Development of Biodegradable Seedling Pots Using Paper and Agricultural Fiber Waste

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Abstract- The growing need for plastic waste minimization and inefficiency of traditional recycling processes have necessitated a critical need for sustainable alternatives in plant nursery activities. This study investigates the production of biodegradable seedling pots from paper waste and fiber waste as an alternative to traditional plastic pots. A biocomposite mixture containing 30% newspaper, 30% tissue paper, 20% corn cob powder, and 20% coconut shell powder was used to prepare seedling pots of the highest strength and environmental friendliness. Prepared specimens were subjected to mechanical testing for compression and flexural strength analysis and a test for seed germination to estimate biodegradability. The test results showed that the pots had satisfactory mechanical strength to withstand watering and handling, as well as promoting normal root growth and natural degradation in soil. The formulation described in this study offers an effective, cheap, and green alternative to synthetic pot replacements. Further research into material proportioning and survivability under various climatic conditions is recommended to improve large-scale utilization.

Key terms: Biodegradable pots, paper waste, fibre blend, mechanical strength, germination of seed.

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I. Introduction

The extensive use of plastic seedling pots in farms and nurseries has resulted in some severe environmental problems since they are not biodegradable. The pots are typically petroleum-based polymers, which are themselves slow to decompose and take centuries. Therefore, they clog the environment and fill landfills and pollute ecosystems. Inadequate air permeability in plastic pots also restricts oxygen supply to plant roots, affecting their health and growth.

In addressing these requirements, scientists and ecologists have turned to biodegradable pots made from waste and natural materials. Such eco-friendly pots offer consumers a green alternative that not only reduces plastic usage but also ensures the health of plants. Biodegradable pots can be planted straight into soil that is degradable because of paper, which eliminates transplant shock and root damage—two of the most crucial elements in plant survival and growth.

Some of the biodegradable containers in use today are peat pots, coir fiber pots, and paper pulp containers. Although they are good producers, all are based upon some materials that are expensive or in short supply worldwide. Besides, work on mixing paper wastes with agricultural fibers such as corn cobs and coconut shells has yet to be very extensive.

This study applies to the production of a fresh mixture of biodegradable potting for seeds from easily attainable waste sources—newspaper, tissue paper, corn cob, and coconut shells. The aim is to create a pot meeting mechanical and functional requirements for nurseries and promoting sustainability and waste reduction. Mechanical properties testing and testing for biodegradability were conducted to establish the performance of pots produced.

Problem Statement

Plastic pots used for seedlings, which are extensively used in greenhouses and nurseries, contribute significantly to environmental pollution because they are both non-biodegradable and fossil fuel derived. While there are biodegradable alternatives, these are either too expensive or produced using limited resources and do not carry the mechanical strength necessary for useful application. Low-cost, eco-friendly waste materials like paper waste, corn cobs, and coconut shells, available in bulk amounts and wasted, have not yet been used. Hence, it is extremely imperative to develop an eco-friendly biodegradable seedling pot using such wastage materials which not only reduces the environmental burden but also serves the functional and structural need of a traditional nursery pot.

1.1. Research Objectives

1)To develop biodegradable seedling trays from composite wastepaper of (tissue paper and newspaper) and natural agriculture fiber (corn cob and coconut shells).

2)To find out the mechanical properties of developed trays by compressive and flexural test to ensure suitability to use in nursery.

3}To check the biodegradation and ability of seed germination of developed trays by conducting soil-burial and seed germination trial on green gram and mustard seed.

4)To determine the impact of different contents of materials on physical strength and decomposition rate of pots.

5)To introduce an affordable, eco-friendly substitute for plastic nursery pots using locally available waste materials.

II. Literature Review

2.1 Use of Biodegradable Material for Nursery Purpose

Plastic pots, even though widely used, are extremely detrimental to the environment since they are non-biodegradable. Scientists have created biodegradable alternatives using recycled and natural content to counteract the same. Biopots made of peat moss, coir fiber, and manure have been widely utilized among the most common ones in nurseries. Evans et al. (2010) reported the physical properties of these biocontainers and mentioned the favorable environmental attributes but also stated structural durability concerns.

2.2 Paper-Based Biodegradable Containers

Paper-based materials and cellulose-based materials are now very much in demand due to their low cost and easy availability. Liu and Wang (2020) showed the application of recycled paper in biodegradable containers, where germination test values were very high. The study did not mention the aspect of how such material can be reinforced to be made stronger.

2.3 Agro-Waste and Fiber-Based Composites

Schettini et al. (2013) conditioned a mixture of hemp fibers and tomato waste of tensile strength 1.2 MPa with sodium alginate binder. Jirapornvaree et al. (2017) in their study made planters using pineapple waste, which disintegrated after 45 days and released nutrients into the soil. They did not, however, quote the tensile strength of the planters.

Fuentes et al. (2021) experimented with the combination of wheat flour, rice husk, and sunflower seed husk in biopots. The research concluded that gelatin-based mixtures provided the best growth conditions to the plants, emphasizing the importance of selecting binder material to maintain pot performance.

2.4 Identified Research Gaps

Whereas other studies have examined a broad array of biodegradable materials, there are few that have utilized powders of corn cob and coconut shell, easily discarded and plentiful. Their potential use in enhancing structural properties of biodegradable packages has not yet been conclusively established.

Besides, most of the existing research does not have complete mechanical tests such as compression and flexural strength analysis, which are imperative in usability determination in nurseries. This paper aims to overcome this limitation by combining wastepaper with vegetable fibers and conducting durability and biodegradability tests on the resulting seedling pots.

III. Materials

3.1 Raw Materials Used

Below are raw materials selected based on their availability, biodegradability, and fiber content:

Newspaper waste (30%)

Used tissue paper (30%)

Corn cobs (20%) – from sweet corn vendors near our area

Coconut shells (20%) – from wastes around our area

Tuber starch – as a natural binder

Water – for mixing and soaking

3.2 Preparation of Materials

Paper Processing: Newspaper and tissue paper were cut into shreds and soaked in water for 24 hours. They were ground for 1 hour until coarse paste was achieved. Hand-pressing and sieving were done to drain excess water.

Corn Cob Powder: Cleaned and dried corn cobs were dried for 24–28 hours at 60 °C tray dryer. Once they turned absolutely dry and hard, they were ground to powder size using mixer and then sieved to uniform texture.

Coconut Shell Powder: Coconut shells were allowed to burn to get charcoal-like material. Ground burnt coconut shells were sieved to fine texture and powder size.

3.3 Seedling Pots Composition

Two batches were prepared with different paper to fiber content ratio. The following are the compositions:

samples	paper	corn	coconut
Sample 1	60%	20%	20%
Sample 2	70%	15%	15%

Tuber starch paste was incorporated at the time of mixing to keep the particles together and provide rigidity.

IV Methodology

4.1 Molding and Drying Process

Homogeneous pulp was formed by mixing the paper paste, corn cob powder, coconut shell powder, and binder.

The mixture was filled in two-dimensional molds:

31 cm × 11 cm rectangular molds (50g mixture)
5 cm × 6.4 cm cylindrical molds (80–100g mixture)
Sun-dried for 5 to 7 days, turned daily for uniform drying. Sometimes oven drying was also done at 60 °C for 6 hours to get structural hardness.

4.2 Mechanical Testing

Compression Strength Test: Conducted on a Texture Analyzer (Model: TA-10) with a box crush test setup. Peak load deflection was measured.

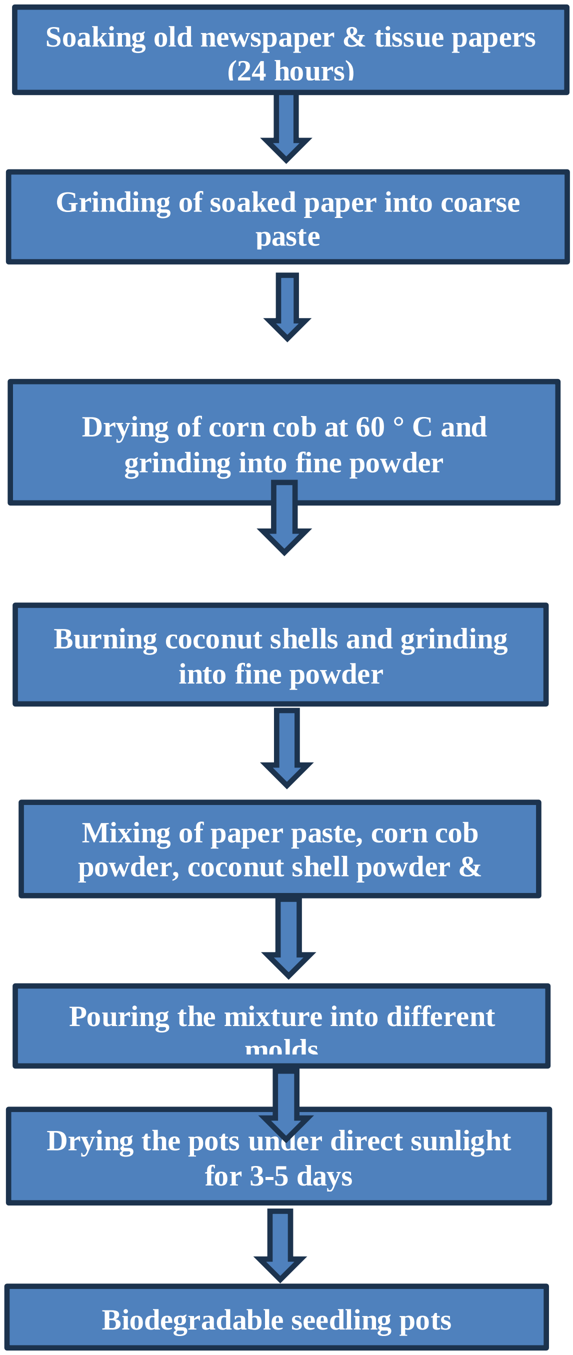
Flexural Strength Test: Bending and breaking strength of small pot sections were evaluated by three-point bending test.

4.3 Seed Germination and Biodegradability Test

Planting Test: Seeds of green gram and mustard were planted in pots, kept under regular care.
Soil Burial Test: Pots were buried in soil and watched over for 30 days for natural degradation.

Root Penetration: The roots were seen to penetrate deep into the walls of the pots, indicating biodegradability anseedligcompatibility.

V . Flow Diagram



VI. Testing

6.1 Compression Strength Test

Objective
To determine the ability of the pot to bear vertical load pressure in storage, handling, and watering.

Method
Equipment: Texture Analyzer (Model: TA-10, PackTest)
Test Speed: 400 mm/min
Mode: Stop at break
Sample Dimensions: 11 cm × 11 cm × 8.5 cm

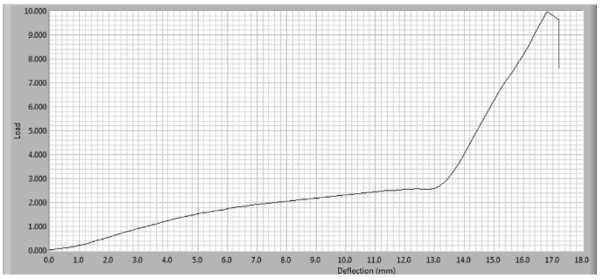


Fig 1.1 Break Test Graph

6.2 Flexural Strength Test

Purpose
Determine the flexibility and bending-resistance and external stress cracking resistance of the pot.
Equipment: Texture Analyzer (Model: TA-10, PackTest)
Speed of Test: 400 mm/min
Dimensions of Sample: 10 cm × 5 cm (flat surface of the pot)
Mode: Three-point bending, Stop at break

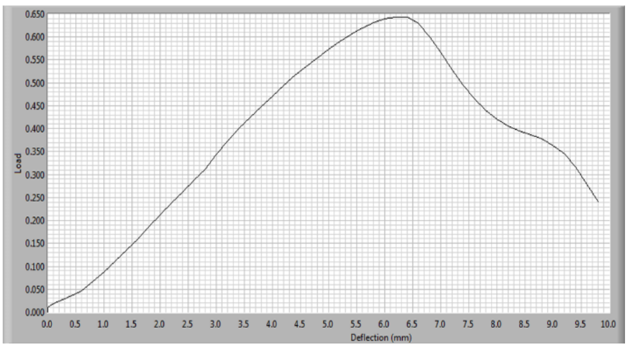


Fig 1.2 Flexural test graph

6.3 Seed Germination Test

Objective
To verify whether the pots allow plant growth and biodegradation in soil.
Method
Seeds Used: Green gram and mustard

Duration: 30 days
Watered at regular intervals and monitored for root growth and pots' strength Observations

Germination Rate:
Green gram: 85%
Mustard: 82%

Roots penetrated pot walls successfully, verifying biodegradability.

Product Outcome:

Fig 2.1 Seedling Pots

VII. Result and Discussion

This chapter presents the results of the mechanical and functional test carried out on the biodegradable seedling pots, with the findings interpreted in terms of material behavior and usability.

7.1 Compression Strength

The compressive experiment showed that seedling pots will withstand a load of 9.969 kgf before attaining breaking point when the extreme deflection is 16.8 mm. The experiments demonstrate that the pots can withstand full bearing loads of seedlings and soil weight under nursery conditions. This comes in handy during irrigation, piling, and transport where mechanical strain cannot be mitigated.

Compared to other biodegradable materials such as peat or coir fiber pots, strength in this research is extremely within acceptable limits. Reinforcement from the structural aspect by corn cob powder and coconut shell powder made the pots easy to handle without breaking or collapsing risks.

7.2 Flexural Strength

At the flexural test, the maximum load was 0.643 kgf at 6.2 mm deflection, and that is evidence that the pots are flexible. That is needed to avoid brittle failure on bending, which can be induced by pot handling or root enlargement. Reinforcement of the fibers improved bending by making the applied stress more uniform.

7.3 Seed Germination and Biodegradability

Both the mustard seeds and the green gram showed excellent germination of 85% and 82%, respectively. Seeds grew well inside the pots and were found with root systems that could easily pass through the pot walls without any obstruction. It is a good sign of both permeability and biodegradation of the pot, i.e., root growth does not obstruct the passage of water in and out.

There was 30-day soil burial followed by decomposition. The lower parts of the pots, being in direct contact with water-moist soil, experienced the highest level of degradation. This agrees with the observation that the pots degrade naturally when planted in the ground, and there is therefore no removal at transplanting time necessary.

7.4 Comparative Discussion

Whereas the bulk of earlier works utilized the usage of materials such as peat, cow feces, or paper pulp for biodegradable packaging, this work is able to effectively employ two lesser-examined agro-wastage products, namely corn cobs and coconut shells. Other than imparting mechanical strength, these fiber additives utilize vast wasted material, adding to waste control systems.

The test results agree with the literature for tensile strength of biodegradable pots, such as the paper of Schettini et al. (2013), which showed a tensile strength of 1.2 MPa for hemp fiber pots. There was no direct tensile test here, but the compression and flexure result is the same level of durability.

VIII. CONCLUSION

In this study, the production of biodegradable seed pots was successfully accomplished from a renewable composite of agricultural fibers and paper waste. Using a biocomposite composite of tissue paper, coconut shells, corn cobs, and newspaper, the project did not only solve issues of wastes but also offered a pragmatic alternative to plastic nursery pots.

Mechanical trials verified that the pots possessed sufficient compression strength (9.969 kgf) and flexural strength (0.643 kgf) to suit nursery requirements. In addition, the pots had excellent seed germination values (>80%) and began degrading naturally after 30 days when planted in the ground, thus their biodegradability.

The innovation was the new combination of easily accessible, wasted local materials—corn cob and coconut shell powder that played primarily the role of enhancing strength and performance in the final product. The use of natural starch as a binder also implied that no additives were utilized, thus environmental friendliness of the product.

In conclusion, it is inferred here that biodegradable seedling pots made of paper wastes and fiber wastes are robust in nature, effective in use, and eco-friendly. More effective material compositions, drying methods, and water-repellency treatments can enable these pots to be manufactured for commercial use by the mass.

IX. REFERENCES

1. Mwangi, R.W., Wagara, I.N., & Kariuki, S.T. (2021). A study on replacing plastic pots with eco-friendly organic alternatives for tree seedling production. East African Journal of Science, Technology and Innovation, 2(3).
(Original source: https://mail.eajsti.org.)

2. Ozolina, S. (2023). Use of furcellaria lumbricalis to create biodegradable pots for seedlings. Engineering for Rural Development Conference, Jelgava.
(DOI: 10.22616/ERDev.2023.22.TF147)

3. Evans, M.R., Taylor, M., & Kuehny, J. (2010). Physical characterization of physical properties in biodegradable containers for greenhouse crops. HortTechnology, 20, 549–555.
(DOI: 10.21273/HORTTECH.20.3.549)

4. Nambuthiri, S., Fulcher, A., Koeser, A.K., Geneve, R., & Nui, G. (2015). Sustaining the future with alternative growing containers: A review. HortTechnology, 25, 8–16.

5. Evans, M.R., & Hensley, D. (2004). Plant growth in pots constructed from peat, plastic, and poultry feather fibers. HortScience, 39, 1012–1014.

6. Zhang, X., Wang, C., & Chen, Y. (2019). Characteristics of biodegradable plug trays for seedlings. Scientia Horticulturae, 249, 177–184.

7. Schettini, E., et al. (2013). Use of tomato and hemp fiber waste in making biodegradable pots: Physical and field tests. Resources, Conservation & Recycling, 70, 9–19.

8. Stone, P. (2017). Evaluation of biosolids as materials for making decomposable plant containers. Master's Thesis, Virginia Polytechnic Institute and State University, USA.

9. Jirapornvaree, I., Suppadit, T., & Popan, A. (2017). Development of compostable pots using pineapple waste. International Journal of Recycling Organic Waste in Agriculture, 6, 345–350.