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Innovative Use of Coir and Abaca Fibers in Mulch Mats and Weaving for Sustainable Agriculture

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Abstract:

Mulching is an essential agricultural practice that enhances soil moisture retention, suppresses weed growth, and regulates soil temperature. However, conventional plastic mulch poses environmental challenges due to its non-biodegradability. This study explores the development and evaluation of eco-friendly mulch mats made from coir (coconut fiber) and abaca (Musa textilis) fibers as sustainable alternatives. The mulch mats were fabricated using different fiber compositions and binder formulations to assess their durability, water retention capacity, biodegradability, and impact on plant growth. Laboratory and field experiments were conducted to evaluate their physical and mechanical properties, decomposition rate, and effectiveness in weed suppression and soil conservation. Results indicate that coir-abaca mulch mats exhibit excellent water retention and biodegradability, making them a promising alternative to synthetic mulches. The study concludes that integrating natural fiber-based mulch mats in agricultural systems can promote sustainable farming practices while reducing plastic pollution.

Keywords: Coir, Abaca, Mulch Mat, Sustainable Farming, Biodegradable Mulch, Soil Conservation.

OBJECTIVES

1. To develop coir and abaca fiber-based mulch mats for eco-friendly farming applications.
2. To evaluate the effectiveness of coir and abaca mulch mats in moisture retention and weed suppression.
3. To assess the biodegradability and environmental impact of coir and abaca-based mats.
4. To compare the performance of coir and abaca mulch mats with conventional plastic mulch mats.
5. To explore the potential of coir and abaca fibers in weaving applications for sustainable products.
6. To determine the cost-effectiveness and feasibility of using coir and abaca fibers in agriculture and weaving.

Introduction:

- **Coir fibre:**

  Coir fibre is a natural lignocellulosic fibre extracted from the husk of Cocos nucifera (coconut). It is one of the most versatile and widely used natural fibres, known for its durability, resilience, and resistance to moisture and microbial degradation. Coir is primarily classified into brown and white fibre, with brown coir being coarse and strong, while white coir is finer and more flexible. Due to its unique properties, coir fibre has found applications in various industries, including textiles, agriculture, construction, and automobile manufacturing. With growing concerns over environmental sustainability,

coir fibre has gained significant attention as a renewable and biodegradable alternative to synthetic fibres. It is extensively used in eco-friendly products such as mats, ropes, brushes, mattresses, and bioengineering applications like erosion control mats and geotextiles. Moreover, its high lignin content enhances its strength and stiffness, making it suitable for composite materials in structural applications. This paper explores the properties, processing techniques, and potential applications of coir fibre, emphasizing its role in sustainable material development and industrial applications.

Fig.1:Coir fibre

Fig.2:Coir husk

Abaca fibre:

Abaca leaf Fiber Abaca plants (or Manila hemp) closely resemble the banana plant and belongs to Musaceae family. They are generally seen in a shady and humid area and grows abundantly in Philippines, Ecuador, and Costa Rica. A mature abaca plant reaches up to a height of 13–22 feet with a pseudo-stem of about 6 –15 inches in diameter. There are around 25 fiber fewer stalks that produce 12–25 leaves. The inner leaves of abaca contain less fiber than outer leaves. In addition to this abaca fiber possess good flexibility and water resistance. An important application of abaca fiber is in the production of ropes, woven fabrics, currency notes, cigarette filter papers, vacuum bags, tea bags, paper pulp, materials for car parts, etc. Owing to its superior mechanical strength it also finds application as a reinforcement material for composites.

Fig.3:Abaca fibre

Fig.4:Abaca fibre

Properties:

- Durability: Coir and abaca fibers are strong and resistant to wear, ensuring long-lasting use.
- Water Retention: Both fibers retain moisture effectively, promoting healthy soil conditions.
- Biodegradability: Coir and abaca are biodegradable, minimizing environmental impact.
- Weed Suppression: They prevent weed growth by blocking sunlight and creating a physical barrier.
- Strength and Flexibility: Abaca fibers are strong yet flexible, ideal for weaving and mulching.
- Breathability: Both fibers allow air circulation, improving soil aeration and root health.

Methodology:

This study focuses on the development and evaluation of mulch mats made from coir and abaca fibers in a 50:50 ratio using both woven and non-woven fabrication techniques. The mulch mats will be assessed for their durability, water retention, biodegradability, and effectiveness in soil conservation.

1. Materials and Preparation

Raw Materials:

- Coir fiber (extracted from coconut husk)
- Abaca fiber (extracted from Musa textilis)
- Ratio: 50% coir – 50% abaca

2. Fabrication of Mulch Mat

Woven Fabric Mulch Mat

- **Coir fiber extractions:**

  There are several de-husking procedures available for the separation of coconut husks from the surface of fruits. A skilled farmer could manually split and peel around 2000 coconuts in a single day (approximately), whereas the household could do 1 to 2 coconuts per day, and hotels 10 to 20 coconuts in a day. An automatic de-husking machine could split and peel around 2000 coconuts every single hour. The coconut husks are collected by the fiber extraction industries from different sources that are not involved with direct de-husking operations. The processes of fiber extractions are defined depending on the usage and quality of the fibers. Generally, the coconut husks in India are buried near the riverbanks in pits dug in a concrete tank filled with water. Sometimes, the coconut husks are also suspended through nets and weighted to ensure that they are submerged under the water in a river. Similar processes were described by Prashant et al. for processing coconut husks to extract coir materials.

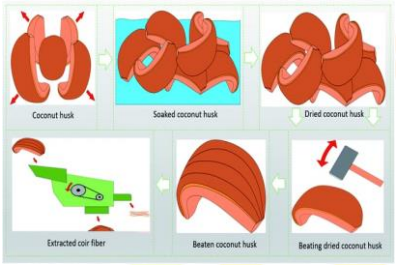


Fig.5 Coir fibre extraction

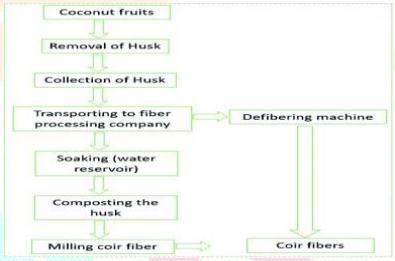


Fig.6 Process flow chart of Coir fibre

- **Abaca fiber extractions:**

  Extraction of abaca fiber The common methods to extract abaca fiber from abaca plants are tuxying and stripping. In tuxying method, abaca fibers are separated by inserting a special knife known as a tuxying knife between the inner and outer layers of the leaf sheath. The collected fibers by either hand stripping or spindle stripping. Both hand stripping or spindle stripping method are used to clean the fibers. Hand stripping is a tedious one, and only 1% of the fiber is recovered by this method. Spindle stripping involves the use of a spindle which is in motion by an electric motor. Here 1.5 to 2% of fiber is recovered. Another method to extract the abaca leaf fiber is called decortication. Here blade of decorticator removes the primary and secondary fibers from the sheaths. Compared to traditional hand stripping and spindle stripping methods, decorticator method produces better the fiber yield. The extracted raw fibers are sun-dried and are then graded based on fiber quality. Proper drying is essential for obtaining a good quality fiber.

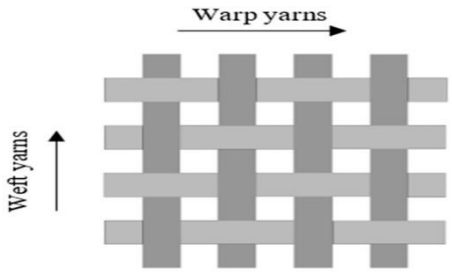


Fig.7 Abaca fibre extraction

- **Plain Weaving:**

  It is simplest and most common of the three basic textile weaves. It is made by passing each filling yarn over and under each warp yarn, with each row alternating, producing a high number of intersections. Plain weave fabrics that are not printed or given a surface finish have no right or wrong side. Air permeability refers to the ability of a fabric to allow air to pass through it. In textiles, the spaces between yarns or fibers play a crucial role in determining how easily air can flow through the fabric. Fabrics with higher air permeability are more breathable, allowing for better comfort, especially in hot and humid conditions, as they facilitate the exchange of heat and moisture between the body and the environment.

Fig.8:Structure of plain weave

- **Cutting and packing:**

  The cutting and packing process of coir and abaca fiber mulch mats ensures uniformity, ease of transportation, and convenience for end users. After weaving, the mats are measured and cut into standard sizes using sharp blades or mechanical cutters, ensuring clean edges and consistency. Any loose fibers are trimmed to enhance durability and appearance. Once cut, the mats are rolled or stacked flat, depending on their thickness and intended use. They are then bundled and secured using biodegradable ties or eco-friendly packaging materials to maintain their shape and prevent damage during transport. Proper labeling and storage in a dry environment ensure the mats remain in optimal condition until they reach consumers.

Testing:

1. Water Absorption:

Coir and Abaca Mulch Mats: Both coir and abaca fibers are highly absorbent materials. Coir, with its porous structure, can absorb a significant amount of water, which helps maintain soil moisture and supports plant growth during dry periods. Abaca, though slightly less absorbent than coir, still holds moisture effectively. Testing water absorption involves measuring the amount of water the mulch mat can hold when fully immersed, giving an idea of how it can help in maintaining adequate moisture levels in the soil beneath it.

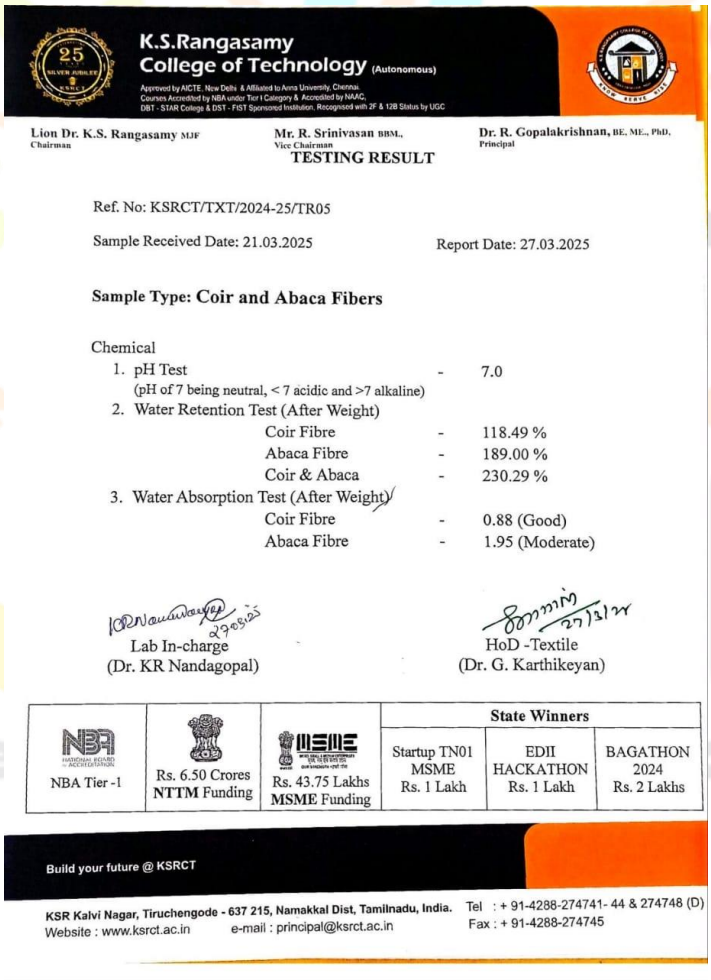
2. pH Test:

The pH of the mulch mats is important because it affects soil health and nutrient availability to plants. Coir has a slightly acidic pH, usually ranging from 5.5 to 6.5, which is ideal for most plants. Abaca fibers also have a mildly acidic pH, though the value may vary depending on processing methods. A pH test can be conducted by extracting a sample of the mulch material, mixing it with water, and measuring the pH using a pH meter or test strips. This helps determine the suitability of the mats for different crops, as some plants prefer slightly acidic or neutral soil conditions.

3. Water Retention:

Water retention is a critical property for mulch mats in agriculture. Both coir and abaca mats are designed to retain moisture on the soil surface, reducing the frequency of irrigation needed. Coir mats are particularly known for their high water retention ability due to their fibrous structure, which holds water while allowing air circulation. Abaca mats also perform well in retaining moisture but may retain slightly less water than coir. To test water retention, a sample of the mat is placed over a soil surface, and the moisture levels beneath it are measured over time to observe how long the mat helps maintain soil hydration.

Test Report:



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TESTING RESULT

Ref. No: KSRCT/TXT/2024-25/TR05

Sample Received Date: 21.03.2025 Report Date: 27.03.2025

Sample Type: Coir and Abaca Fibers

Chemical

1. pH Test - 7.0
   (pH of 7 being neutral, < 7 acidic and >7 alkaline)
2. Water Retention Test (After Weight)
   - Coir Fibre - 118.49 %
   - Abaca Fibre - 189.00 %
   - Coir & Abaca - 230.29 %
3. Water Absorption Test (After Weight)
   - Coir Fibre - 0.88 (Good)
   - Abaca Fibre - 1.95 (Moderate)

Lab In-charge (Dr. KR Nandagopal) — HoD -Textile (Dr. G. Karthikeyan)

NBA Tier -1	Rs. 6.50 Crores NTTM Funding	Rs. 43.75 Lakhs MSME Funding	State Winners: Startup TN01 MSME Rs. 1 Lakh	EDII HACKATHON Rs. 1 Lakh	BAGATHON 2024 Rs. 2 Lakhs

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Conclusion:

The development of coir-abaca mulch mats presents a sustainable and biodegradable alternative to synthetic mulches in agriculture. Utilizing a 50:50 ratio of coir and abaca Fibers, these mats offer effective soil moisture retention, weed suppression, and environmental benefits. Their natural composition supports soil

health and eco-friendly farming practices, reducing dependence on plastic-based materials. Additionally, proper packing and storage methods ensure their longevity and usability. The adoption of coir-abaca mulch mats can significantly contribute to sustainable agriculture, waste reduction, and environmental conservation.

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