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Utilization of Groundnut Shell as a Carrier for Bacillus Megaterium in Bio-Fertilizer Production

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ABSTRACT

The growing demand for sustainable agricultural practices has led to increased interest in biofertilizers as an eco-friendly alternative to chemical fertilizers. Biofertilizers rely on microbial inoculants to enhance plant nutrient availability, but their effectiveness depends significantly on the carrier material used for microbial survival and application. This study investigates the potential of groundnut shell as a carrier for biofertilizer production, addressing both agricultural productivity and waste management challenges. Groundnut shells, an abundant agricultural byproduct, were processed and inoculated with Bacillus megaterium, a phosphorus-solubilizing bacterium, to evaluate their viability as a microbial carrier. Experimental trials on maize (Zea mays) showed that plants treated with groundnut shell-based biofertilizer exhibited improved growth parameters, including increased stem thickness, leaf count, and chlorophyll intensity compared to the control. The findings highlight groundnut shell as a viable and sustainable carrier material, offering a dual benefit of enhancing crop productivity while mitigating agricultural waste. This study underscores the potential for integrating agricultural waste into biofertilizer production to promote sustainable farming practices.
Keywords: Sustainable Agriculture, Microbial Carrier, Waste Management, Agricultural byproduct

INTRODUCTION

Agriculture plays a crucial role in food security and economic development, particularly in developing countries like Nigeria [1]. However, soil nutrient depletion remains a major challenge due to intensive farming practices and over-reliance on chemical fertilizers [2]. While chemical fertilizers enhance crop yield, their excessive use has been linked to soil degradation, water pollution, and environmental imbalances [3]. As a result, there has been a global shift toward sustainable alternatives such as biofertilizers, which leverage beneficial microorganisms to improve soil fertility and crop productivity [4]. Biofertilizers contain living microbes that enhance nutrient availability through natural processes such as nitrogen fixation, phosphate solubilization, and organic matter decomposition [5]. These microorganisms, including Bacillus megaterium, require a stable carrier medium to ensure their viability during storage and application [6]. Traditionally, carriers such as peat and lignite have been used, but their limited availability and environmental concerns necessitate the exploration of alternative materials [7]. Groundnut (Arachis hypogaea) is a widely cultivated oilseed crop, generating large quantities of shells as waste during processing [8]. Improper disposal of groundnut shells contributes to environmental pollution, making it imperative to find value-added applications for this byproduct [9]. This study explores the potential of groundnut shells as a sustainable carrier for biofertilizer production, assessing their physicochemical properties, microbial viability, and impact on plant growth [10]. By repurposing agricultural waste into a valuable biofertilizer component, this research aims to contribute to sustainable agriculture while addressing waste management challenges [11].

MATERIALS AND METHODS

Materials

The materials used in this study included groundnut shells collected from Sabon layi Market, Bali Local Government, Taraba State, Nigeria. The biofertilizer formulation involved Bacillus megaterium, a phosphorus-solubilizing bacterium. Laboratory equipment used included an autoclave, biosafety cabinet, weighing balance, rotary shaker, Petri dishes, test tubes, incubator, and nutrient broth.

Preparation of Groundnut Shell Carrier

The collected groundnut shells were cleaned to remove dirt and contaminants. They were then coarsely ground using a mortar and pestle and sieved to obtain fine particles suitable for microbial inoculation. To eliminate native microbial contaminants, the groundnut shell particles were sterilized using an autoclave at 121°C and 15 psi for 20 minutes.

Preparation of Bacillus megaterium Inoculum

Nutrient broth (NB) was prepared by dissolving 13 g of nutrient media stock in 500 mL of distilled water. The solution was autoclaved at 121°C for 20 minutes and allowed to cool. A sterile wire loop was used to inoculate Bacillus megaterium into the nutrient broth. The inoculated broth was incubated at 37°C for 48 hours to allow bacterial growth.

Biofertilizer Formulation

The biofertilizer was prepared by mixing the bacterial culture with the sterilized groundnut shell carrier. A total of 50 mL of the Bacillus megaterium inoculum (containing approximately 25×10^2 CFU/mL) was added to 50 g of groundnut shell substrate under aseptic conditions. The biofertilizer mixture was stored at room temperature and air-dried for 48 hours before application.

Application of Biofertilizer to Maize Plants

A greenhouse experiment was conducted using maize (Zea mays) as the test crop. Three treatment groups were established as shown in figure 1:

Sample A Sample B Sample C

Figure.1 Treatment A: Biofertilizer mixed with soil before seed planting (30:70 ratio).
Treatment B: Biofertilizer applied to the soil after seed germination.
Control (Treatment C): Soil without biofertilizer application.

Each treatment was monitored for plant growth parameters, including plant height, stem thickness, leaf count, and chlorophyll intensity over a 4-week period.

Results and Discussion

Growth Performance of Maize Plants

The effects of the groundnut shell-based biofertilizer on maize (Zea mays) growth were assessed by comparing plant height, stem thickness, leaf count, and chlorophyll intensity across different treatments [12]. The findings are summarized in Table 1.

Table 1: Effect of Biofertilizer on Maize Growth				
Test	**Height**	**Color intensity**	**Stem thickness**	**No of leaves**
Sample B (before germination)	36cm	Dark green	3.95cm	8
Sample A (after germination)	28cm	Light green	2.90cm	6
Sample C (control)	18cm	Pale green	2.0cm	4

Maize plants in Treatment A (biofertilizer mixed with soil before planting) exhibited the highest growth performance, with taller plants, thicker stems, and a higher number of leaves. Treatment B (biofertilizer applied after germination) also showed improved growth compared to the control but was less effective than pre-planting application. The control group (Treatment C), which did not receive biofertilizer, exhibited the poorest growth, with shorter plants, thinner stems, and pale green leaves—indicative of phosphorus deficiency.

Role of Bacillus megaterium in Plant Growth

The improved plant growth in biofertilizer-treated maize can be attributed to the presence of Bacillus megaterium, a known phosphorus-solubilizing bacterium [12]. Phosphorus is a critical nutrient for root development, energy transfer, and overall plant health. The plants in Treatment A likely had better phosphorus availability due to early microbial colonization, leading to increased nutrient uptake and chlorophyll production [13].

The observed chlorophyll intensity differences suggest that plants in the biofertilizer-treated soils had a more efficient photosynthetic process compared to the control [14]. This aligns with previous studies highlighting the role of biofertilizers in enhancing plant metabolic activities and stress tolerance [15].

Viability and Sustainability of Groundnut Shell as a Carrier

The effectiveness of a biofertilizer depends not only on microbial activity but also on the carrier material used [16]. The results indicate that groundnut shells provided a suitable environment for Bacillus megaterium, allowing microbial survival and activity even after air-drying for storage. The high silica (SiO_2) content (approximately 15.92%) in groundnut shells contributed to their resistance to microbial degradation, ensuring long-term viability [17]. Additionally, utilizing groundnut shells as a biofertilizer carrier presents an environmentally sustainable solution by repurposing an abundant agricultural waste product [18]. This approach not only improves soil fertility but also reduces waste accumulation and pollution associated with improper disposal methods such as burning or landfill dumping [19].

Implications for Sustainable Agriculture

The findings of this study reinforce the role of biofertilizers in sustainable agriculture. By integrating agricultural waste into biofertilizer production, farmers can reduce dependence on chemical fertilizers, minimize environmental pollution, and enhance soil health [20]. Furthermore, groundnut shell-based biofertilizers offer a cost-effective alternative for small-scale farmers who may not have access to commercial biofertilizers [21].

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study demonstrates that groundnut shell is a viable and sustainable carrier for biofertilizer production. The incorporation of Bacillus megaterium into groundnut shell-based biofertilizer significantly improved maize (Zea mays) growth, with plants showing increased height, thicker stems, and higher chlorophyll intensity compared to untreated control plants. The effectiveness of the biofertilizer was more pronounced when applied before seed germination, suggesting that early microbial colonization enhances nutrient availability and uptake.

Groundnut shells, an abundant agricultural byproduct, provide an effective medium for microbial survival due to their high silica content and structural stability. Their use in biofertilizer production not only improves crop yield but also offers an environmentally friendly alternative to traditional waste disposal methods, such as incineration or landfilling. The findings highlight the potential for integrating agricultural waste into sustainable farming practices, reducing dependency on synthetic fertilizers while enhancing soil fertility.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Field Trials and Long-Term Studies: Further research should be conducted to evaluate the long-term effects of groundnut shell-based biofertilizers under various soil and climatic conditions.
2. Scaling Up Production: Efforts should be made to develop large-scale production techniques for groundnut shell-based biofertilizers to enhance their commercial viability.

3. Nutrient Enhancement Strategies: Additional studies should explore the incorporation of other beneficial microbes, such as nitrogen-fixing bacteria, to further enhance the nutrient profile of the biofertilizer.
4. Farmer Awareness and Adoption: Awareness programs should be initiated to educate farmers on the benefits of using biofertilizers and encourage the adoption of sustainable agricultural practices.
5. Government and Policy Support: Policymakers should consider incentives for biofertilizer production and utilization to promote environmentally friendly agricultural inputs.

Limitations

This study faced challenges related to limited laboratory resources, including the unavailability of certain reagents and an unstable power supply, which may have influenced experimental conditions. Additionally, the study was conducted in a controlled greenhouse environment; field trials under real agricultural conditions are necessary to further validate the findings.

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