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Harnessing Banana Peel Waste for Bio-fertilizer Production: A Mini-review

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Abstract

The request for sustainable agriculture has resulted in a rising interest in bio-fertilizers, with banana peel waste being recognized as a rich organic resource. This study investigates the potential of banana peels in the creation of bio-fertilizers. It provides a comprehensive analysis of their historical importance, methods of production, and considerations regarding toxicity. This review examines the nutrient-rich composition of banana peels and their positive impact on soil health and crop productivity, based on an analysis of available literature. The results suggest that banana peels can enhance soil composition, augment nutrient accessibility, and promote advantageous microbial activity, so serving as a feasible substitute for synthetic fertilizers. Moreover, the research highlights significant obstacles in the manufacturing and use of bio-fertilizers made from banana peels, such as the need for standardization and scalability. Additionally, it strongly recommends the improvement of production procedures.

Keywords: bio-fertilizer, Agriculture, Banana peels, Toxicity

Introduction

Bananas are an important crop worldwide, but it is mostly cultivated and consumed fruit in tropical and subtropical regions. Every day, several tons of banana peel wastes and other by-products like leaves, pseudostem, stalk, and inflorescence are generated in fruit markets and home garbage. These banana peels were disposed into the environment without any treatment, and they make up 35%–50% of the total mass of the fruit(Padam et al., 2014). Over time, scientific research has reaffirmed the benefits of these peels, leading to their integration into modern agriculture as a sustainable bio-fertilizer. The agriculture industry would benefit financially from the conversion of banana peel into a valuable product(Zou et al., 2022). The agriculture sector contributes towards a one-third share of the global gross domestic product. However, with the increasing trend in human population, the world's population has been. The agriculture sector contributes towards a one-third share of the global gross domestic product. However, with the increasing trend in human population, the world's population has been estimated to rise to 9.5 billion by 2050, leading to high food demand

Besides the availability of limited fertile land, urbanization, unexpected weather events connected to climate change, and abiotic and biotic stresses are the major constraints for the production of several crops. Furthermore, soil quality, availability of nutrients, environmental conditions as well as the biological health of the soil are other important criteria for improving crop yield per unit area for achieving the targeted goal of food security. Thus, the utilization of banana peels as bio-fertilizers has emerged as a promising solution (Ammar et al., 2023). Since then, banana peels have shown promising eco-friendly alternatives to conventional fertilizers. One of the most significant advantages of banana peel bio-fertilizer is its low toxicity. Unlike chemical fertilizers, it is environmentally safe, posing no health risks to humans and reducing the potential for groundwater contamination (Hussein et al., 2019). This paper explores the production of banana peels as bio-fertilizers, their historical significance, and the production processes through consulting relevant literature in the area.

Bio-fertilizers

A bio-fertilizer is a substance containing living microorganisms. When applied to seeds, plants, or soil, it colonizes the rhizosphere or the interior of the plants and promotes plant growth by increasing the nutrient supply to the host plant. It also promotes biodiversity and aligns with the principles of sustainable agriculture by nurturing healthy soil ecosystems. Table 1 highlights the various types of bio-fertilizers, their contributions to plant growth, and the crops that benefitted from the application of these bio-fertilizers (Daniel et al., 2022).

Table 1 Categories of some bio-fertilizers and their role in crop growth performance.

Type of biofertilizer	Contributions to plant growth	Beneficial Crops
Azotobacter	N/ha/yr. Supplies 20-40 mg N/ ha. Promotion of growth substances such as Indole Acetic Acid, Gibberellic acid, etc. Results in a 10–15% increase in crop yield. Biological control of plant diseases and destroy plant pathogens. Maintains the fertility status of the soil.	Mustard, Sunflower, Grapes, Sugarcane, Banana, Watermelon, Papaya, Coconut, Plantation and Forest crops
Blue-green algae	Fixes almost 20-30 kg N/ha in lowland rice fields. Promote the production of growth substances.	Rice, Banana
Potassium-Solubilizing Bacteria (KSB)	Functions in mobilizing elementary K into available form for crop uptake. Enhanced solubilization of fixed micronutrients such as zinc.	It is applied in almost all crops as well as in combination with other bio-fertilizers
PGPR	Increases crop yield with the range from 7% to 33%. Promotes plant growth through increased phytohormones and water& minerals uptake. Suppress the growth of harmful bacteria on the root surface.	Used in all crops
Micro-nutrients Bio-fertilizer	These are strains of microorganisms that help in the transformation of unavailable micronutrients present in organic and mineral matter to available for plant uptake, they include; Sulfur solubilizers, Silicon solubilizers, Zinc mobilizers, etc.	Used in all crops in combination with other type of bio-fertilizers

Source:(Mahmud et al., 2021)

Banana peels

Banana peel is the outer shell (cover) of the banana fruit, as shown in Figure 1. It is a by-product of home consumption and the processing of bananas. It is also used as an ingredient in cooking, water purification, the manufacture of many biochemical products, and inorganic waste production. Banana peels are used as feedstock for livestock, goats, monkeys, poultry, rabbits, fish, zebras, and so on (Hikal et al., 2022)

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Figure 1: Photo of a Banana Peel

History of Banana and Banana Peels

The historical significance of banana peels and their integration into indigenous agricultural practices highlight their longstanding role as a valuable resource. Over time, research and innovation have paved the way for the modern production process of banana peel bio-fertilizer, which involves collection, drying, grinding, composting, and sieving. This process converts discarded banana peels into a nutrient-rich organic input that enriches the soil and supports healthy crop growth (Hikal et al., 2022). Banana cultivation has a long history, and so does the utilization of its peels. Indigenous agricultural practices in many regions have employed banana peels as a natural source of essential nutrients for crops. (Hikal et al., 2022). The history of banana peels is interweaving with the cultivation and consumption of bananas, which dates back thousands of years. Here's a brief overview of the historical significance of banana peels:

1. **Ancient Origins:** Bananas are believed to have originated in Southeast Asia, particularly in the region that includes present-day Malaysia and Indonesia. Archaeological evidence suggests that bananas were cultivated as far back as 5000 BC. Initially, the wild bananas had large seeds and were not as palatable as the cultivated varieties we know today.
2. **Early Use of Banana Peels:** The early cultivation of bananas for their fruit primarily focused on the edible pulp. However, indigenous communities in regions like Southeast Asia, Africa, and South America began to realize the potential of banana peels as a valuable resource. They used banana peels in various ways, including as a source of food for livestock and as an organic material to enrich soil.

3. **Cultural Significance**: Bananas and their peels have played a significant role in various cultures and cuisines. In some Southeast Asian and Indian traditions, banana leaves and peels have been used for serving food, while the peels themselves were sometimes used in traditional medicine.
4. **Modern Utilization:** As the commercial cultivation of bananas expanded globally, the focus remained primarily on the fruit. However, modern agricultural practices have revived interest in banana peels. Researchers and farmers have recognized their potential as a source of essential nutrients for crops and a sustainable organic resource.
5. **Contemporary Agricultural Practices**: In recent decades, banana peels have been studied and developed for use in agriculture as bio-fertilizers and organic soil amendments. Their rich nutrient content, including potassium and phosphorus, has made them a valuable input for sustainable farming practices.

The historical journey of banana peels from being an underutilized byproduct to a valuable resource for agriculture demonstrates the evolving relationship between human society and the natural world. Today, banana peels play a role not only in agriculture but also in efforts to reduce waste and promote sustainable practices.

Chemical Composition of Banana Peel

Banana plants belong to the *Musaceae* family. Banana plants are derived from three genera (Musa, Ensette, and Musella) under the same family, but they universally comprise several species in *Musa.* It has been shown that banana peel (*Musa sapientum*) contains many nutrients and minerals (Hikal et al., 2022). Figure 2 illustrates the chemical composition of the banana peel.

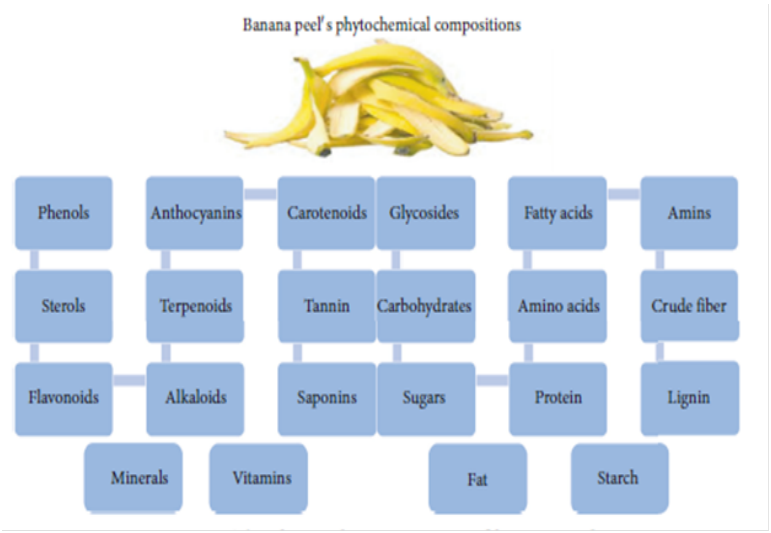

Figure 2: Mineral composition of banana peel

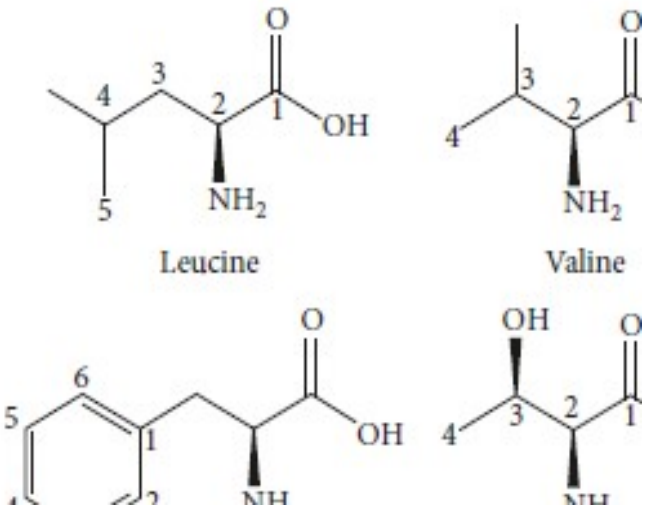

Figure 3: The chemical structures of some amino acids found in a banana peel: leucine, valine, phenylalanine, and threonine.

Production Process of Banana Peel Bio-fertilizer

The process of converting banana peels into bio-fertilizers involves several steps. First, the peels are collected and dried to reduce moisture content. They are then crushed or ground into a fine powder. Subsequently, this powder is composted or fermented to enhance its nutrient content. The resulting product can be directly applied to soil or mixed with other organic materials to create a well-balanced bio-fertilizer rich in essential nutrients such as potassium, phosphorus, and calcium.

The production process of banana peel bio-fertilizer involves several key steps to transform discarded banana peels into a valuable organic input for agriculture:

A. Collection and Sorting: Banana peels are collected from various sources, such as households, food processing units, or banana plantations. They can be fresh or dried.

B. Drying: If the banana peels collected have high moisture content, they are typically dried to reduce their water content. This can be done through sun drying or mechanical drying methods. Drying helps prevent mold growth and improves the shelf life of the final product.

C. Grinding or Crushing: Dried banana peels are then ground or crushed into a fine powder. This step increases the surface area of the peels, making them more accessible for microbial action during composting.

D. Composting or Fermentation: The ground banana peel powder is typically subjected to composting or fermentation. In composting, it is mixed with other organic materials like kitchen scraps, leaves, or manure. The mixture is turned periodically to allow for aeration and microbial breakdown. Alternatively, banana peels can undergo anaerobic fermentation, which involves placing the ground peels in an airtight container with microorganisms. Fermentation is particularly useful for households or small-scale operations.

E. Curing: After the composting or fermentation process, the banana peel material is left to cure. This allows the breakdown of organic matter to continue and ensures the elimination of any potential pathogens or pests.

F. Sieving: The cured banana peel material is sieved to remove any larger, unprocessed residues. The resulting product is a fine, nutrient-rich powder.

G. Packaging: The final product is packaged in suitable containers, such as bags or sacks, ready for distribution and use in agriculture.

The resulting banana peel bio-fertilizer is rich in essential nutrients such as potassium, phosphorus, and calcium. It can be applied to soil to enhance its fertility and provide the necessary nutrients for crop growth. This organic fertilizer is not only environmentally friendly but also contributes to sustainable agriculture by recycling waste materials and reducing the reliance on chemical fertilizers.

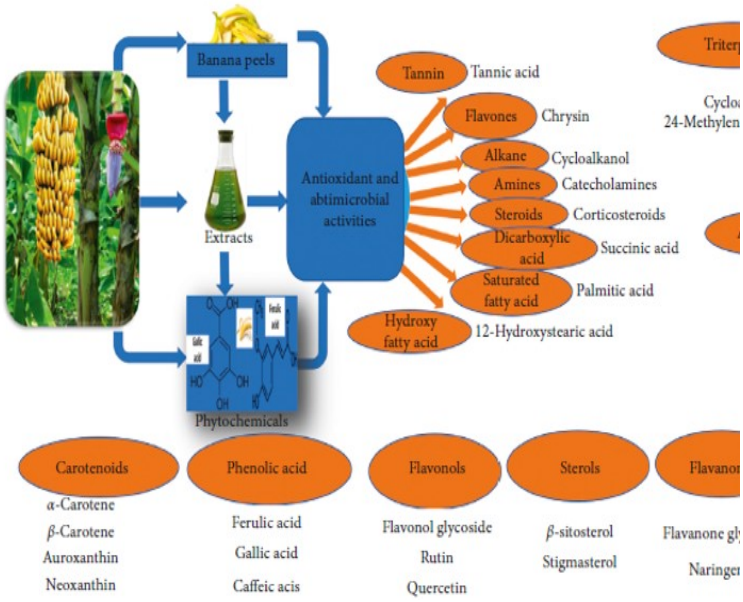

Figure 5: Banana Peel's Biological Active Compounds with Antioxidant and Antimicrobial Effects

Toxicity of Banana Peel Bio-Fertilizer

One of the significant advantages of banana peel bio-fertilizers is their low toxicity compared to chemical fertilizers that can harm the environment and groundwater, banana peel-based bio-fertilizers are environmentally friendly and pose no threat to human health. They do not contain harmful chemicals or synthetic additives, making them a safe and sustainable choice for organic farming. Here are some key points regarding their toxicity:

a) Environmentally Safe: Banana peel bio-fertilizer is derived from natural, organic materials, making it environmentally safe. It does not contain synthetic chemicals, heavy metals, or harmful substances that can negatively impact the environment.

b) Non-Hazardous to Human Health: Unlike chemical fertilizers, banana peel bio-fertilizer poses no direct health risks to humans. It is safe to handle, and there is no risk of skin irritation or harmful exposure when applying it to crops.

c) Reduces Groundwater Contamination: Chemical fertilizers can leach into groundwater, leading to contamination and potential harm to ecosystems and human water supplies. Banana peel bio-fertilizer, being organic, significantly reduces the risk of groundwater pollution.

d) Biodiversity-Friendly: The use of organic bio-fertilizers like banana peel-based products promotes soil health and enhances biodiversity. These fertilizers encourage the growth of beneficial soil microorganisms and earthworms, contributing to a balanced and thriving ecosystem.

e) Sustainable Agriculture: Banana peel bio-fertilizer aligns with sustainable agriculture practices. Its low toxicity and organic nature support the principles of eco-friendly and organic farming, helping to reduce the environmental footprint associated with agricultural activities.

Conclusion

Based on the previous empirical paper, the banana peel has great application potential in bio-fertilizers as an alternative to conventional fertilizers. Regarding mineral content, banana peel is appreciated with phosphorus, iron, calcium, magnesium, and sodium promotes plant growth and development. Peel wastes can be exploited as a commercial source of bio-fertilizer as banana is widely cultivated worldwide. The use of banana peel can have positive implications: firstly, banana peel may benefit the environment by using secondary processing materials, and secondly, it may provide a new perspective for consumers and producers about developing value-added products. In conclusion, the utilization of banana peels as bio-fertilizers offers a promising and sustainable solution for modern agriculture. This organic resource, once considered agricultural waste, has undergone a remarkable transformation, providing numerous benefits for both farming and the environment. Their historical use and modern production techniques have paved the way for banana peel bio-fertilizers to improve soil health and enhance crop productivity. Moreover, their low toxicity and organic nature align with the principles of eco-friendly and organic farming, making them an excellent choice for farmers looking to reduce their environmental footprint. As agriculture strives to become more sustainable, banana peel bio-fertilizers offer a promising solution to nourish the soil, reduce waste, and promote eco-conscious practices.

Recommendations

Certainly, here are some recommendations regarding the utilization of banana peel bio-fertilizers in agriculture:

i. **Education and Awareness:** Promote awareness and provide education to farmers about the benefits of banana peel biofertilizers. Outreach programs, workshops, and information campaigns can help ensure that farmers understand the advantages of using this organic resource.

ii. **Research and Development:** Continue research and development efforts to refine the production process of banana peel bio-fertilizers. Investigate innovative methods for composting and fermentation to enhance nutrient content and efficiency.

iii. **Quality Control Standards:** Establish quality control standards to ensure the consistency and safety of banana peel bio-fertilizer products. This will build trust among farmers and consumers and promote product reliability.

iv. **Government Support:** Governments can incentivize the production and use of organic bio-fertilizers, including banana peel-based products. Financial support, subsidies, or tax incentives can encourage their adoption in agriculture.

v. **Integration into Organic Farming Practices:** Encourage the integration of banana peel bio-fertilizers into organic farming practices. Organic certification bodies can recognize these as compliant with organic farming standards.

vi. **Waste Management Programs:** Promote waste management programs that encourage the collection and

processing of banana peels for bio-fertilizer production. This can reduce waste in landfills and contribute to a circular economy.

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