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Application of coir-based agro-textiles in vegetable crop cultivation: Physical properties, field performance, and farmer acceptability

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Abstract

The present study investigates the application of coir and coir-jute blended agro-textiles in vegetable crop production. The study focuses on mulch mats, seedling bags, trays, and vegetable growing pots developed using coir (100%), coir-jute (50:50), and coir-jute (70:30) blends. Physical and morphological properties of raw fibres and developed products were assessed, while field trials on tomato and brinjal crops evaluated soil health, water retention, crop yield, and weed management. Results revealed that coir-jute (70:30) blends provided superior soil improvement, water use efficiency, and crop yield enhancement. Farmers demonstrated high acceptability of these products, citing their durability, biodegradability, and environmentally sustainable advantages. These findings highlight coir-based agro-textiles as effective tools for promoting sustainable vegetable cultivation in Haryana, India.

Keywords: Coir, jute, agro-textiles, vegetable crops, mulch mats, soil health, sustainable agriculture

Introduction

Vegetable cultivation is essential for food and nutritional security, income generation, and livelihood sustainability, particularly in agrarian regions of India. However, vegetable production systems face several challenges, including water scarcity, soil degradation, excessive weed growth, and increasing reliance on chemical inputs and plastic-based agricultural materials. Although plastic mulches and synthetic nursery products are widely used, their non-biodegradable nature leads to soil contamination and disposal-related environmental problems. Consequently, there is an urgent need for sustainable and eco-friendly alternatives that enhance crop productivity while reducing environmental impact.

Agro-textiles, a key segment of technical textiles, have gained importance due to their ability to improve soil conditions, conserve moisture, regulate temperature, and protect crops throughout the growth period. India, with its strong agricultural base and abundant natural fibre resources, offers significant potential for the adoption of biodegradable agro-textiles in vegetable cultivation. However, the widespread use of synthetic agro-textiles has

raised concerns regarding long-term soil health and environmental sustainability, emphasizing the need for natural fibre-based solutions.

Among natural fibres, coir-based agro-textiles present a promising alternative due to their biodegradability, renewability, and functional suitability. Coir fibre, derived from coconut husk, possesses high lignin content, excellent moisture retention capacity, resistance to microbial degradation, and durability under wet conditions. These characteristics make coir suitable for agricultural products such as mulch mats, seedling trays, seedling bags, and vegetable growing pots. Blending coir with jute fibre, known for its high tensile strength, flexibility, and hygroscopic nature, further improves the mechanical stability and performance of agro-textile products, making coir-jute blends particularly suitable for sustainable vegetable cultivation.

Coir and coir-jute based agro-textiles provide multiple agronomic benefits, including moisture conservation, temperature moderation, weed suppression, improved soil structure, and enhanced root aeration. Earlier studies have reported improvements in crop yield, soil properties, and

water-use efficiency using jute and coir agro-textiles (Adhikari *et al.*, 2016, Bhavani *et al.*, 2017; Dewi *et al.*, 2024) ^[1, 5, 7]. However, systematic evaluations under real-field conditions, particularly addressing physical properties, field performance, and farmer acceptability, are limited. Therefore, the present study evaluates the physical and morphological properties of coir-based and coir-jute blended agro-textile products and examines their field performance and acceptability among farmers in vegetable crop cultivation. The findings aim to support the adoption of biodegradable agro-textiles as sustainable alternatives to plastic-based materials in Haryana, India.

Review of Literature

Agro-textiles have emerged as an important technological intervention for improving agricultural productivity while promoting environmental sustainability. Several studies conducted in India and across the world have highlighted the role of agro-textiles in conserving soil moisture, regulating temperature, suppressing weeds, and enhancing crop growth. Beena and Anil(2011) ^[4] reported the effectiveness of coir nonwoven bio-rolls and basket liners in promoting rapid root growth and improving aeration and moisture retention. Sornapudi and Kyatam (2024) ^[16] emphasized the usefulness of natural fibre-based ground covers for long-term weed control and moisture conservation, reducing dependency on chemical herbicides. Natural fibres such as coir and jute have gained attention due to their biodegradability and functional advantages. Coir fibre is known for its high lignin content, durability under wet conditions, excellent moisture retention, and ability to improve soil aeration and structure (Bhavani *et al.*, 2017;Mahish and Nayak, 2017) ^[5, 10]. Jute fibre, owing to its tensile strength, hygroscopic nature, and soil-conditioning properties, has been widely used for mulch mats, erosion control, and nursery applications (Adhikari *et al.*, 2016; Mridha *et al.*, 2025) ^[1, 13]. Studies have shown that coir-jute blends combine the advantages of both fibres, offering better flexibility, durability, and performance compared to single-fibre agro-textiles (Islam *et al.*, 2019) ^[8].

Numerous field studies have demonstrated the positive impact of agro-textile products on crop production. Jute and coir mulch mats have been reported to significantly improve soil moisture retention, reduce soil erosion, suppress weed growth, and enhance yields in crops such as tomato, chilli, broccoli, capsicum, groundnut, banana, and maize (Das *et al.*, 2017; Bhavani *et al.*, 2017; Manna *et al.*, 2018; Kundu *et al.*, 2019) ^[6, 5, 9]. Nonwoven agro-textiles were also found to regulate soil temperature and create favourable microclimatic conditions, resulting in early crop maturity and improved yield (Ansary *et al.*, 2021; Sharma *et al.*, 2022) ^[3, 14].

Despite the proven agronomic benefits, the adoption of natural fibre-based agro-textiles remains limited. Farmer awareness, usability, cost-effectiveness, and field-level performance play a crucial role in adoption decisions (Singh *et al.*, 2025) ^[15]. Moreover, limited studies have simultaneously evaluated the physical properties, field performance, and farmer acceptability of coir-based and coir-jute blended agro-textile products under real-field conditions. Therefore, the present study aims to bridge this gap by systematically assessing coir-based agro-textiles for

vegetable crop cultivation.

Materials and Methods

Study Area: Experiments were conducted in Haryana, India (Hisar, Sirsa, Khanpur, Barwala, Adampur, Nanakpur, Rtakhera, FarmaiKalan) to represent diverse agro-climatic conditions and soil types.

Fibre and Product Development

Coir (100%) and coir-jute blends (50:50 and 70:30) were used to develop mulch mats, seedling bags, seedling trays, and vegetable pots at NITRA Technical Campus, Ghaziabad, and College of Agricultural Engineering and Technology, Hisar.

Physical and Morphological Analysis

Fibres were evaluated for length, fineness, elongation, moisture content, wax content, and tenacity. SEM analysis was performed to study surface morphology.

Field Testing

Tomato and brinjal crops were grown to assess soil health, water retention, crop yield, weed density, and farmer acceptability.

Antimicrobial Activity

Products were tested against *Staphylococcus aureus* and *Klebsiellapneumoniae* to evaluate potential microbial resistance.

Results

Table 1: Knowledge and Awareness of Farmers

Parameter	High Knowledge (%)	Low Knowledge (%)
Agro-textile products	85.00	46.67
Use in cucumber cultivation	63.33	20.00
Use in pomegranate	20.00	80.00
Crop cover & shade nets	48.33	51.67
Black polythene fibres	75.00	25.00
Jute fibres	41.67	58.33
Nonwoven technique	70.00	30.00
Productivity enhancement	63.33	36.67
Shelf life knowledge	63.33	36.67

Table-1 presents the knowledge levels of respondents regarding the use of agro-textile products in vegetable crop cultivation. The data shows that 85% of respondents have a high level of knowledge about agro-textiles in general, while 46.67% had low knowledge about specific products. The table also highlights that 63.33% of respondents were knowledgeable about the use of agro-textiles in cucumber cultivation, whereas only 20% had knowledge about their use in pomegranate crops. Awareness of specific textile fibres such as black polythene (75%) and jute fibres (41.67%) was also recorded. Additionally, 70% of respondents were aware of nonwoven techniques used in developing agro-textile products, and 63.33% recognized their productivity-enhancing properties. Most respondents also acknowledged the shelf life of these products to be 2–4 years. The table provides an overview of the readiness of farmers to adopt coir-based and coir-jute blended agro-textiles.

Table 2: Physical and Morphological Properties of Raw Fibres

Fibre	Length (mm)	Fineness (denier)	Elongation (%)	Moisture Content (%)	Wax Content (%)	Tenacity (g/Tex)
Jute	670-750	20	2-8	12-15	0.3-0.7	30-35
Coir	40	75	1.1-1.5	9-11	1.8	30-35

Table- 2 compares the key physical properties of jute and coir fibres. Jute fibres were longer (670–750 mm), finer (20 denier), and had higher moisture content (12–15%), while coir fibres exhibited greater wax content (1.8%) and similar tenacity (30–35 g/Tex). Elongation of jute fibres ranged

from 2–8%, while coir ranged from 1.1–1.5%. These properties indicate that jute fibres contribute tensile strength and flexibility, whereas coir adds resilience and durability. The data emphasizes the complementary nature of coir and jute fibres for developing agro-textile products.

Table 3: Physical Properties of Developed Agro-Textiles Coir (100%)

Product	Thickness (mm)	Weight (g/m ²)	Tensile Strength (MPa)	Elongation (%)	Bending Length (mm)
Vegetable Growing Pot	11.64	18.8	0.63	9.2	50
Mulch Mat	4.8	12.5	0.42	6.8	28
Seedling Tray	6.2	13.1	0.50	7.5	35
Seedling Bag	5.4	12.0	0.39	6.0	30

Table- 3 presents the physical properties of agro-textile products developed using 100% coir fibre. The vegetable growing pot recorded the maximum thickness (11.64 mm), tensile strength (0.63 MPa), elongation (9.2%), and bending length (50 mm), indicating higher rigidity and strength. Mulch mats showed comparatively lower thickness (4.8 mm), tensile strength (0.42 MPa), and bending length (28 mm), suggesting greater flexibility suitable for mulching

applications. Seedling trays and seedling bags exhibited intermediate values of thickness, tensile strength, elongation, and bending length, reflecting a balanced combination of strength and flexibility required for nursery use. Overall, the developed coir-based agro-textile products showed adequate physical properties for their respective agricultural applications.

Table 4: Degradation over 21 Days

Product	Blend	Weight Loss (%)	Tensile Strength Loss (%)
Mulch Mat	Coir (100%)	13.60	63.63
Seedling Tray	Coir (100%)	11.50	33.33
Mulch Mat	Coir-Jute (50:50)	14.60	65.60
Seedling Tray	Coir-Jute (50:50)	13.50	34.33
Mulch Mat	Coir-Jute (70:30)	16.10	67.10
Seedling Tray	Coir-Jute (70:30)	14.10	36.30

Table 4 shows the weight loss (%) and tensile strength reduction (%) of coir and coir-jute blend agro-textile products after a 21-day field trial. Coir (100%) mulch mats showed the highest degradation with a 13.6% loss in weight and 63.63% reduction in tensile strength, whereas seedling trays exhibited the least reduction (11.5% and 33.33%,

respectively). In coir-jute 50:50 and 70:30 blends, mulch mats again had the highest degradation, and seedling trays the least. These findings highlight the varying durability of products, guiding their selection for specific agricultural applications.

Table 5: Field Performance

Parameter	Coir-Jute 50:50	Coir-Jute 70:30	Conventional
Aggregate Stability (%)	78	82	60
Nitrogen (kg/ha)	180	192	140
Phosphorus (kg/ha)	15.5	16.2	12
Potassium (kg/ha)	285	295	250
Microbial Biomass (µg/g)	450	480	320
Water Holding Capacity (%)	82	80	45
Irrigation Frequency (days)	15	15	5
Water Use Efficiency (g/L)	6.20	6.10	3.5
Tomato Yield (kg/ha)	36,200	37,500	25,000
Brinjal Yield (kg/ha)	28,500	29,900	22,000
Weed Density (per m ²)	15	13	80
Weed Coverage (%)	12	10	75

Table- 5 presents the effect of coir-jute blend (70:30) agro-textiles on soil parameters such as aggregate stability, nutrient content (N, P, K), microbial activity, and microbial biomass content. The data indicates that the 70:30 blend

significantly improved soil structure and fertility, enhancing aggregate stability to 82%, nitrogen content to 192 kg/ha, phosphorus content to 16.2 kg/ha, potassium content to 295 kg/ha, and microbial biomass to 480 µg/g. These

improvements reflect the ability of coir-jute agro-textiles to enhance soil health and promote sustainable agriculture. The coir-jute 50:50 blend increased water holding capacity to 82%, soil moisture to 25%, and improved water use efficiency to 6.20 g/L. The 70:30 blend resulted in higher yields, with tomato at 37,500 kg/ha and brinjal at 29,900 kg/ha. These results demonstrate the efficacy of agro-textile products in enhancing water conservation, irrigation efficiency, and productivity.

This table also shows weed density (per m²) and weed coverage (%) for conventional farming versus coir-jute 70:30 agro-textiles. Conventional methods had 80 weeds/m² and 75% coverage, whereas the coir-jute 70:30 blend reduced weed density to 13 weeds/m² and coverage to 10%, eliminating the need for chemical herbicides. These results confirm the potential of coir-jute agro-textiles for sustainable weed management in vegetable crops.

Discussion

This study demonstrated that coir-jute blends, particularly at a 70:30 ratio, improved soil health, water retention, crop yield, and weed management in vegetable cultivation compared to conventional practices. The enhanced performance is attributed to the complementary properties of coir and jute: coir provides structural stability and slow biodegradation, while jute adds flexibility and better water retention. These results align with previous findings showing that natural fibre mulches enhance soil structure, nutrient cycling, and moisture conservation (Adhikari *et al.*, 2016; Bhavani *et al.*, 2017) ^[1, 5].

Physical analyses revealed that vegetable growing pots had the highest thickness and tensile strength, whereas mulch mats were thinner and more flexible, suitable for soil covering and weed suppression. Seedling trays and bags offered intermediate properties for nursery use, consistent with earlier studies emphasizing product-specific fibre composition (Manna *et al.*, 2018; Islam *et al.*, 2019) ^[11, 8].

Degradation over 21 days showed faster breakdown in mulch mats than seedling trays, which is desirable for gradual soil integration while maintaining tray integrity for seedlings. Similar biodegradation patterns in coir and jute products have been reported by Das *et al.* (2017) ^[6] and Kundu *et al.* (2019) ^[9].

Field trials indicated improved soil fertility under coir-jute 70:30 mulch, with higher aggregate stability, nutrient content, microbial biomass, and water use efficiency. Weed density and coverage were significantly reduced, minimizing chemical herbicide use, consistent with reports on natural fibre mulches (Bhavani *et al.*, 2017; Sharma *et al.*, 2022) ^[5, 14].

High farmer acceptability reflects recognition of these products' durability, biodegradability, and environmental benefits, supporting previous findings on adoption of eco-friendly agro-textiles (Singh *et al.*, 2025) ^[15]. Overall, the 70:30 coir-jute blend offers an optimal balance of strength, biodegradability, and field performance, promoting sustainable vegetable cultivation. Future studies should explore long-term trials and large-scale economic feasibility.

Conclusion

The present study confirms that coir-based agro-textiles,

especially coir-jute blended products, are effective and sustainable alternatives to conventional agricultural materials in vegetable crop cultivation. The use of these agro-textiles improved soil moisture retention, soil health, crop yield, and weed suppression while reducing environmental impact. Among the tested materials, the coir-jute (70:30) blend showed the best overall field performance, providing an optimum balance of strength, durability, and biodegradability.

Physical property evaluation and SEM analysis supported the functional efficiency of the developed products, indicating good fibre bonding, structural stability, and suitability for nursery and field applications. The positive response and high acceptability among farmers further demonstrate the practical feasibility and adoption potential of coir-based agro-textiles. Overall, the study highlights the potential of coir and coir-jute agro-textiles to promote sustainable vegetable production by enhancing productivity while maintaining soil and environmental health.

Recommendations

1. Develop and promote coir-jute (50:50 and 70:30) blend mulch mats for sustainable vegetable farming.
2. Encourage use of coir-based seedling trays, bags, and pots to enhance root growth and transplant success.
3. Conduct targeted farmer training programs to increase adoption of coir-jute agro-textiles.

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