banana peel 10%	90±0.01	6.55±0.52	15.65±2.55	22.20±2.38	2.00±0.02	0.43±0.02	0.33±0.06	1881±214	27.36±5.40
F8 - Nendran banana peel 5%	80±0.02	5.65±0.94	13.10±2.26	18.75±2.78	1.80±0.20	0.41±0.04	0.30±0.01	1500±222	13.76±1.05
F9 - Red banana peel 10%	90±0.01	5.00±1.03	19.70±3.02	24.70±3.93	1.60±0.27	0.36±0.04	0.29±0.09	1323±353	26.82±8.37
F10 - Red banana peel 5%	80±0.02	7.55±0.57	19.10±1.82	26.65±2.16	2.00±0.02	0.40±0.03	0.30±0.02	2148±172	16.80±1.41
F11 - Distilled water	80±0.02	5.75±1.01	16.10±2.13	21.85±2.95	1.50±0.20	0.29±0.02	0.21±0.03	1980±235	19.28±2.01

highest in F5 - Green Banana Peel 10% of 2106±262 compared with F11 - Normal Water (Table 1).

The response index indicated the highest number of parameters has positive (+) values of different banana peel aqueous extracts effect of a Black gram (Fig 2). Whereas, the negative Response Index had very few parameters as for 5% aqueous extract of banana peel effects of shoot Length (-0.370 and -0.229), total length (-0.228 and -0.165) and Vigour index-I (-0.390 and -0.320) of F6 - Green Banana Peel 5% and F8 - Nendran Banana Peel 5 % respectively (Fig 3). Whereas, the Vigour index-II (0.272) had a positive Response Index F6 - Green Banana Peel 5% only and remaining all 5% banana peel extracts had a negative Response Index (Table 2).

About the 10% aqueous extract of banana peel effects of length (0.122) of F7 - Nendran Banana Peel 10% had a positive response and remaining all the varieties have negative response index (Fig 4). The Vigour index-I also has only one (F5 - Green Banana Peel 10% - 0.060) positive response and the remaining all have negative responses. Except for the Shoot Length (-0.029) of F7 - Nendran Banana Peel 10%, Dry Weight (-0.167) of F5 - Green Banana Peel 10 % and the Vigour index-II (-0.184) of F5 - Green Banana Peel 10 % had a negative response and the remaining all the varieties and parameters had a good response index of the Black gram plant growth.

Out of a total of eleven parameters studied, the 5% and 10% aqueous extracts of banana peel showed negative effects on Black gram growth. However, out of 90 values observed (excluding F11 - distilled water as the control), 68 parameters showed a positive response index, indicating that banana peel extract was a good potential source for enhancing Black gram germination, growth and development.

The aqueous extract of banana peel treatment excelled on the distilled water (control) in traits of the black gram plant growth. According to Ogunlade *et al.* (2021), banana peels contain various nutritive components, including carbohydrates (59-67%), proteins (0.9-5.3%), starch (3.5-6.3%), fiber (19.2-31.7%), crude fat/lipids (1.24-5.93%) and ash (3.95-9.60%). The positive growth response observed in black gram may be attributed to the enzymatic protein complexes and bio-stimulants present in banana peel extracts. These components are effective in small quantities, supporting early plant development. Additionally, banana peel extract enhances the availability of essential nutrients such as nitrogen, phosphorus and potassium. Biofertilization plays a key role in this process by facilitating nutrient transformation and mobilization through microbial activity, particularly nitrogen, which is a vital component of amino acids and other essential plant compounds (Fredeen, 1989; Bar-Yosef *et al.*, 1972).

Proteins and nitrogen play a vital role in nearly all physiological processes and biochemical interactions within the protoplasm, including enzymatic reactions. This contributes to enhanced plant growth, increased plant size

Table 2: Effect of different varieties of banana peel aqueous extracts on germination and seedling growth of black gram.

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)	Total length (cm)	No. of leaves	Fresh weight (g)	Dry weight (g)	Vigor index-I	Vigor index-II
F1 - Morris banana peel 10%	0.000	-0.042	0.064	0.038	0.063	0.033	0.045	-0.095	0.207
F2 - Morris banana peel 5%	0.000	0.272	0.203	0.222	0.167	0.065	0.160	0.119	-0.111
F3 - Rasthali banana peel 10%	0.110	-0.095	0.038	0.006	0.167	0.171	0.160	-0.017	0.126
F4 - Rasthali banana peel 5%	0.000	0.038	0.238	0.194	0.250	0.293	0.250	0.068	-0.268
F5 - Green banana peel 10%	0.110	-0.095	0.108	0.062	0.167	0.216	-0.167	0.060	-0.184
F6 - Green banana peel 5%	0.000	0.050	-0.370	-0.228	0.211	0.256	0.364	-0.390	0.272
F7 - Nendran banana peel 10%	0.110	0.122	-0.029	0.016	0.250	0.326	0.364	-0.053	0.295
F8 - Nendran banana peel 5%	0.000	-0.018	-0.229	-0.165	0.167	0.293	0.300	-0.320	-0.401
F9 - Red banana peel 10%	0.110	-0.150	0.183	0.115	0.063	0.194	0.276	-0.497	0.281
F10 - Red banana peel 5%	0.000	0.238	0.157	0.180	0.250	0.275	0.300	0.078	-0.148
F11 - Distilled water	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

and greater root development. The notable increase in xylem and phloem percentages observed may be attributed to the beneficial effects of banana peel extracts from varieties such as Morris, Rasthali, Red Banana, Nendran and Green Banana. These extracts likely promote the production of key biochemical compounds, including vitamins and plant hormones like auxins, cytokinins and gibberellins, which are essential for regulating and stimulating plant growth (Glick, 2014).

The banana peel extracts from varieties such as Morris, Rasthali, Red Banana, Nendran and Green Banana may contribute to enhanced black gram growth due to their high potassium content. Similar effects have also been observed in crops like carrots, where the total yield improved. As an organic substance of natural origin, banana peel extract is typically applied as a foliar spray to supply essential nutrients that support plant growth (Clarkson, 1985). The potassium present in banana peels

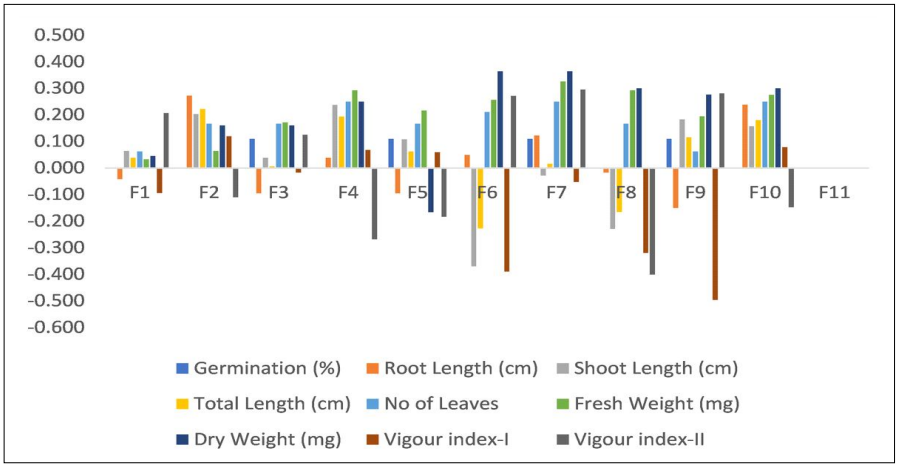

Fig 2: Response index of all the treatments from F1 to F11 effect on black gram.

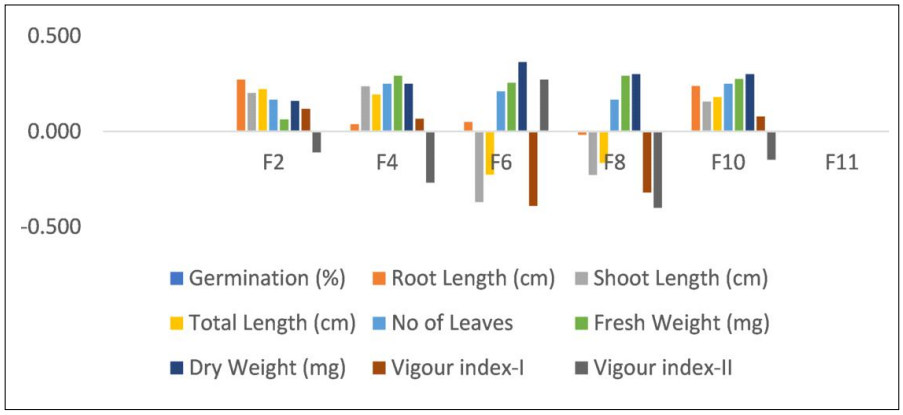

Fig 3: Response index of all 5% treatments effect on black gram

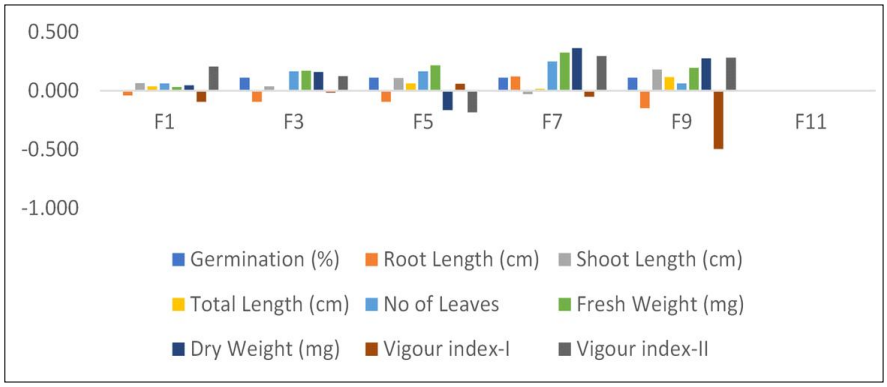

Fig 4: Response index of all 10 % treatments effect on black gram.

is readily absorbed and efficiently transported within the plant. It plays a crucial role in activating respiratory enzymes, generating adenosine triphosphate (ATP), regulating photosynthesis, enhancing carbon dioxide uptake and maintaining the plant's electrochemical balance (Maathuis, 2009). This positive impact is reflected in increased plant biomass, particularly in root development and overall yield. The foliar application of banana peel extract has been shown to significantly enhance the soluble solids content in carrot roots, although the extent of this improvement can vary depending on factors such as plant maturity, agricultural practices and environmental conditions (Dudas *et al.*, 2017). Moreover, while banana peel extract has demonstrated clear benefits for plant growth and development, its full potential in supplying essential nutrients, vitamins and secondary metabolites remains an area for further research and exploration. The use of banana peel extract as a natural and low-cost biostimulant aligns well with sustainable agricultural practices, making it a feasible option for farmers, especially in resource-limited constraints.

CONCLUSION

The study demonstrated that aqueous extracts of banana peels exhibit significant bio stimulant potential on the germination and early seedling growth of black gram (*Vigna mungo*). Among the treatments, 5% aqueous extracts generally performed better than 10%, with Morris (F2) and Rasthali (F4) peels at 5% showing notable improvements in root length, shoot length, total plant length and vigor indices. While a few treatments showed marginal negative effects, the overall response indices were predominantly positive, confirming banana peels as a sustainable, nutrient-rich and effective organic growth promoter. These findings support the use of banana peel waste as an eco-friendly agricultural input, contributing to a circular bioeconomy and sustainable crop production.

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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

All authors declared that there is no conflict of interest.

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