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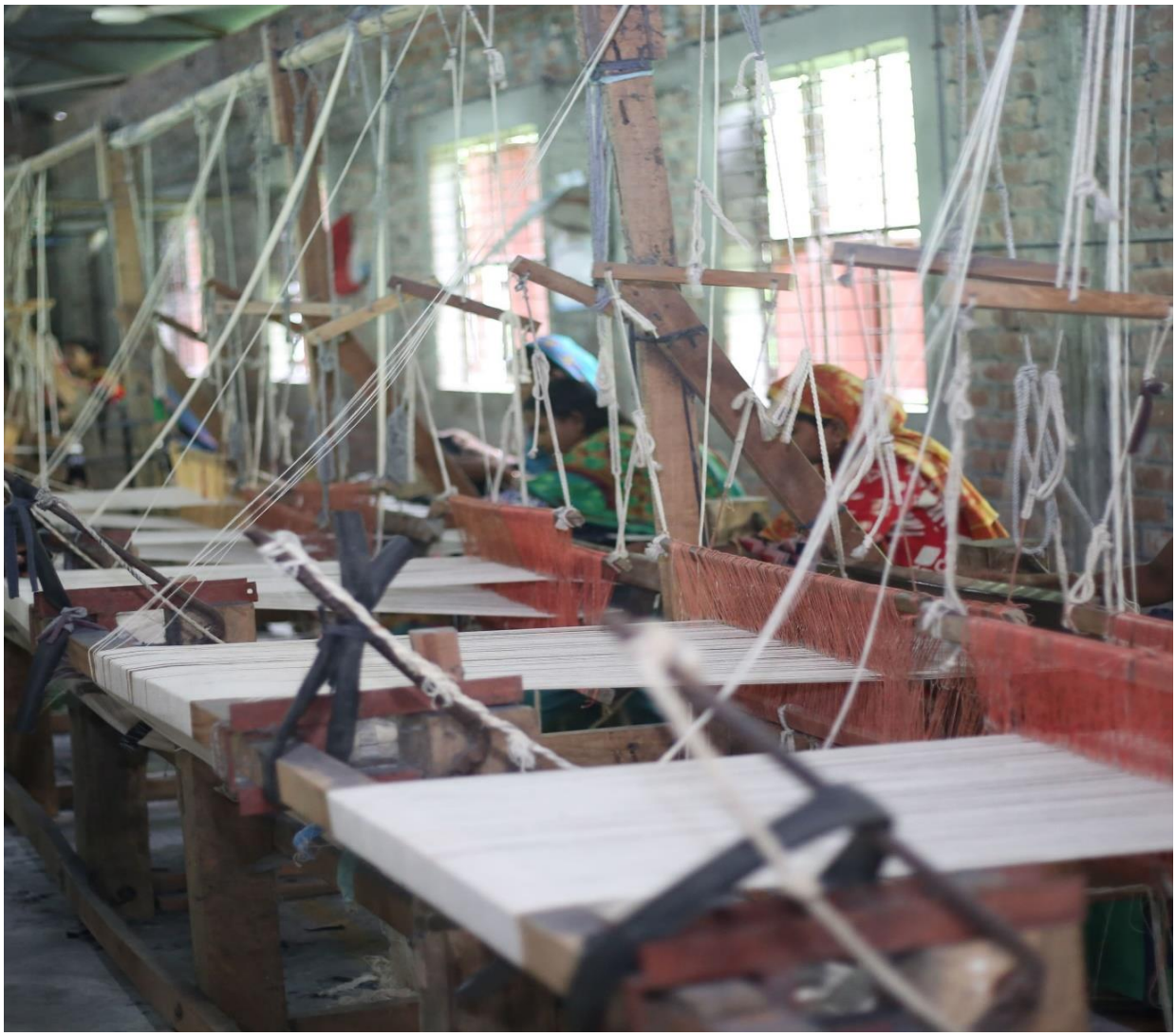

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Review

Impact of textiles in agriculture industry

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ABSTRACT

Agriculture is the backbone of our country. Now it is saying that textiles can be the backbone of agriculture. Textile fabrics have a long history of use in agro-tech sectors to protect, gather, and store products. Between the 18th century and the end of the 19th century, agricultural development occurred, which saw a massive and rapid increase in agricultural productivity and vast improvements in farm technology. From then, Textiles have always been used extensively in the course of food production, most notably by the fishing industry in the form of nets, ropes, and lines but also by agriculture and horticulture for a variety of covering, protection, and containment applications. However, modern textile materials are also opening up new applications. Lightweight Spun bonded fleeces are now used for shading, thermal insulation, and weed suppression. Heavier non-woven, knitted, and woven constructions are employed for wind and hail protection. Fibrillated and extruded nets are replacing traditional baler twine for wrapping modern circular bales. Capillary non-woven matting is used in horticulture to distribute moisture to growing plants. Seeds themselves can be incorporated into such matting along with any necessary nutrients and pesticides. Agriculture, forestry, horticulture, floriculture, fishing segments, landscape gardening, animal husbandry, aquaculture, and agro-engineering are all these sectors combined and are popularly called as Agro-tech sector. Agro textiles are the application of textile materials in those sectors. It is a very important segment of Technical Textile. The word "AGRO TEXTILES" is now used to classify the woven, non-woven, and knitted fabrics, applied for Agro tech industries including livestock protection, shading, weed and insect control, and extension of the growing season. With the continuous increase in population worldwide, stress on crops has increased. So, it is necessary to increase the yield and quality of agro-products. However, it is not possible to meet fully with the traditionally adopted ways of using pesticides and herbicides. Today, agriculture and horticulture have realized the need of tomorrow and opting for various technologies to get higher overall yield, quality, and tasty agro-products.

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1. Introduction

Globally, one of the major issues is food security due to the threat of climatic changes caused by the utilization of non-biodegradable petroleum-based agricultural products. A few reports demonstrated that approximately 10–40% of losses occurred in crop production because of the drastic increase in climatic temperature. This created a driving force in the agro-textile sectors to improve the yield and quality of the crop every year. Current cultivation practices involve the utilization of herbicides and pesticides to prevent crop losses, however, these interventions are expensive and have a long-lasting ecological impact on soil microflora and the environment. With a significant increase in environmental awareness and development in technology, considerable attention has been diverted to the utilization of textile fibers in agriculture. The textile sector plays a vital role in the development and circulation of the world economy, so it is considered one of the largest industries among numerous sectors around the world.

By utilizing biotechnology, the textile sector brings a revolution to textile processing. Agriculture, forestry, horticulture, floriculture, fishing segments, landscape gardening, animal husbandry, aquaculture, and agro-engineering are all these sectors combined and are popularly called as Agro-tech sector. Agro textiles are the application of textile materials in those sectors. It is a very important segment of Technical Textile. Textile processing has led to the synthesis of a huge number of cellulose fibers that can be used in multiple sectors ranging from biomedical to agriculture. The cellulose-based agricultural products are environmentally friendly with low manufacturing costs.

Subsequently, the other concerns associated with petroleum-based products can be reduced along with greenhouse gas emissions. Agro-textile products (shade nets, harvest nets, and mulch mats) are capable of supporting agriculture by protecting crops from harsh weather conditions and unwanted pests without impacting the environment as these textile products are biodegradable and non-toxic.

Agro-textiles also help in water conservation, moisture retention, weed suppression, and light reflection. Agro-textiles prevent the soil from drying out and maintain homogeneity thereby increasing the crop yield. Agro-textiles restrict the farmer from the overutilization of harmful pesticides that have a long-lasting impact on the soil as well as the microflora through the utilization of agro-textile covers such as weed control mats, crop covers, and others. The best-known products are shade nets and thermal screens; their usage can save up to 40% on energy in heating greenhouses. The utilization of shades and nets further improves the quality of fruit, prevents staining, and improves the crop by maintaining overall uniformity in terms of color. Crop covers sustain an optimal micro-climate which protects plants from adverse weather conditions.

Various remarkable properties of agro-textile-based products in agriculture are resistant to ultraviolet radiation and micro-organisms and have high tensile strength and biodegradability over petroleum-based products which make them suitable aspirants to overcome numerous conventional problems of agriculture. Textile covers are capable of retaining 15–60 g/m2 of water and some tend to retain around 100–500 g/m2 which further facilitates the availability of water under drought conditions.

1.2 History of Agro Textile

Agriculture is the backbone of our country. Now it is saying that textiles can be the backbone of agriculture. Textile fabrics have a long history of use in agro-tech sectors to protect, gather, and store products. Between the 18th century and the end of the 19th century, agricultural development occurred, which saw a massive and rapid increase in agricultural productivity and vast improvements in farm technology. From then, Textiles have always been used extensively in the course of food production, most notably by the fishing industry in the form of nets, ropes and lines but also by agriculture and horticulture for a variety of covering, protection and containment applications.

However, modern textile materials are also opening up new applications. Lightweight Spun bonded fleeces are now used for shading, thermal

insulation and weed suppression. Heavier non-woven, knitted and woven constructions are employed for wind and hail protection. Fibrillated and extruded nets are replacing traditional baler twine for wrapping modern circular bales. Capillary non-woven matting is used in horticulture to distribute moisture to growing plants. Seeds themselves can be incorporated into such matting along with any necessary nutrients and pesticides.

The bulk storage and transport of fertilizers and agricultural products is increasingly Undertaken using woven polypropylene FIBCs (flexible intermediate bulk containers – big bags) in place of jute, paper, or plastic sacks. Today, modern textile materials and constructions have helped to increase the strength, lightness, and durability of traditional products, as well as open up completely new markets.

1.3 Manufacturing Processes of Agro Textiles

Several techniques of fabric production can be used to produce agro-textiles. Each method offers specific advantages for the particular product. The techniques are:

1.4 Weaving and Woven Products

Woven products are manufactured by using weaving machines, especially Sulzer projectile weaving machines. The range of light to heavy and wide-width fabric production is possible with the Sulzer projectile weaving machine. The machines with weaving widths of 540 cm to 846 cm are available for the production of agro-textiles.

The nets with a mesh width of 1.8 mm to 40 mm can be produced. Other methods of fabric manufacturing such as air-jet and rapier weaving machines are not preferred for the manufacture of such fabrics as they do not have the required weaving width.

1.5 Knitting

The warp knitting technique is most widely used in comparison to weft knitting. Warp-knitted protective nets are used in different sectors and are produced on Raschel machines. Agro nets are produced in various constructions or lapping. Here, the construction or lapping is a way in which individual yarn systems are converted into fabrics.

1.6 Non-Woven

There are many techniques to produce non-woven fabrics. Spun bonding and needle punch techniques are mainly used for the production of non-woven agro-textiles. The spun bonded fabric has a high and constant tensile strength in all directions. It has also good tearing strength.

Needle-punched fabric plant bags provide advantages over conventional fired clay pots. All natural fibers offer an added advantage of that the container decomposes after being planted in the ground. Thermal Bonding, Stitch-bonded, Hydro entangled & Wet non-woven are also used.

1.7 Agro-Textile-Based Nets and Their Significance

A shade net is mainly made up of polypropylene and polyethylene which are treated with UV-resistant agents during fiber manufacturing to provide enhanced resistance to UV degradation. The polyethylene polymer is a relatively low-melting material (137°C). Bird protection nets are developed from polypropylene or high-density polyethylene (HDPE) monofilament yarn, these yarns are ultraviolet (UV)-stabilized and knitted into a durable mesh fabric. Sunscreen, insect meshes, weed control fabric, and greenhouse covers are typically made of UV-resistant polyethylene fibers.

Various agro-textile products are commonly implemented in the agricultural field such as bird protection nets which offer the passive protection of seeds, crops, and fruits from damage caused by birds. The open mesh net fabrics not only prevent the crop from birds but also provide excellent air circulation which facilitates the optimum growth of the plant; plant nets are composed of polyolefin fibers which are mainly used for tomato crops. The purpose of the plant net is to keep the fruits away from the damp soil which eventually decays the crop. The plant net allows the fruit to grow vertically; monofil nets are designed to protect young branches and flowers against blustery weather and also prevent sand and wind erosion.

The nets are set at a right angle to the wind to protect plants against the harmful effects of adverse weather conditions; root ball nets are designed in such a way that when transplanted, roots can protrude through them.

They are developed for safe and speedy growth of young plants as the root system remains intact through the net; insect protection nets are made up of polyethylene monofilament meshes to preclude insects from the greenhouses; weed control fabrics halt the growth of unwanted weeds in an environmentally friendly manner and also allow air, water, and fertilizer to sieve through the fabric for plant growth; and fruit covers are made up of non-woven fabric which promotes better growth and enhances the harvest. They tend to protect vegetables, fruits, and plants against snow, rain, frost, and heat.

1.8 Coir-Based Products and their Effect on Plants

A variety of coir-based products are widely used in agriculture such as erosion control blankets, basket liners, bio-rolls, grow sticks, etc. An erosion control blanket is composed of a woven coir mat that protects seeds or seedlings from wind and rain and further facilitates growth; it also protects soil from erosion and mulching action. The basket liners of the coir provide better aeration for growth as air can flow more effectively through the holes of the coir pad. They also help in the vigorous growth of roots.

Bio-rolls are composed of non-woven coir filled with coir pith composite which facilitates rapid root growth. A growth stick consists of a wooden pole wrapped with coir fibers which provides support to the plant or a creeper. Other natural fibers such as hemp and sisal are used to develop baler twines which are made up of two or three threads twisted together. Baler twines are used for crop wrapping (tomato, grape yards).

1.9 Agro-Textile-Based Delivery of Fertilizers for Enhancing Plant Yield

Agro-textiles are used as a carrier material where fertilizers are coated through absorption or adsorption onto the non-conventional fibers that further lead to improving crop yield. Demonstrated that the combination of fertilizer (nitrogen, phosphorous, potassium) with rice straw tends to elevate the concentration of soil extractable glomalin and total glomalin. The glomalin is the glycoprotein secreted by arbuscular mycorrhizal fungi (AMF) which maintains the stability of soil aggregation. AMF are root symbiotic fungi that play a crucial role in maintaining the soil environment by extending the root system into the soil. Glomalin was correlated with soil carbon and nitrogen, linked with an oligosaccharide, and sequestered toxic elements in the soil. The total glomalin concentration of NPKs (nitrogen, phosphorous, and potassium) was increased to 5.67% when compared with the control plot.

Soil Strengthening Using Agro-Textile Fibers

In a study, the strengthening of cohesive soil was investigated through kerosene-coated coir fiber. Kerosene served as a coating agent that tended to lower the water absorption capacity of coir by up to 170%.

The purpose of kerosene coating was to prevent the coir fiber from moisture-induced degradation which further imparts strength and stress-strain response of high-plasticity clay up to 52%. The quantity of bamboo fiber had a direct relationship with the “California bearing ratio” value of soil (a penetration test that determines the force per unit area), which was considerably increased at 1.2% bamboo fiber dosage.

1.10 Role of Agro-Textiles in Crop Improvement

Several scientists have proved the influence of jute agro-textiles in the improvement of broccoli productivity, 800 g/m2 of jute agro-textile showed a significant result with an average weight of broccoli of 1.2 kg and length of 29.5 cm. The yield was around 4.44 tons/ha and the moisture-holding capacity was 49.05%. The jute agro-textile is composed of a natural jute bast fiber product which is eco-friendly and biodegradable and facilitates plant growth by providing essential plant nutrients through lignin decomposition.

Another study investigated the effect of non-woven ramie fiber film on the root zone environment of rice seedlings. The film was used as a pad on the bottom surface of the seedling tray which tended to enhance the oxygen supply that promoted root respiration; therefore, it had a direct impact on the growth of seedlings. The result of the study showed a significantly higher concentration of soil inorganic nitrogen and decreased organic matter in soil which led to enhanced growth and development of rice seedlings.

A group of scientists used non-woven agro-textiles of 10 g m−2 and 17 g m−2 mass per unit area to protect radish seeds from spit germination and low temperature. Both agro-textile covers enhanced the temperature during the daytime in contrast to the uncovered control plot and tended to improve the germination by around 19% and reduced the germination time.

1.11 Next-Generation of Agro-Textiles

Plastic-based mulching film utilization in horticulture extensively caused a serious environmental impact due to non-biodegradability. Plastic film waste causes environmental pollution, so to mitigate such problems, biodegradable and renewable materials were used for soil mulching. Various biodegradable materials are natural polymers including starch, cellulose, and chitosan which were efficiently designed to retain their mechanical and physical properties during their implementation until the end of their life span. These materials were directly introduced into the soil as they have been degraded by soil microflora which converts them into carbon dioxide or methane and water.

The biodegradable extruded mulching films were formed through the thermo-plasticizing process (the polymer was softened when heated and hardened when cooled down). The spray of mulch solution (water-based natural polysaccharide solution) was released on the field, thus covering the cultivated soil with a protective thin geo-membrane.

Another popular utilized practice in horticulture is transplantation where the seedlings are transferred into the soil or a large container. Commonly, farmers use pots or cell trays composed of fossil raw materials such as polystyrene, polyethylene, and polypropylene that resist proper root growth as roots tend to circulate over the root ball during transplanting, but the roots can be damaged. An effective alternative to petroleum-based thermoplastic pots may be biodegradable pots that are engineered in such a way that water, air, and roots will penetrate the walls of the pot ensuring healthy root growth. The biodegradable pots can be planted directly into the soil, ensuring no pot disposal, and reducing cost, labor, and environmental pollution. The mechanism of biodegradation of pots involves the conversion of pots into biomass and inorganic products.

1.12 Recycling of Agro-Textiles

The current best practice involves the production of value-added products from waste material toward the fulfillment of a sustainable approach which is part of the circular economy. A circular economy revolves around utilizing textile waste to develop new products. Numerous key elements are associated with the circular economy, viz., the utilization of renewable and reusable resources as raw material, remanufacturing resources to enhance the life span of the product and use the waste resource to recycle or reuse the waste. To achieve this, materials that are meant for landfills or incineration can be recycled into new products/ materials with better quality and higher environmental value.

1.13 Major Agro-Textile Projects

The seventh framework program includes the development of new agro-textiles with tailored biodegradability from renewable resources and BIOAGROTEX, Belgium. The BIOAGROTEX project aims to develop a completely bio-based agro-textile with controlled durability as an alternative to existing PP-based agro-textiles or natural fiber-based agro-textiles with a very short lifespan. Manufacturing of biopolymer formulations using various fiber extrusion techniques including tape or monofilament, staple fiber, and multifilament extrusion on laboratory, pilot, and industrial scales including a range of further industrial processing trials such as knitting, weaving,

and needle felt production. Two families of biopolymers are evaluated.

The use of bio-polyesters as melt-processable polymers, with a focus on PLA, and the use of starch-based formulations. Natural fibers from recycled or from low-value agricultural fractions, and property optimization by (enzymatic) pre-treatment to optimize yield and properties are developed. Bio-resins (furan-based) for refining NF-based products, extending the self-life without affecting the mechanical properties, processing experimental fibers into non-woven structures and finishing them on a pilot scale, and further scaling to fully integrated industrial processes are developed.

Both pathways are supported by laboratory-scale biodegradation tests and detailed chemical analysis of the degradation routes along with the evaluation of the ecological impact and the possible ecotoxicity tests. A set of optimized biopolymer resins or thermoplastics has been defined and can be processed with existing machines to provide excellent processability and properties. Based on these results, different types of agro-textiles can be defined and used directly in the field. The first commercial achievements have already been achieved and hundreds of thousands of m2 of specialized agro-textiles are already on sale based on the current development on the market

2.1 Conclusion

Agro-textiles provide potential applications in agriculture fields where agro-textile covers help crops to germinate and grow faster. Moreover, it has an overall impact on the plant morphology such as higher plant heights and leaf areas. A variety of fibers from agro-textiles tends to help by improving soil conditions, and also provide organic carbon to the soil when degraded. Next-generation agro-textiles seem to have an inclination toward eco-friendly and biodegradable material drawn from agriculture or farms.

Hence, lignocellulosic-based agro-textiles may prove to be an economic and environmentally friendly alternative and may be a boon for agriculture. 'Agro textiles' gives multidimensional views and solutions to the problems being faced by agro-industry. Textiles prove to be flexible in their suitability for specific geographical locations. So now it is our turn, to carefully and beautifully shape this infant technology, to contribute to the nation's economy.

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