

Technical Textiles for Agricultural Applications

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Abstract

Agricultural textile product groups, agro textiles, are innovative products that are designed specially for the agricultural applications and practices. Increasing population of the world causes intensive stress on the agricultural crops and requires increased yield and quality of agro-products. To reply the increasing crop demand agro processing sector has experienced expansion during the last 5 decades, starting with simple domestic/cottage level textile based solution and continuing with advanced fiber and textile technologies at industrial level currently. Agricultural textile products help to reply the urgency of the agricultural crops demand with their excellent environmental resistance, mechanical properties, easy process ability and durability characteristics.

Agro textiles provides multidimensional solutions to the variety of agro industry problems with the advantages of flexible, light, strong, long lasting and other specific properties textile structures. This study has been focused on the technical information and market potential of the agricultural textile where it has already reached up to the 8% of the technical textile market in the world.

Keywords: Agricultural textiles, fiber, sheet, net, web, woven fabric, knitted fabric

1. INTRODUCTION

Textile product groups are various, where product ranges start from the traditional textile and clothing products, to the technical applications of building and construction; technical components of footwear and clothing; geotextiles and civil engineering; technical components of furniture, household textiles and floor coverings; filtration, conveying, cleaning and other industrial uses; hygiene and medical; automobiles, shipping, railways and aerospace; environmental protection; packaging; personal and property protection; and sport and leisure[1]. Agricultural textiles is one of the widening technical textile

group that are also known as Agrotech or Agro textiles. In more detailed definition agriculture textiles are used for crop protection, fertilization, aquaculture, horticulture and forestry.

Agro textile products can be classified as; landscape fabric that is used for weed control; wind protection fabric that is used for protection of crops from the wind; frost cover fabric that is used for adjustment of weather conditions from the sudden changing of temperature and seasonal changes; shade cloth that is used for protection of crops and livestock from the harmful effects of sun shine; poultry curtain that is used for light control, thermal protection, and ventilation control; drainage textiles that are used to solve the problems of surface water and drained soil; sealing sheet that is used as tanks for fluid products or liquid manure; agricultural belting; tarpaulins; anti-insect fabrics; flower and vegetable support mesh and livestock ground fabric. Ultimately sensor equipped agro textiles are also started to be used in the detection of agricultural human activities of digging, harvesting and bed making.

Food is one of the main human need that is increasing constantly depending on the increasing world population (Figure 1). Agricultural activities, lands, and workers are unfortunately declining in many developed and developing countries. The food security has become one of the major concern for the governments as result of increasing population, declining agricultural activities, and climate changes. Undesired scenarios about the food security enforces the industries to improve agro-tech sector to maintain and improve better yield.

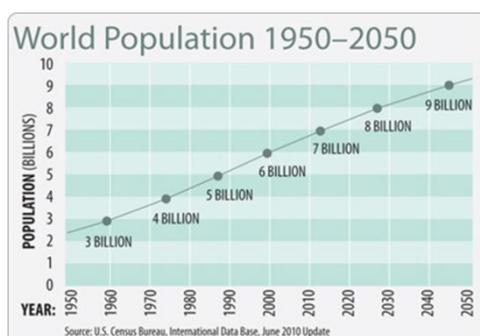


Figure 1 Increasing world population [2]

Agricultural activities are expected to be practised providing the need of tomorrow using various technologies to get higher yield, better quality and more tasty products. Adaptation to the hi-tech farming technique, where textile structures are used, could help to enhance quality and yield of agricultural products. Textile structures in various forms are used in shading purposes in shade house, green house and in any other open fields to control environmental factors of temperature, rain, snow, water fall, and humidity. Such shade purposed textile materials are also useful to avoid damage from wind, rain and birds. Crop protection and weed control are another major challenges beside the shading materials. Fruit coloring purposed materials, growth stimulating materials, transport purposed materials, and livestock protection materials are also textile based product groups that have been used in agro tech industry.

Agro tech industry applications of textile based products have been segmented to the fruticulture, horticulture, landscaping, forestry, and retailing. In total agro textile items contribute 8% share in the technical textiles market volume with consumption accounting for around 8.2% by volume and 6.4% by value of the global technical textiles market in 2010. However, the sector is among those with the strongest growth predictions based on the projected increase in global population and the demand for higher quality food. In developing countries the market is estimated to be growing by around 8-10% a year[3]and around 3,9% a year in developed countries.

Advantages of agro-textile use can be listed as;

- decrease the requirement of fertilizers, water, harmful pesticides, and herbicides
- render a healthy farming culture,
- an eco-friendly technique,
- Prevention of the soil from drying out - increase crop yield,
- thermal protection, saving up to 40% on energy in heating greenhouses,
- prevention of staining and improved uniformity of color,
- increased early maturing of crops and non-seasonal plants,
- protection from climatic changes and its effect,
- avoiding of branches from breaking, increase the cleanliness of the crop.

2. TEXTILE FIBERS AND MANUFACTURING TECHNIQUES USED FOR AGROTEXTILE PRODUCTION

Agro textile products are most commonly produced using man made (synthetic) fibers due to their high strength, durability and other suitable properties. Natural fibers are also used in the sector in less amount of share because of their biodegradability properties, natural fertilizing aspects, and esthetic advantages. Most commonly preferred manmade fibers are nylon, polyester, polyethylene, polyolefin, and polypropylene; and natural fibers are jute, wool, coir, sisal, flax, and hemp. Reason for the high preferability of the manmade fibers can be listed as their favorable price performance ratio, light weight with high strength and long service life. Whereas the natural fibers provides the advantages of high moisture retention, wet strength, and biodegradability.

Mainly desired fiber properties are listed in Table 1. The essential fiber properties help with the growth and harvesting of crops and any other farm based consumable items.

Table 1. Desired fiber properties in agro textile products

	Desired fiber property	Expected product property
1	Tensile strength and elongation	long term durability and service life
2	Solar radiation withstanding	long term durability and service life
3	Ultraviolet radiation withstanding	light permeability 80 to 90%
4	Bio degradability	bio-degradation in the nature
5	Abrasion Resistance	long term durability and service life
6	High potential to retain water	capable of 15 to 60 g/m ² / 100 and 500 g/m ² water carry
7	Protection property	protection from wind and creation of a micro-climate
8	Resistance to microorganisms	resistant to microorganism to protect the living being
9	Stable construction	be stable for any application
10	Lightweight	fabric should be such that it will bare by the plant
11	Resistance to toxic environment	long term durability and service life

Manmade textile fibers are mostly used in continues filament form, and natural fibers are used in long staple yarn form at Agro textiles surface production processes. Fiber based surfaces can be processed directly from the fiber as it is in the nonwoven surface production. Woven, knitted, knotted, twine, and braided textile surfaces (Figure 2) are basic fabric types applied for agricultural and horticultural uses; forestry; floriculture and landscape gardening, as well as in fishing and aquaculture.

Woven products can be manufactured by using traditional weaving machines especially projectile weaving machines. The range of light to heavy and wide width fabric production is possible with

weaving width of 540 cm to 846 cm. The nets with a mesh width of 1,8 mm to 40 mm can be produced.

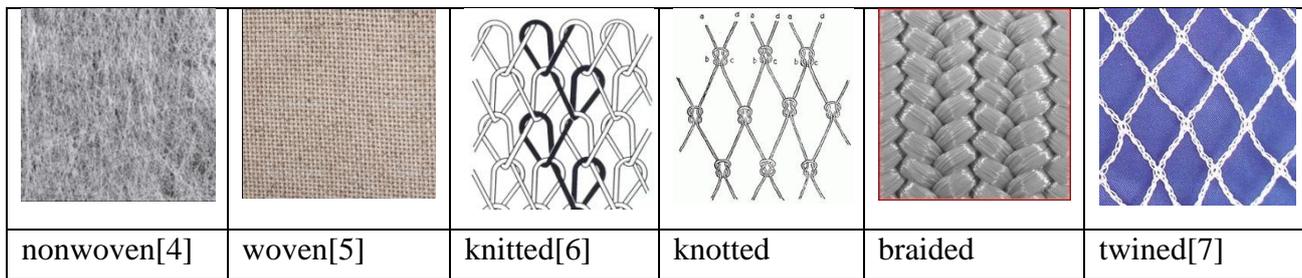


Figure 2 Textile surface types, used in agro textiles

Knitting production can be made either warp or weft knitting machineries. Warp knitting technique is most widely used in comparison to weft knitting. Warp knitted protective nets are produced on Raschel machines.

Non-woven techniques are vary, spun bonding and needle punch techniques are mainly used for the production of non-woven agro-textiles. The spun bonded fabric has high and constant tensile strength in all directions with good tear 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-wovens are also used[8].

Agro textile products are classified according to their quality aspects which are tested via well-defined standard test methods. Some of the advised test standards that are defined by Chinese authorities are given in

Table 2.

Table 2 Agriculture Textiles Standard in China [9]

number	Name of the standard
GB/T 19791-2005	The criterion Insect proof net design And its installation for greenhouse
GB/T 25414-2010	Thickness limit and test method of mulch film for cotton planting
GB/T 25413-2010	Limit and test method for residual quantity of agricultural mulch film
GB/T 25412-2010	Mulch film residue collector
GB/T 12735-1991	Fatigue test method for agricultural V-belts
GB/T 3939.1-2004	Nomenclature and signs of main fishing gear material–Netting twine
GB/T 3939.2-2004	Nomenclature and signs of main fishing gear material–Netting
GB/T 19599.1-2004	Testing method for fishing nets of synthetic fiber–Weight of netting
GB/T 19599.2-2004	Testing method for fishing nets of synthetic fiber–Size of netting
GB/T 21292-2007	Fishing nets Determination of mesh breaking force of netting
GB/T 18673-2008	General technical specifications for machine weaving netting for fisheries
GB/T 6964-2010	Determination of mesh size of fishing nets

1. APPLICATION OF AGROTEXTILES

Agro textile term is used to define the whole group of textile fiber based materials and product that are used in any application related to agricultural crop activities, horticultural and floriculture activities, forest based activities, animal husbandry activities, and fishing and other aquaculture activities.

Agricultural crop purposed products are listed in the

Table 3 Table 1

Table 3 Agricultural crop purposed applications

name	product data
Sunscreen:	Warp-knitted nets. Protection of fields and greenhouses from the intense solar radiation for healthy plant growth and good harvest. 45%, 65% & approximately 85% shadow.
Bird protection nets:	Knitted monofilament nets. Effective passive protection of seeds, crops and fruit against damage caused by birds and a variety of pests. Strong yet lightweight, providing protection to the fruit without restricting plant growth. Extremely durable and hard-wearing.
Plant net:	Ground growing fruits can be kept away from the damp soil by allowing them to grow through vertical or tiered nets in order to keep the amount of decayed fruit to a minimum. Made from polyolefin type of fiber.
Ground cover:	Ground cover is used for long- term weed control, moisture conservation and separation; protection from UV rays. 100% polypropylene is used.
Windshield nets:	Windshields are used in farming to protect fields of young plants, fruits, trees or the harvest from being damaged by the wind. It also prevents plants being cooled by wind too.
Root ball net:	It is used to maintain safe and speedy growing of young plants such that root system is not damaged when they are dug up, transported or replanted.
Insect meshes:	The fine woven or knitted screens are used to protect plants from insect attack (without the use of insecticides).
Mulch mat:	They are used to suppress weed growth in horticulture applications, They help to reduce the need for herbicides required for weed control Needle punched non-woven and black plastic sheet are used for this application, Bio degradable and non-biodegradable types of mulch mats are available.
Monofil nets:	Tough, knitted Monofil, nets are used as windbreak fences and shading/privacy screens to provide micro-climate around the plants.
Cold and frost control fabrics:	These fabrics can be laid directly on the plants, unlike plastic covers that can attract frost, and burn any leaf that touches them, and protect the plant from the unexpected frost.
Nets for wrapping and covering transport pallets:	Transportation boxes and pallets are covered with large mesh nets to prevent damage of goods during transportation.
Anti-hailstone nets:	These fabric nets are used to cover plants and fruit orchards to protect them from being damaged by hailstones, but does not restrict their growth. The nets are primarily made from polyethylene monofilaments.
Harvesting net:	These nets are laid on ground or tied under the trees so that fruits fall directly on to the net and labor charges are reduced.
Packing materials for agricultural products:	Nets can be used as packing sacks for vegetables, tubular packing nets for fruits and wrappers for Christmas trees.

Application of agro textile materials in horticulture is also an expanding market with applications of non-woven mats, movable screens for glass/poly houses, non-woven sheets, mixed bed for mushrooms, cordage and strings. Light resistant woven and non-woven polyester fabrics are used hail protection fabrics, mulch net, rain protection fabrics, wind control fabrics, and harvesting nets.

Animal husbandry purposed agro textile products are nylon and polyester identification belts of cows, nets and non-woven fabrics to filter the milk, and underlay to reduce mud on cattle paths and trails.

Aquaculture purposed fishing and water based application of agro tex products are mostly warp knitted knotless nylon or HDPE monofilament-multifilament nets providing energy saving.

4. SUSTAINABILITY IN AGROTEXTILES

Agro textiles are mainly manufactured using oil based synthetic fiber which has high load of environmental effect both in their manufacturing phases and also during their biodegradation period. Fluctuating oil-prices and threat of oil-shortages, greenhouse gases, environmental effects and climate changes, are all major influential factors on the future of our oil based economy and oil based textile items. As an alternative to the oil based economy, bio based materials and manufacturing processes improvement in Europe and other developed parts of the world.

In the agro textile market, there are quite promising works and initiatives are already started on the case of bio based material utilization. As an alternative to the mostly consumed oil based fibers types of polyolefin, polyamides and polyester fiber groups, natural fiber and bio based fiber based agro textile products are presented to the market.

Oil based textile fiber used agro textile products -in most cases- are difficult to recover from the fields at the end-of-life. Such fiber based materials results even worse pollution on soil, water, and other living creatures and recovery of their harms are expensive and not attractive. In case of natural fiber based agro textile utilization; fast degradation in the natural environment is possible. PLA fiber as one of the established bio based fiber type has also used in the manufacturing of agro textiles as ground covers [10], weed control products[11], insect screens [12]. Bio based fiber formulations can be utilized in the complete range of textile surface processing, including production of non-wovens, knitted and woven fabrics. Such bio based fibers can also be engineered items with the designing possibilities of functionalization-flame retardancy and anti-microbial properties- controlled or improved durability-3 to 5 years, color alternatives.

Natural fibers that are used to manufacture agro textile products provides environmental friendly and promising opportunities. The mostly preferred natural fibers are jute, coir, wool, sisal, and hemp. They are commonly used to produce agro textiles for the purposes of weed management and agro-mulching; sampling bags, baler twines, bed for seed germination, packaging of agricultural products like seeds, food grains, sugar, vegetables, fertilizers[13]

Jute is one of the cheapest and the strongest of all natural fibres and considered as fibre of the future including agro-textiles. Jute has many advantageous properties of high tensile strength, high moisture absorption & retention capacity, unique drape ability, porous structure, thermal resistance. It is one of the most commonly used and accepted natural fiber that has been used to provide higher agricultural productivity by improving agronomical characteristics of soil and by reducing growth of unwanted vegetation. Main application areas in the agro textile market can be listed as soil conservation and reduction of nutrient loss; nursery seed bed cover; shade over nursery; weed management & agro-mulching; afforestation in semi-arid zone; sleeves for growth of sapling; air layering and wrapping/covering of plants. Mulch mat, sleeve for nursery use, and agro bags are some of the main agro textile product groups.

Coir [14] is biodegradable and the hardest, hygroscopic natural fiber that provides many advantageous in agro textile products of erosion control, reinforcement and stabilization of soil with it's the greatest tearing strength, retained as such even in very wet condition. It is naturally resistant to rot, moulds and moisture. Coir can be converted to coir yarn and then to woven mesh matting, which is used mainly controlling soil erosion and conditioning the soil. One more conversion of coir is to coir nonwoven, which is also used for controlling erosion and conditioning the soil by more ground cover and soil retention. Nonwoven coir is also used for basket liners, mulching mats, grow sticks, cultivation mats for plants, roof green application, portable lawn or instant lawn and many more applications [15].

Wool fibres are traditional raw materials for textiles; and re also adapted for agro textile production. It has excellent mechanical and comfort properties. A major advantage of using wool for technical purposes is that the fibre diameter plays a minor role here, and this allows also cheap wool or even fibres from recycled textiles to be embedded into various products. Wool has better insulation properties under moist condition than polypropylene/polyethylene and can prevent seedling damage from ground frost thus enabling earlier sowing and a longer growing season. The wool keeps the soil temperature constant and compared with black plastic, does not give a wind tunnel effect, which dries out the soil [16]. Wool fiber is used in Mulch mats production in needle punched nonwoven form providing biodegradation over one to five year period and gets incorporated into the soil as fertilizer/conditioner for the next crop. Further, wool mulch mats allow water to enter in to the soil (unlike black plastic), and also act as a barrier to prevent excessive soil desiccation during dry period.

Sisal and Hemp fibre based baler twines are used in grape yards for tying. These twines are strong thread composed of two or three smaller threads or strands twisted together and mainly used for crop wrapping. This is also used in tomato plantations and can also be used for all heavy fruit and vegetable plantations to hold it on its stem or branch[17].

5. CONCLUSION

Agro textile utilization in the modern agricultural, horticultural, floricultural, aqua cultural and animal husbandry activities has become popular during the late decade. Environmental control purposes, creation of optimum plant growing conditions, application of high technology farming methods, enhanced crop quality and the enhanced overall yield aims are main driving forces behind the agro textile product utilization. Shading material needs, improvements of pesticide and herbicide control products, and other multidimensional features and solution alternatives of the agro textiles have helped to increase the market volume in the developed and developing countries in the world.

As one of the popular alternative fiber based agro textile group, natural fiber based agro textiles have drawn a flourishing market in the agro textile industry with consumption accounting for around 8.2% by volume and 6.4% by value of the global technical textiles market in 2010. However, this sector is among those with the strongest growth predictions based on the projected increase in global population and the demand for higher quality food. Internationally, the agro- textile market has grown from 1615000 tons (US\$6.5 billion) in 2005 to 1958000 tons (US\$8.1 billion) in 2010, at an average growth rate of 3.9% per annum. The global end- use consumption of agro-textiles has increased from 3.3% in 2000 to 3.9% by 2010; according to a David Rigby Associates study. Unbounded fabrics are increasing in agricultural applications at the expense of woven fabrics. Textile is only a relatively small branch, cost- based reasons, the global textile market in agricultural produce about 200 million tons, valued at 5 billion U.S. dollars, an increase of potential.

Currently worldwide known agro tex producers are ACME mills-USA, Bonar-Belgium, Fiberweb-UK, Texel-Canada; where new producers are penetrating to the market from other countries; India, Taiwan,

France, China, Uruguay, Turkey, Germany, Slovenia, Poland, Czech Republic, Thailand, Singapore, Spain, Nederland, Greece, and Hungary [18].

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