

Natural fibre based non-woven agrotextile mulch: A boon for natural farming

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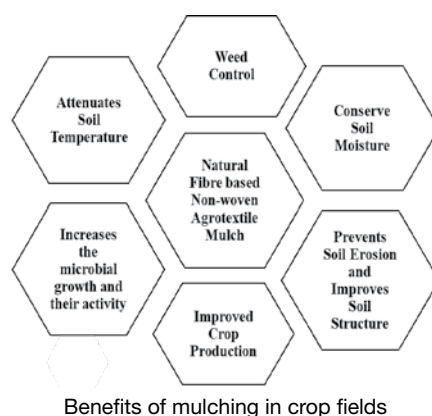
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Natural fibres play a key role in the emerging green economy, which focuses on concern for the environment, the well-being of fibre producers and consumers. One very important application of natural fibres encompasses the emerging sector like natural fibre based agrotextile to tackle alarming plastic pollution, especially growing microplastic fragments in crop fields. As conventional approach of traditional agriculture poses serious threats to the environmental sustainability, natural farming has emerged as a dynamic alternate farming system during the last two decades. Natural fibre based agrotextile mulch can be a vital component of natural farming system in resource limited agriculture. Several studies have highlighted the spectacular benefits of natural fibre based agrotextile applications in different crops in terms of soil moisture conservation, soil temperature control, weed control, microbial population, crop production enhancement and improved fruit quality.

Keywords: Crop yield, Natural farming, Natural fibres, Non-woven mulch, Plastic pollution

GREEN consumption of the world is rising from last two decades. This has resulted in the exploration of different natural fibres and the ecotextiles being seen as the developing trend in textile industry and getting attention from researchers and academicians for its inherent properties of environment friendliness and region specific abundance as a substitute of synthetic fibres. World production of all fibres is estimated to have reached 110 million tonnes in 2019, of which natural fibres are accounted for 30% of the total production. One very important application of natural fibres is in natural fibre based agrotextile to tackle alarming plastic pollution, especially growing microplastic fragments in crop fields. Gradual decline in soil health, loss of productivity, soil infertility, desertification, reduced agro-diversity, pesticide pollution and emerging pest-resistance poses serious concern to the sustainability of food production system through

the conventional approach. Natural fibre based agrotextile mulch can be a vital component of natural farming system in resource limited agriculture as mulching is an effective method of manipulating the crop-growing environment to increase crop yield and improve product quality.



Conventional mulching process

The popular organic mulching materials, such as straw and grass have been widely practiced since time immemorial. Synthetic mulch

(polyethylene film) with better durability, malleability, lightweight and low cost has gained gigantic popularity all over the world. Despite of multiple benefits that the material offers, researchers expressed their concerns on plastics due to inadequate end-of-life treatment, low recyclability and reusability rates, and high potential of disintegration into microplastics. In 2015, 6300 million tonnes of plastic waste was generated, 9% of which was recycled, 12% incinerated and the remaining 79% was sent to landfills or leaked to the environment. In such crucial juncture, natural fibre based non-woven agrotextile mulch being biodegradable, eco-friendly and cheap can be a sustainable alternative to the synthetics.

Natural fibre based non-woven agrotextile mulch

Agro-textile is an emerging sector of 21st century technical textiles with expected market size of 13.04 billion by 2028 registering a

healthy CAGR (Compound Annual Growth Rate) of 4.7%. Jute is a major commercial fibre crop of India and is one of the major candidate for sustainable development in the field of geotextiles and agrotextiles. With the advancement and improvements made in the non-woven production technologies, non-woven agrotextiles are gaining more and more advantage towards traditional agrotextiles. The term 'non-woven fabric' in the textile manufacturing industry denotes to fabrics or felts which are bonded by chemical, mechanical, heat or solvent treatment.

The institute has developed a non-woven Jute Agro-textile (JAT) technology, having different GSM through garneting cum cross lapping followed by needle punching. Non-woven agro-textile mulch are highly porous and vary from 250–650 gsm with thickness 3–6 mm, width 100 ± 10 cm having very high water absorption and retention capacity. Jute and other natural fibres have good potential as non-woven mulch due to their unique properties such as air permeability, water permeability and transmissivity, thermal, compressional properties etc (Table 1). They can withstand solar and UV radiation much better than synthetic fibres. Jute mulch fabrics are laid over the raised-bed and holes are made according to the plant-to-plant spacing. Jute non-woven felts are commercially produced in jute mills like Gloster Ltd, Birla Jute mill etc in West Bengal.



Laying of jute non-woven mulch fabric on raised-bed for transplanting seedling

Table 1. Important properties of jute non-woven mulch vs plastic

Parameter	Non-woven (100% pure jute)	Non-woven (50% pure jute and 50% Caddies)	Plastic	Implication
Tenacity (cN/tex)	0.2–0.8	0.15–0.35	3.3–6.67	Mechanical properties determine durability
Breaking elongation (%)	20–40	15–35	56–82	
Thickness (mm)	2.5–5.5	3–6	30–90 micron	
Air permeability (cm ³ /cm ² *s)	70–200	50–130	~ 0	Hydro-physical properties control soil micro-environment
Water flow rate (ml/s)	3–6	5–8	~ 0	
Transmissivity (m ² /s)*10-2	1.25–2.0	1.0–2.5	~ 0	
Apparent Opening Size (AOS), O95 (mm)	0.15–0.45	0.15–0.45		

Benefits of jute non-woven mulch

Weed control: In vegetable crops, weeds pose serious problem due to the competition they render to the cultivated species for nutrition and water. Due to the chemical fertilizers and frequent irrigations, helping the weeds to grow vigorously, the cultivated plants are stunted if proper weeding is not carried out. Jute non-woven mulch is able to suppress weed growth very effectively compared to the conventional mulch practices by 90% or more by reducing weed seed germination, weeds growth and thereby sharply reducing the need of herbicides.

Soil moisture conservation: The use of non-woven samples restricts the evaporation loss in between 64% and 67% while compared to the control in laboratory study.

In greengram (*Vigna radiate* L.), water use efficiency (WUE) of the crop was increased significantly by 70.27%, whereas there has been enhancement of WUE by 30–50% on summer tomato, strawberry etc.

Soil temperature modulation: The soil temperature in the pot experiment with plastic mulch shows increasing trend in temperature. Whereas, 250 g/m² non-woven jute cover in the pot restricts the abrupt rise in soil temperature to the tune of 30% as compared to control. Mulching reduces soil temperature in summer, raises it in winter and prevents the extremes of temperatures by 1–7°C.

Soil microbial population: Research data indicated that the application of jute non-woven mulch enhances soil microbial population *vis-a-vis* enzymatic activity in the soil as compared to un-mulched soil. Greater microbial activity in mulched soil alters the microbial community structure in the soil. Soil microorganism played important roles in nutrient cycling. A higher soil microbial activity leads to higher nutrient recycling and better crop growth. Mulching stimulates soil micro-organisms such as fungi, bacteria, actinomycetes and other organisms owing to the development of loose, well aerated soil conditions, uniform moisture and temperatures, resulting in a more rapid breakdown of organic matter in the soil and release of plant nutrients for crop growth.

Soil erosion prevention: Mulch protects the surface of the soil against unfavourable factors, reduces



Weed growth in strawberry field under no mulch (top) and mulched plot (bottom)

nutrient leaching and improves growing conditions for vegetables. Non-woven mulch helps in keeping the fine grain subgrade soils from mixing with permeable granular material and thus preventing the collapse of the structure.

Crop production enhancement: Studies by ICAR-National Institute of Natural Fibre Engineering and Technology (NINFET) showed significant enhancement in crop growth, yield and fruit quality in various horticultural crops due to application of jute non-woven mulch. One such study revealed 11–40% higher strawberry yield in jute non-woven mulch over polyethylene mulch. For broccoli, jute non-woven mulch with thickness of 350 gsm resulted in highest growth and yield of the crop and subsequent improvement in soil health. Another study reported that jute non-woven mulching significantly increased yields by 40%, WUE (yield per unit water) and NUE (yield per unit N) by up to 60%, compared with no mulching in tomato crop. Application of jute agro-textile mulches increased the yields of capsicum and pointed gourd and that of sweetlime and turmeric compared to control where no mulching materials were used.

It has been found that mulch helps keep fruits clean from contacting the ground, reduces soil rot, fruit cracking and blossom end rot in many cases. Fruits tend to be smoother with fewer scars. Mulching provides a favourable environment for growth, which results in more vigorous, healthier plants. Jute non-woven mulch upon biodegradation enriches soil with 20% more organic carbon than plastic mulch.



Broccoli in jute non-woven mulch plot

Economic benefits

Jute non-woven mulch fabric of 400 gsm costs around ₹40–50/m² and mulch requirement will vary from crop to crop depending on row-to-row spacing. Use of non-woven mulch essentially reduces the requirement of irrigation water, synthetic fertilizer, harmful pesticides and herbicides, and subsequently reduces the cost of cultivation.

Broccoli: It leads to increase in yield from high value vegetable crops like broccoli, viz. net return of approx. ₹20000 per 1000 m² could be earned.

Tomato: Estimated cost of cultivation per 1000 m² is around ₹36200 for without mulch field and ₹54300 for jute mulch field. Crop yield can vary from 4200 kg (without mulch) to 5100 kg (JAT) which leads to net profits of ₹68800 for without mulch and ₹73200 for JAT. So, approx. ₹4400 extra could be earned using JAT mulch.

Sweet lime and turmeric intercropping: Estimated cost of cultivation per 1000 m² is around ₹17280 for traditional without mulch field and ₹29600 for JAT field. Number of sweet lime production can vary from 10200 pcs (without mulch) to 30000 pcs (JAT) which leads to net profits of ₹10200 for without mulch and ₹30000 for JAT for sweet lime. Turmeric yield can vary from 8300 kg (without mulch) to 10700 kg (JAT) which leads to net profits of ₹49800 for without mulch and ₹64200 for JAT. So, approx. ₹21,880 extra could be earned using JAT mulch.

The following are the economic benefits in terms of Benefit Cost Ratio (BCR) when calculated during studies on different crops (Table 2).



Strawberry under jute non-woven mulch

Table 2. Economic benefits in terms of Benefit Cost Ratio (BCR) on different crops

Crop	Benefit Cost Ratio (BCR)	
	JAT mulch	Without mulch
Tomato	1.90	1.50
Chilli	1.81	1.37
Broccoli	1.78	1.30
Capsicum	1.55	1.31
Brinjal	1.45	1.30

Improved seedling production using wool based nursery pots

Wool is another important natural fibre, which yields 10–15% of waste during wool processing. The of waste wool can be converted to non-woven sapling bag which can be used as an alternative to the ecologically polluting polythene sapling bags used in different horticulture, forestry and agro-forestry nurseries. These bags are breathable, help in root growth, drain excess water and are biodegradable. They improve germination of different crops by 8–10% and different growth parameters of seedlings by 50–300% over plastic bag or container. There is a dramatic enhancement of soil microbial populations that helps in mineralization of nitrogen required by the seedlings. Wool nursery pot generally conserve more water, provide better aeration and temperature control, enhances microbial population, and upon decomposition release more nitrogen and organic carbon than plastic pot, thus enhances seedling growth.



Capsicum seedling in Wool nursery pot

Challenges and opportunities

Plastic low cost mulching has gained popularity due to its low costs. However, it posed a serious threat to our environment for its non-biodegradable nature. Cost effective non-woven mulching materials made up of natural fibre are gaining importance for application in agricultural and

horticultural crops due to their multifarious positive effects on the crop as well as soil health and a better alternative to plastic conventional mulching. Natural fibre based non-woven mulch, although costlier than synthetics, are still environment friendly, perform through better approach and render enhanced harnessing of the return per unit area. Availability of natural fibre in large quantity for production of non-woven mulch is considered as the core challenge. Processing of natural fibre through non-woven approach is another challenge as the technology is so much popular in our country. However, non-woven mulch technology may be one of the best options for harnessing additional income.

SUMMARY

Mulch in agricultural fields provides many benefits to crop production through soil and water conservation, enhanced soil biological activity and improved chemical and physical properties of the soil. Increase in soil temperature and moisture content stimulate root growth, which leads to greater plant growth. Therefore, mulched plants usually grow and mature more uniformly than un-mulched plants. Jute non-woven mulch has various beneficial effects to the horticultural crop production, including an increase in soil moisture, reduction in weed growth, maintenance of soil temperature, enhancement in quality produce and yield,

promoting earlier harvest of the crop, reducing fertilizer leaching, protecting the surface of the soil against unfavourable factors, adding organic matter, stimulating soil microflora, and taking part in nutrient cycle. In view of the available facts, it can be concluded that in the context of water scarcity, jute non-woven agrotextile is the most viable solution for quality production of horticultural crops and for promoting natural farming by reducing the requirement of pesticides and synthetic fertilizers.

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