Jute Agrotextile Mulching: A Climate-Resilient Approach to Natural Resource Management in Agriculture

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Introduction

Climate change presents unprecedented challenges to agricultural sustainability worldwide. Rising temperatures, erratic rainfall patterns, increased frequency of droughts and soil degradation threaten food security and farmer livelihoods. In this context, climate-resilient agricultural practices that effectively manage natural resources while maintaining productivity have become imperative. Jute agrotextile mulching represents an innovative, eco-friendly solution that addresses multiple climate-related challenges in agriculture while promoting sustainable resource management (Kundu et al., 2018). Notably, the Technology Demonstration Component (TDC) of the National Innovations in Climate Resilient Agriculture (NICRA) Project has incorporated various Natural Resource Management (NRM) practices to address climate vulnerabilities. Among these practices, mulching methodologies, including jute agrotextile mulching, have been also adopted and demonstrated by Krishi Vigyan Kendras (KVKs) across India as effective NRM interventions. This intervention effectively regulates soil hydrothermal regimes by conserving moisture and moderating soil temperature fluctuations, thereby maintaining physiological functions and productivity even under moisture-deficit conditions.

Understanding Jute Agrotextile: Jute agrotextiles are permeable fabrics manufactured from 100% natural, biodegradable jute fibers, available in both woven and non-woven forms. Woven jute agrotextile feature an open mesh structure, while non-woven variants have no open areas, making them more effective for specific applications (Manna et al., 2018). The composition of non-woven jute agrotextile includes approximately 60% cellulose, 23% hemicellulose and 13% lignin, creating a completely biodegradable material that eventually enriches the soil with organic matter (Kundu et al., 2018). Unlike plastic mulches that contribute to environmental pollution, jute agrotextiles offer a sustainable alternative with multiple agronomic and environmental benefits. As defined by Kundu et al. (2018), jute agrotextile is "A kind of natural technical textile, usually either in woven or non-woven form, made from 100% natural eco-friendly fibre of jute plant used on soil to achieve higher agricultural productivity by improving agronomical characteristics of soil and by reducing growth of unwanted vegetation."

The benefits of jute agrotextile based mulching are discussed briefly,

A. Soil Moisture Conservation: Water scarcity represents one of the most significant challenges in climate change scenarios. Jute agrotextile mulches excel at soil moisture conservation by reducing evaporation rates and improving water retention in the root zone. Research by Manna et al. (2018) demonstrated that non-woven jute agrotextile mulch (NJATM) of 400 gsm thickness maintained the highest soil moisture content (12.70% at 15 days after planting) compared to bare soil (6.58%). This moisture retention capacity remained consistent throughout the growing season. Das et al. (2017a) also validates these findings, reporting that 500 gsm non-woven agrotextile mulches recorded the highest moisture content (7.968%) at 15 days after sowing, which was statistically at par with 300, 350 and 400 gsm mulches. In water-

stressed conditions, this improved moisture conservation translates directly to climate resilience in agro based activities.

Weed Suppression and Reduced Chemical Inputs: Climate change often leads to altered weed dynamics, with many invasive species thriving under elevated CO_2 levels and warmer temperatures. Jute agrotextiles provide effective weed suppression by creating a physical barrier that blocks light from reaching weed seeds, inhibiting their germination and growth. Multiple studies revealed that non-woven jute agrotextile mulches significantly reduced weed density across different weed categories. Das et al. (2017b) further confirmed these findings, reporting that the Weed Control Efficiency (WCE) for broad-leaved weeds was highest with 300, 350, 400 and 500 gsm mulches. For grasses and sedges, the WCE was highest in 350, 400 and 500 gsm mulch treatments. Wilen et al. (1999) attributed this weed suppression to the mulches' ability to reduce light, which stressed existing weeds and prevented the germination of many weed species, especially those with small seeds.

B. Soil Erosion Control: Increased intensity of rainfall events due to climate change accelerates soil erosion, threatening agricultural productivity and sustainability. Jute agrotextiles provide effective protection against soil erosion by absorbing the kinetic energy of raindrops, reducing splash erosion, and slowing surface runoff. Research in hilly regions of Tripura, India, demonstrated that 300 gsm jute agrotextiles reduced soil loss by 12.5% on sloping lands (10-15% gradient) compared to unmulched controls (Datta et al., 2005). Bu et al. (2013) also reported that geotextile mulches reduce soil erosion from the impact of heavy raindrop, surface runoff and wind - all of which are exacerbated by climate change. This erosion control capability is particularly important in upland and hillside farming systems that are especially vulnerable to climate change impacts. By preventing soil erosion, jute mulches help maintain soil fertility, preserve topsoil and contribute to prevention of land degradation in the context of climate change adaptation.

C. Enhanced Crop Productivity: Climate resilience ultimately aims to maintain or improve agricultural productivity despite changing conditions. Jute agrotextile mulches consistently demonstrate significant yield improvements across various crops. Manna et al. (2018) reported that broccoli yields increased from 3.25 t/ha in unmulched plots to 8.53 t/ha with 350 gsm NJATM - an impressive 162% yield increment. Similar yield improvements have been documented for other crops: 66.8% increase in sesame pod yield, 15% in groundnut pod yield and 40.9% in upland rice grain yield (Datta et al., 2005). For high-value crops like capsicum and pointed gourd, geotextile mulches increased yields by 105% and 40%, respectively (Saha et al., 2006). Das et al. (2017b) documented a substantial yield increase in French bean using biodegradable geotextile jute mulches, with maximum yield (3215.25 kg/ha) recorded in 500 gsm mulch plots - a 242% increase over unmulched controls (939.2 kg/ha).

D. Soil Health Improvement: Climate-smart agriculture emphasizes practices that improve soil health while sequestering carbon. Jute agrotextiles contribute positively to both objectives. As they decompose, jute mulches add organic matter to the soil, improving its structure, water-holding capacity and microbial activity. Yadav et al. (2008) noted that mulches encourage the proliferation of micro-arthropods, earthworms and other beneficial microorganisms in the rhizosphere that bring about changes in the status of soil fertility. The application of jute mulches creates favourable conditions for soil microorganisms by moderating soil temperature and moisture, enhancing biological activity in the rhizosphere.

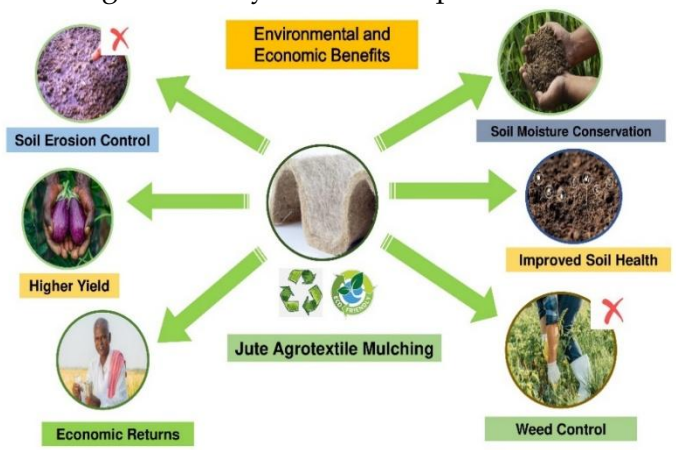

Fig. 1. Environmental and Economic Benefits of Jute Mulching as NRM Practice

Beyond environmental benefits, climate resilience must address economic and social dimensions. Jute agrotextiles offer several advantages in this regard. As a natural fiber produced primarily in India and Bangladesh, expanded use of jute products strengthens rural economies and provides income opportunities for farming community. The reduced labour requirement for weeding also addresses farm labour shortages and allows farmers to allocate resources more efficiently.

Conclusion

Jute agrotextile mulching represents a holistic approach to climate-resilient agriculture that addresses multiple challenges simultaneously. By conserving soil moisture and other benefits these biodegradable mulches offer a sustainable alternative to synthetic materials in the pathway of resilience building in agriculture. As global agriculture faces increasing pressure to produce more food with fewer resources under changing climatic conditions, nature-based solutions like jute agrotextiles may warrant greater attention from researchers, extension services, and policymakers. For widespread adoption, further research on optimizing jute mulch applications for different cropping systems and agro-ecological zones is needed, alongside policy consideration that recognize their multiple environmental benefits in the context of climate change adaptation and mitigation.

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