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# AGRICULTURAL RESIDUE BASED BRIQUETTES: A NOVEL APPROACHES TO SOIL ENRICHMENT AND CROP GROWTH

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## Abstract
Agricultural residues are often treated as waste and disposed of through open burning, which leads to environmental pollution and loss of valuable nutrients. The present study investigates the potential of agricultural residue-based briquettes prepared from orange peel, sugarcane bagasse, and pineapple peel as a sustainable approach for soil enrichment and crop growth. The residues were processed using grinding tools and compressed using a hand-operated briquetting machine. The prepared briquettes were dried under sunlight and subjected to traditional stove pyrolysis to produce ash rich in mineral nutrients. The ash obtained from individual briquettes was applied to brinjal (Solanum melongena) plants grown in alluvial soil using grow bags. Plant growth parameters such as plant height, two-leaf stage development, leaf count, flowering stage, fruiting stage, and harvesting stage were monitored. The experiment aimed to compare the effect of ash from different briquette residues on crop growth performance. Results indicated variations in plant growth parameters depending on the type of agricultural residue used. Among the tested materials, one residue showed better improvement in plant growth and soil nutrient enrichment compared to the others. The findings suggest that agricultural residue briquettes can serve as a sustainable alternative for waste management and soil fertility enhancement, promoting eco-friendly agricultural practices

***Keywords:*** Agricultural Residues, Biomass Briquettes, Brinjal (Solanum melongena), Briquette Ash Application Crop Growth Monitoring, Soil Enrichment, Sustainable Waste Management,
Traditional Pyrolysis,

## 1. Introduction:

Agricultural activities and food processing industries generate a large quantity of organic residues every year. In many regions, such residues are often discarded as waste or burned in open fields, which contributes to environmental pollution and the loss of valuable nutrients. Therefore, sustainable methods for utilizing agricultural residues are essential for both environmental protection and agricultural productivity.

One promising approach for agricultural waste management is the conversion of biomass residues into briquettes. Briquetting is a mechanical process that compresses loose biomass materials into compact solid blocks that can be used as a renewable fuel source. Agricultural residues such as orange peel, pineapple peel, and sugarcane bagasse are rich in organic matter and can be effectively converted into briquettes using simple technologies such as hand-operated briquetting machines. These briquettes can be dried naturally using sunlight and later utilized for energy generation through combustion or pyrolysis in traditional stoves commonly used in rural households.

Briquettes are compacted biomass materials used as an alternative energy source. During combustion or pyrolysis, these briquettes produce ash that contains essential plant nutrients such as potassium, calcium, magnesium, and phosphorus. When applied to soil, briquette ash can improve soil fertility and plant growth.

During the combustion or pyrolysis of biomass briquettes, ash is produced as a by-product. This ash contains important mineral nutrients such as potassium, calcium, magnesium, and phosphorus that are beneficial for plant growth. When applied to soil, biomass ash can improve soil fertility, enhance nutrient availability, and support crop development. Therefore, the reuse of briquette ash in agriculture provides a dual advantage by managing agricultural waste while simultaneously improving soil health and crop productivity.

Vegetable crops such as brinjal (Solanum melongena) are widely cultivated and require adequate soil nutrients for proper growth and yield. Brinjal plants respond well to organic soil amendments and are suitable for controlled experiments using grow-bag cultivation methods. Monitoring plant growth parameters such as plant height, early leaf development, number of leaves, flowering stage, fruit development, and harvesting stage provides valuable information regarding the effectiveness of soil amendments.

In this study, agricultural residues including orange peel, sugarcane bagasse, and pineapple peel were utilized to produce briquettes using a hand-operated briquetting machine. The residues were first cleaned, sun-dried, and ground using a grinding tool before briquette formation. The prepared briquettes were then subjected to a traditional stove pyrolysis process, which is also commonly used for domestic cooking. The ash produced from the pyrolysis process was collected and applied to alluvial soil used for brinjal cultivation in grow bags.

The main objective of this research is to evaluate the effect of briquette ash derived from different agricultural residues on soil enrichment and crop growth. Growth parameters such as plant height, two-leaf stage development, leaf count, flowering stage, fruit formation, and harvesting stage were monitored throughout the cultivation period. The results obtained from the three treatments were compared to determine which agricultural residue-based briquette provides the most effective improvement in plant growth and soil fertility.

This research highlights the potential of agricultural residue briquettes as a sustainable and eco-friendly solution for waste management, renewable energy generation, and soil fertility enhancement. By integrating biomass energy production with agricultural nutrient recycling, this approach can contribute to sustainable farming practices and improved crop productivity.

## 2. Problem Statement

Agricultural and fruit processing activities generate a large quantity of organic residues such as orange peel, pineapple peel, and sugarcane bagasse. In many rural and semi-urban areas, these residues are often discarded as waste or burned openly, which leads to environmental pollution, unpleasant odours, and the loss of valuable organic nutrients.

At the same time, many agricultural soils suffer from declining fertility due to continuous cultivation and excessive dependence on chemical fertilizers. Organic soil amendments can help improve soil structure, nutrient content, and microbial activity, but affordable and locally available solutions are still needed.

Biomass briquetting provides a promising method for converting agricultural residues into compact fuel that can be used for domestic energy production. During the pyrolysis of these briquettes, ash rich in mineral nutrients is produced as a by-product. This ash has the potential to be reused as a soil amendment for crop growth and soil enrichment. However, limited studies have investigated the effectiveness of briquette ash derived from different agricultural residues, particularly fruit waste materials such as orange peel and pineapple peel.

Furthermore, there is insufficient comparative research evaluating how different residue-based briquettes influence plant growth parameters such as plant height, leaf development, flowering stage, fruit formation, and yield. Understanding these effects is important for determining the most suitable agricultural residue for briquette production and soil application.

Therefore, this study aims to address the problem of agricultural residue waste management while simultaneously improving soil fertility and crop growth. By converting orange peel, sugarcane bagasse, and pineapple peel into briquettes and applying their ash to alluvial soil used for brinjal cultivation in grow bags, this research evaluates which residue-based briquette provides the best performance in terms of plant growth and soil enrichment

## 3. Materials And Methods

### 3.1 Materials

The materials used in this study included agricultural residues such as orange peel, sugarcane bagasse, and pineapple peel, which were collected from local markets. A hand-operated briquetting machine was used to produce briquettes from the processed biomass materials. The residues were ground into smaller particles using a household grinding tool (mixy) and dried under sunlight before briquette formation. A traditional stove was used to carry out the pyrolysis process and produce ash from the briquettes. Alluvial soil was used as the growing medium, and brinjal seeds (Solanum melongena) were selected as the experimental crop. The experiment was conducted using grow bag and tools such as a measuring scale, containers for ash collection, and watering equipment were used for plant growth monitoring and maintenance.

### 3.2 Methods

### 3.2.1 Agricultural Residue Collection

Agricultural residues such as orange peel, sugarcane bagasse, and pineapple peel were collected from nearby fruit markets and juice processing units. These residues were selected because they are commonly available agricultural wastes and contain high organic matter suitable for briquette production. The collected residues were transported to the experimental site for further processing.

### 3.2.2. Cleaning

The collected residues were manually cleaned to remove soil particles, dust, stones, and other impurities. Proper cleaning is necessary to improve the quality of briquettes and prevent contamination during the pyrolysis process.

a) orange peel b) sugarcane bagasse c) pineapple peel

**Figure 1: Raw material collection and cleaning process and sun drying process**

### 3.2.3. Sun Drying

After cleaning, the residues were spread uniformly on clean plastic sheets and exposed to direct sunlight for approximately 2–3 days. Sun drying helped to reduce the moisture content of the biomass materials. Lower moisture content improves grinding efficiency and increases the quality and durability of the briquettes.

### 3.2.4. Grinding

The dried residues were ground into smaller particles using a household grinding tool (mixy). Grinding helped to obtain a uniform particle size, which is important for efficient briquette formation. Uniform particle size improves compression during briquetting and enhances the structural strength of the briquettes.

a) orange peel b) sugarcane bagasse c) pineapple peel

**Figure2: Grinding process of individual raw material**

### 3.2.5. Briquette Formation

The powdered biomass materials were then compressed using a hand-operated briquetting machine to form compact cylindrical briquettes. Briquetting increases the density of loose biomass materials and makes them easier to handle, transport, and burn. Separate briquettes were produced for each agricultural residue to allow comparison of their effects.

a) orange peel b) sugarcane bagasse c) pineapple peel

**Figure 3: Briquettes formation (Hand operator)**

### 3.2.6. Secondary Drying

After briquette formation, the briquettes were again subjected to secondary sun drying for 24–48 hours. This step was carried out to remove any remaining moisture and improve the mechanical strength of the briquettes. Proper drying also helps in efficient combustion during the pyrolysis process.

a) orange peel b) sugarcane bagasse c) pineapple peel

**Figure 4: Secondary drying process of individual briquettes**

### 3.2.7. Pyrolysis Process

The dried briquettes were subjected to a traditional stove pyrolysis process, which is commonly used for domestic cooking purposes in rural areas. During this process, the briquettes were burned in a controlled manner. Thermal decomposition occurred in the biomass material, releasing volatile gases and leaving behind mineral-rich ash as a residue.

a) orange peel b) sugarcane bagasse c) pineapple peel

**Figure 5: Traditional stove pyrolysis process of individual briquettes**

### 3.2.8. Ash Collection

After complete combustion of the briquettes, the remaining ash was carefully collected. The ash was stored in clean and dry containers to prevent contamination and moisture absorption. This ash was later used as a soil amendment for the crop experiment.

a) orange peel b) sugarcane bagasse c) pineapple peel

**Figure 6: Ash collection of individual briquettes**

### 3.2.9. Soil Preparation

The crop experiment was conducted using grow bags or pots filled with alluvial soil. Alluvial soil was selected because it is fertile and suitable for vegetable cultivation. The soil was loosened and mixed thoroughly to ensure proper aeration, drainage, and uniform distribution of nutrients.

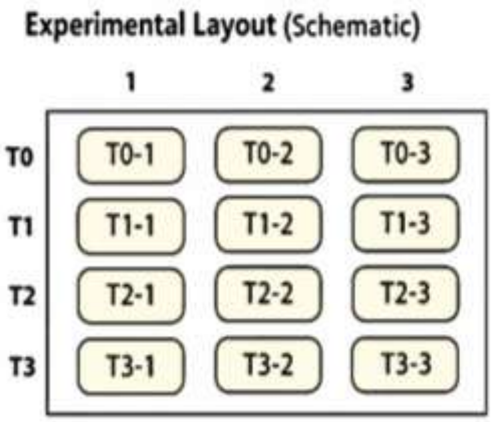


**Figure 7: Experimental layout setup**

### 3.2.10. Seed Sowing

Brinjal seeds (Solanum melongena) were selected as the experimental crop. The seeds were sown in the prepared grow bags at a depth of approximately 1–2 cm. Adequate spacing was maintained between plants to allow proper growth and development. After sowing, the soil was watered regularly to maintain adequate moisture for seed germination.

### 3.2.11. Ash Application

The collected briquette ash from each agricultural residue was applied separately to the soil in the grow bags. Each type of ash represented a different treatment in the experiment. The treatments were applied carefully to ensure uniform distribution of nutrients in the soil.

### 3.2.12. Growth Monitoring

Plant growth was monitored throughout the experimental period. Several growth parameters were recorded at regular intervals, including:

- Plant height (cm) – measured using a measuring scale.
- Two-leaf stage development – observed during the early growth stage.
- Leaf count – total number of leaves per plant recorded periodically.
- Flowering stage – time taken for the appearance of the first flower.
- Fruit stage – number of fruits formed on each plant.
- Harvesting stage – mature fruits were harvested and yield was recorded.

### 3.2.13. Data Analysis

The recorded observations were compiled and analysed to evaluate the effect of different briquette ashes on crop growth. Average values of plant height, leaf number, flowering time, and fruit yield were calculated. The results were then compared among the four treatments to determine which agricultural residue-based briquette provided the best performance in terms of soil enrichment and crop growth

## 4. Results:

The growth performance of brinjal plants was evaluated under four treatments using ash derived from different agricultural residue briquettes. The observed growth parameters included plant height, two-leaf stage development, leaf count, flowering stage, fruit formation, and yield at harvest. The results obtained from the experiment are presented below**.**

### 4.1 Plant Height Observation

| Weeks | Orange peel ash | Sugarcane bagasse ash (cm) | Pineapple peel ash (cm) |
|---|---|---|---|
| **Week 1** | 6 | 7 | 6 |
| **Week 2** | 12 | 14 | 13 |
| **Week 3** | 20 | 24 | 22 |
| **Week 4** | 30 | 35 | 32 |
| **Week 5** | 38 | 45 | 41 |
| **Week 6** | 45 | 52 | 48 |

### 4.2 Two-Leaf Stage Development:

| Treatments | Days to reach Two leaf stages |
|---|---|
| **Control** | 9 days |
| **Orange peel ash** | 9 days |
| **Sugarcane ash** | 8 days |
| **Pineapple peel ash** | 9 days |

### 4.3 Leaf Count Observation:

| Treatments | Leaf count per plants |
|---|---|
| **Control** | 27 |
| **Orange peel ash** | 28 |
| **Sugarcane ash** | 32 |
| **Pineapple peel ash** | 29 |

### 4.4 Flowering Stage observation

| **Treatments** | **Days to first flower** |
|---|---|
| **Control** | 39 Days |
| **Orange peel ash** | 38 Days |
| **Sugarcane bagasse ash** | 35 Days |
| **Pineapple peel ash** | 37Days |

### 4.5 Fruit Development:

| **Treatments** | **Average number of fruits** |
|---|---|
| **Control** | **7** |
| **Orange peel ash** | 8 |
| **Sugarcane bagasse ash** | 11 |
| **Pineapple peel ash** | 9 |

### 4.6 Harvest Yield:

| **Treatments** | **Yield per plant(g)** |
|---|---|
| **Control** | 300 |
| **Orange peel ash** | 320 |
| **Sugarcane bagasse ash** | 410 |
| **Pineapple peel ash** | 350 |

### 4.7 Overall Result:

Among the four treatments, sugarcane bagasse briquette ash showed the best performance in terms of plant height, leaf development, early flowering, fruit formation, and final yield. This indicates that sugarcane bagasse briquette ash has higher potential for soil enrichment and crop growth improvement

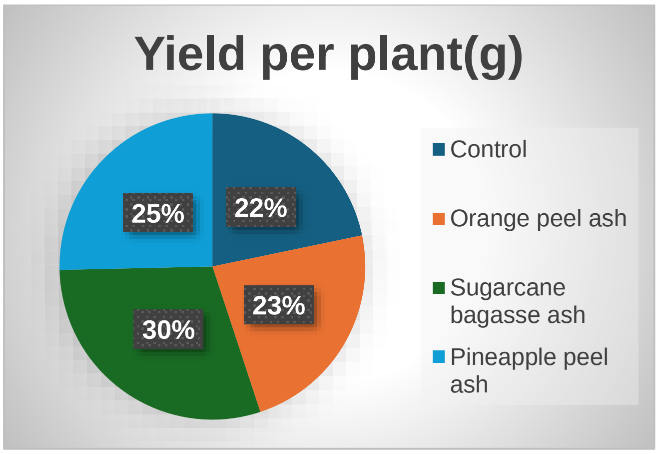


**Figure 8: Yield comparison chart**

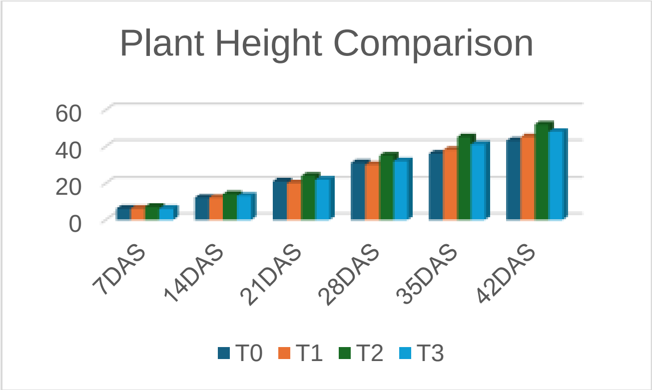


**Figure 9: Plant height comparison**

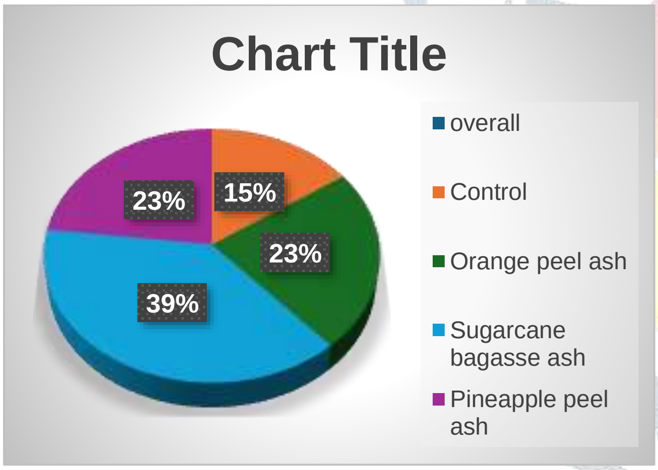


**Figure 10: Overall comparison of individual briquettes treatments**

## 5. Discussion

The present study evaluated the potential of agricultural residue-based briquettes as a source of ash for soil enrichment and crop growth improvement. Briquettes were prepared from three different residues—orange peel, sugarcane bagasse, and pineapple peel—and the ash obtained after the pyrolysis process was applied to brinjal plants grown in alluvial soil using the grow bag method. The growth performance of the plants was assessed through parameters such as plant height, leaf development, flowering stage, fruit formation, and final yield.

The results indicated that the application of briquette ash had a positive influence on plant growth and development. Biomass ash is known to contain essential plant nutrients such as potassium, calcium, magnesium, and trace minerals that contribute to improved soil fertility. When applied to the soil, these nutrients enhance plant metabolic activities, promote vegetative growth, and improve crop productivity. In the present study, all three treatments showed improvement in plant growth parameters, indicating that agricultural residue ash can serve as a beneficial soil amendment.

Among the treatments tested, the ash derived from sugarcane bagasse briquettes produced the best results in terms of plant height, leaf count, earlier flowering, and fruit yield. This may be attributed to the higher mineral

content present in sugarcane bagasse ash, particularly potassium and calcium, which play an important role in plant growth and fruit development. Potassium helps regulate water balance and enzyme activity in plants, while calcium contributes to cell wall formation and overall plant strength.
The results also showed that orange peel ash and pineapple peel ash improved plant growth compared to untreated soil, although their effects were slightly lower than those observed with sugarcane bagasse ash. This difference may be due to variations in the nutrient composition of the residues used for briquette production. Fruit peel residues generally contain organic compounds that contribute to soil fertility, but their mineral composition may vary depending on the type of fruit waste.
Another important aspect of this study is the use of a simple and low-cost briquetting and pyrolysis method. The use of a hand-operated briquetting machine and traditional stove pyrolysis demonstrates that this technique can be easily adopted by small-scale farmers or rural households. This approach not only provides a method for managing agricultural waste but also creates an additional benefit by producing nutrient-rich ash that can be used to improve soil fertility.
The findings of this study support the concept of integrated waste management and sustainable agriculture. By converting agricultural residues into briquettes and utilizing the resulting ash as a soil amendment, it is possible to reduce environmental pollution while enhancing crop growth and productivity. This approach promotes the recycling of organic waste materials and contributes to the development of environmentally friendly agricultural practices.
Overall, the results of this research highlight the potential of agricultural residue briquettes as a sustainable solution for both biomass energy production and soil fertility improvement. Further studies involving larger field trials and detailed soil nutrient analysis could provide deeper insights into the long-term benefits of this approach for agricultural systems.

## 6. Conclusion

This study investigated the potential use of agricultural residue-based briquettes as a sustainable approach for soil enrichment and crop growth improvement. Agricultural residues such as orange peel, sugarcane bagasse, and pineapple peel were successfully converted into briquettes using a hand-operated briquetting machine. The briquettes were then subjected to a traditional stove pyrolysis process, and the resulting ash was applied to alluvial soil for the cultivation of brinjal plants using the grow bag method.
The results of the experiment showed that the application of briquette ash positively influenced plant growth parameters, including plant height, leaf development, flowering stage, fruit formation, and final yield. Among the three treatments, the ash derived from sugarcane bagasse briquettes demonstrated the best performance in enhancing plant growth and productivity. This improvement may be attributed to the higher mineral nutrient content present in sugarcane bagasse ash, which supports plant development and soil fertility.
The findings of this study highlight the potential of agricultural residue briquettes not only as an alternative biomass fuel but also as a valuable source of soil nutrients. The use of briquette ash as a soil amendment provides a practical solution for agricultural waste management while simultaneously improving crop growth. Overall, this research demonstrates that converting agricultural residues into briquettes and utilizing their ash for soil enrichment is an effective, low-cost, and environmentally friendly approach that supports sustainable agriculture and resource recycling.

## 7.Future scope

The present study demonstrates the potential of agricultural residue-based briquettes as a sustainable method for soil enrichment and crop growth improvement. However, further research can be conducted to expand and improve this approach in several ways.
Future studies can focus on conducting large-scale field experiments instead of pot or grow bag experiments to evaluate the effectiveness of briquette ash under real agricultural field conditions. This will help determine the practical applicability of this method for farmers.
Additional research can also be carried out to analyse the nutrient composition of briquette ash, including important elements such as potassium, calcium, magnesium, and phosphorus. Detailed soil analysis before and after ash application would provide better understanding of how briquette ash improves soil fertility.

The study can also be extended by testing different types of agricultural residues, such as rice husk, coconut shell, corn cobs, and banana waste, to identify other potential biomass materials suitable for briquette production and soil enrichment.

Further investigation can be conducted on the long-term effects of briquette ash application on soil properties, including soil pH, microbial activity, and nutrient availability. This will help determine whether continuous application of briquette ash can sustainably improve soil health.

In addition, the development of improved briquetting technologies and efficient pyrolysis systems may enhance briquette quality and ash production. This could make the process more efficient and economically beneficial for farmers and rural communities.

Overall, future research can contribute to the development of integrated systems that combine agricultural waste management, renewable energy production, and sustainable soil fertility improvement, thereby supporting environmentally friendly and resource-efficient agricultural practices

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