

THE FUTURE OF ORGANIC COLORED COTTON

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Abstract: Organic fibers are produced without chemical fertilizer, pesticides and genetically modified seeds (GMO). They require more time, labor and cost as they need special care than conventional fibers. Organic fibers alone are not safe, as added finishes can have toxic-effects. Therefore, Global Organic Textile Standard (GOTS) includes environmental-ecological, social and economic aspects of the production such as: prevention of pollution, contribution to prevention of global warming, decrease of waste and recycling. The economic impacts include the cost value of the organic fiber production and selling. On the social level, the future of the production of organic fibers in the world depends on textile, agriculture and environment-ecology. As people are becoming more conscious about their health and environment by wearing organic textile products, especially cotton, they are willing to spend more to wear these organic textiles. This research paper will look into the organic colored cotton and its future.

Keywords: Organic fibers, organic textiles, colored cotton, environmental protection, pesticide.

1 INTRODUCTION

Fibers can come from different sources, natural and synthetic. The natural textile fibers are extracted from either animal sources like mohair, wool and silk, or from vegetable sources like cotton, kapok, linen, ramie, hemp, jute and sisal. The man-made fibers, such as acetate and viscose, are usually extracted in the lab and their polymer is generated from a cellulosic source such as wood and linters. For example, silkool from Glycine max, kazein from milk, ardil from peanut, zein from maize, are all obtained from natural sources, however they're not generated in a traditional fiber structure, but with special treatments applied they can be extruded into fibers and then they will be known as regenerated-fibers. Polyvinylchloride, polyethylene, polypropylene, polyamide, polyester, polyacrylonitrile, polybenzimidazole polymer etc. are synthetic fibers made out of synthesizing chemicals obtained from crude and then extruded into fibers through the spinnerets, after being treated with special treatments. Natural fibers are dated to 8000 B.C. and still are being used around the world; however, the regenerated and synthetic fibers have been produced subsequently in 19th century, since the industrial revolution, which has brought conjointly environmental pollution whereas industrial production has been enhanced by various industrial chemicals, like crude, coal and gas [1].

Cotton is the most generally used natural almost pure polysaccharide fiber round the world, with softness and breathability that have made it the world's most popular natural fiber. Cotton has a great wicking ability as it absorbs moisture readily, which makes cotton clothes comfortable in hot weather, while having high strength in soap

solutions, which means they are easy to wash. Cotton in its natural state and never dyed at all, can be identified as entirely organic. And since the naturally colored cotton is natural, and more desired than the chemically died one, naturally colored cotton is gaining its popularity as companies seek more sustainable solutions [2].

Organic fibers are the special production of typical natural fibers that do not use chemical fertilizers; cyanogenic pesticides (insecticides, defoliant, herbicides or fungicides) and genetically altered seeds (GMO). Organic fibers follow conjointly a certification for organic fibers methods of production [3]. The objective of the production of organic fibers is to mainly protect the natural sources, in addition to people's health besides all living creatures and their maintainable life conditions [4]. Certification of organic fibers requires hard procedures such as ceasing the utilization of chemical fertilizers and pesticides no less than three years, followed by organic cultivation. Organic fibers consume solely permissible substances that should cover physically the areas of cultivation fields, by using organic fertilizers for the reason of the enrichment of soil organically etc. Cotton with naturally colored lint, aside from white, is often referred to as colored cotton. Naturally grown, colored and white linted cottons are found from ancient times. However, colored cotton is being utilized since 2500 B.C. Colored cotton variations were known under cultivation in Asia, predominantly the Indian subcontinent, central Asian Republics of former Soviet Union and China as well. India was popular in producing varieties of brown linted types of tree cotton (*G. arboreum* L.) known as Cocanada 1, Cocanada 2. However, the Red Northerns were under marketable cultivation primarily on black soils

under special circumstances in some areas of Andhra Pradesh. The red linted colored cotton were predominant and in high demand because of their higher coloring qualities, especially its color fastness. The advancements and new regulations of dyeing techniques have contributed significantly. The cultivation of colored cotton became discouraged and virtually abandoned in the latter half of this century, as many linted colored cotton variations didn't gain popularity among growers and were not in high demand for many reasons, primarily because of short productivity per unit area, poor quality of fiber physical appearance and uneven distribution of colors. The demand to use cotton around the world is increasing and there is a big need to increase the production, as the population demands for products and clothing made out of cotton are increasing. The advancement of technology in the mills during the processes of spinning, weaving or knitting and sorting the various shades of cotton during the production and separating the shades and colors, in addition to the different treatments and synthetic dyes, all have made it easier to separate the superior fiber quality cotton from others. In many cases white linted superior quality types of cotton replaced the less quality colored cotton. Therefore, the agriculture of colored cottons continued in exclusivity as novelty niche cotton and was favored for its aesthetic qualities. Recently with the companies being more aware about sustainability and trying to avoid using textiles, that can harm the environment, colored cottons started to get more attention and started to receive more recognition as being environmentally friendly. As people became aware of the danger, toxicity and the pollution of synthetic dyes, which they have on the environment and humans, the interest in cultivation of organic colored cotton has increased considerably. The only way to grow eco-friendly cotton is by organically grow colored cotton without the harmful chemicals used in the dyes or during the dyeing processing itself [5].

2 NATURALLY COLORED COTTON

As naturally colored cotton has increased in popularity recently and many companies are using the neutral shades of colored cotton as fashionable and trendy colors in their fashion collections of apparel, many farmers are asked and in some cases are even paid not to produce the colored variety and to concentrate on the organic naturally colored cotton with the off-white shade as they are coming back into fashion. Many Spanish companies are cultivating cotton that grows naturally with the neutral like mocha, green and taupe (Figure 1). The nature of these organic colored cotton fibers can be subject to emerge in varied tones and

for the colors to change after washes, and to fade with exposure to the sun. The naturally colored cotton found in small farms in Brazil, where every farmer owns his or her land and grow organic cotton using biodynamic growing practices, only to produce super quality organic colored cotton. Growing organic cotton starts with the seeds being free from any genetic modification or added chemicals and the fibers never dyed or chemically treated during the processing. One washing process to remove the vegetable fats derived from the weaving process is used during the process and nothing more.



Figure 1 Photo credit: organic cotton colors

During the talk at Texworld Paris in September 2017, Mr. Santi Mallorqui Gou said: "We are used to having a fabric and giving it 20 to 40 different treatments. From spraying, coating, softeners, anti-crease finishes, anti-microbial treatments, antiseptics and enzyme treatments, there's so much added to fiber and fabrics during finishing stages" [2]. As all these processes contain many chemicals which we don't know how they interact with the wearers. About 20 percent of fibers considered as waste because they are collected during the process of cleaning or being too short to turn into yarns, gets turned into accessories or paper to ensure that the loop is completely closed.

2.1 Companies producing exclusively organic colored cotton (NCC ECOBRANDS)

NCC ECOBRANDS produce organic colored cotton exclusively and the cotton is purchased from the company through a guaranteed system. Embrapa Cotton supports the plantation of the organic colored cotton and the labor is carried out by the Margarida Maria Alves settlement in the city of Juarez Távora (PB). The size of the plantation is around 18 hectares of land which depends on a rainfed agriculture system. The plantation does not use any pesticides or synthetic fertilizers. However, processing of the cotton takes place in the actual settlement.



Figure 2 Photo is the courtesy of NCC ECOBRANDS posted on May 12, 2016

During the processing a special machine separates the seed of the fiber, then the seeds stay in the settlement for a period till the next planting season, then the fibers go through the spinning process in Campina Grande and Joao Pessoa. Goats and Cattle goats are harvested, which makes another source of income for cotton producers as they feed on the remained vegetation. The plants remaining are usually removed by the farmers to clean the fields and prepare them for another season in the following year. Organic colored cotton made a huge appearance during the 41st São Paulo Fashion Week – SPFW, 2016, which is considered one of the biggest fashion weeks in the world. The corporation of Cotton Natural Color with the fashion designer João Pimenta resulted in an amazing collection of apparel emphasizing on the usage of sustainable raw material as he created the summer collection of 2016.

2.2 The Biodynamic Institute – IBD

The IBD works on issuing the certifications of the color cotton produced in Juarez Távora, proving that it is a purely organic product. For the certificate to be issued by IBD, many regulations and procedures have to take place including the verification if the planting of the cotton follows the labor laws and the Brazilian Forest Code. The IBD certification has a special advantage being

internationally credible, as it is monitored by the International Federation of Organic Agriculture Movements (IFOAM – England); JAS (Japan); USDA (United States); DAR (Germany) and Demeter International [6].

2.3 Cotton producers in the world

Identity programs identify the world cotton production as it is increasing in the marketing channels around the world, by the program or initiative under which it is produced. There are four major identity cotton world production. They are: Better Cotton Initiative (BCI), Cotton made in Africa (CmiA), Organic and Fairtrade, which its production was estimated at 3.4 million tons in 2016/17 and that makes around 15% of the world total production of cotton [7]. The Fairtrade was estimated at 3.4 million tons in 2016/17, up from 2.6 million tons in 2015/16 and 2.1 million in 2014/15. The world cotton production under the four identity programs is increasing and BCI is targeting to account of 30% of world production by 2020. The four identity cotton programs totaled 8% of world cotton production in 2014/15 with BCI and CmiA combined scored 7.6% of the total production. 12% of the world's total cotton production were credited to the identity in the year 2015/16 and the score of 15% in the year 2016/17 with BCI and CmiA accounting for almost all.

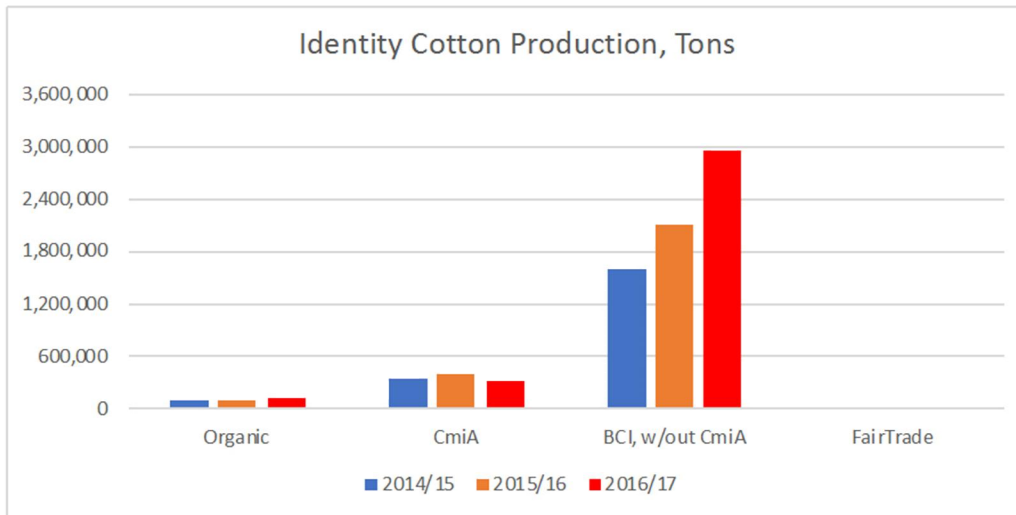


Figure 3 Identity cotton production from 2014-2017

Table 1 Production of BCI Cotton in 2016/2017

Production of BCI Cotton in 2016/17						
	ha	kg/ha	tons	% of total	farmers	tons/farmer
Australia	62 000	2 226	138 000	4	76	1 816
Brazil	607 000	1 730	1 050 000	32	195	5 385
China	401 000	2 324	932 000	29	51 746	18
CmiA	1 182 000	271	320 000	10	780 000	0.4
India	501 000	649	325 000	10	303 886	1
Israel	8 000	1 750	14 000	0	84	167
Kazakhstan	2 000	500	1 000	0	43	23
Madagascar	7 000	143	1 000	0	2 106	0.5
Mozambique	59 000	153	9 000	0	68 599	0.1
Pakistan	359 000	880	316 000	10	90 441	3
South Africa	7 000	571	4 000	0	553	7
Tajikistan	13 000	1 000	13 000	0	1 051	12
Turkey	16 000	1 875	30 000	1	342	88
USA	85 000	1 282	109 000	3	121	901
total	3 309 000	986	3 262 000		1 299 243	3
total less CmiA	2 127 000	715	2 942 000		519 243	6

2.4 World cotton production

The production of cotton is mainly grown commercially in around 80 countries in the world, even though the oilseeds, grain and oilseeds are grown in nearly every country. Approximately 2.5% of the world's fertile land is utilized to produce cotton. The estimated value of the world cotton production during the period of the month of August 2017 to the month of July 2018 accounted to be about \$ 50 billion US dollars [7]. If we draw a comparison between the world cotton production and the world soybeans, maize, wheat or rice productions, we find that each accounted for a total of \$130 billion US dollars to \$160 billion US dollars. Therefore, cotton world production is not considered the largest crop in terms of land area or in production value. In addition, cotton is considered mainly a fiber crop and not a food crop. Therefore

it is not associated with food security which is a main focus of government concern.

Cotton Producers 2017/18

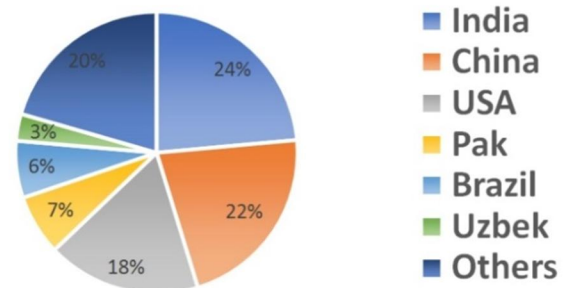


Figure 4 Cotton producers of 2017/18 with India being the most producers with 24%

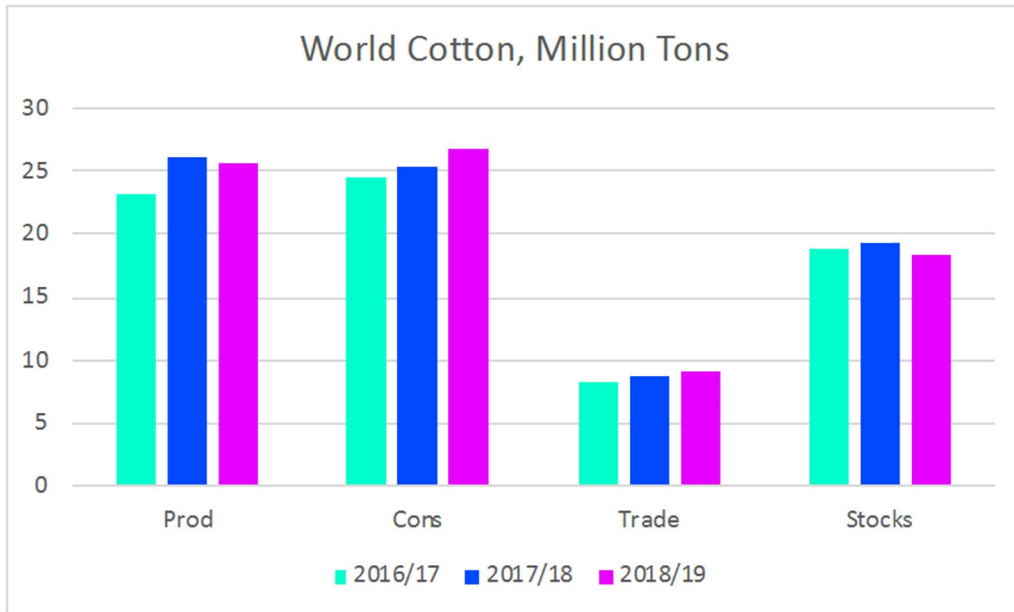


Figure 5 World cotton production in million tons

It was noticed that the world cotton production was increased to 26 million tons during the season which ended in July 2017. The production is expected to remain the same during the season starting in August 2018. The world cotton production forecast is predicting that the world cotton production in general will climb to approximately 27 million tons in the year 2018/19, which will mark a complete recovery prior to the recession period. However, the world trade in cotton is predicted to rise around 9 million tons, which will mark the highest number in few seasons ago. India, China and the United State of America take the lead accounting for about two-thirds of the world cotton production, whereas China, India and Pakistan account for a similar percentage of the world cotton consumption.

According to the Daily Records report of January 2019 [8], the top ten countries in the world that produced cotton are India being ranked at number one with 5879 thousand metric ton, China as number two with 4953 thousand metric ton, United States of America as number three with 3738 thousand metric ton, Pakistan being number four with 1676 thousand metric ton, Brazil as number five with 1529 thousand metric ton, Australia as number six with 914 thousand metric ton, Uzbekistan as number seven with 811 metric ton, Turkey ranked as number eight with 697 thousand metric ton, Turkmenistan as number nine with 288 thousand ton and finally as number ten, Burkina Faso with 283 thousand metric ton.

2.5 About DNFI

The Discover Natural Fiber Initiative (DNFI), formed in January 2010 as an outgrowth of the International Year of Natural Fibers 2009, was declared by the United Nations General Assembly. The main drives of the existence of DNFI are to develop the welfares of the industries of all the natural fibers and to encourage the enlarged utilization of natural fibers in the world economy. Another important factor about DNFI is that it is a voluntary association with interests in promoting natural fibers through consultation and collaborations. The organization serves as a platform for an exchange of information by generating statistics about fiber production and their end uses. Another important goal of the organization is to raise awareness about the benefits of using natural fibers and how beneficial is that to the world economy and the consumers.



Figure 6 Cotton being cultivated by women in Pakistan scoring as the fourth country in the word production of 2019 with 1676 thousand metric ton. Photo is courtesy of Daily Record Report [8]

3 HOW MUCH OF THE WORLD'S CLOTHING IS MADE FROM COTTON?

60% of women clothing items contain cotton fibers according to cotton Inc. About 40% of women's clothing items are made from 100% cotton. However, a total of 75% of summer garments must contain cotton, whereas only 60% of winter wear has it and that proves that cotton is a must to have in the summer because of its wicking ability and its characteristics to make the wearer comfortable, able to breath and feels cool while wearing cotton in the hot weather. Cotton is an essential textile to have. 48% of women's knit blouses contain cotton. On the other hand, 75% of men's clothing contain cotton or cotton blend fibers, while 85% of men's garments are made using 100% cotton. Cotton is used to make variety of men's clothing items including: suits, dress shirts, underwear and men's casual clothing, including jeans and sweatshirts and also business wear [9].

3.1 Differences between conventional, organic, Pima and Egyptian cotton

The *conventional cotton* is the word that is commonly used to describe the cotton grown using modern farming methods. The latest technologies and newest methods of production are usually utilized to enable the most efficient ways of production with keeping the safety of the environment in mind and moving recently towards sustainability. Conventional cotton can be grown by using transgenic plant varieties (GMO) or in a greenhouse. Furthermore, the conventional cotton farming techniques are used all over the world. *Organic cotton* is a method of cotton farming that does not use pesticides and non-GMO seeds. This method takes a lot more water and land, resulting in less than one percent of the organic cotton grown globally. *Pima cotton* is an American type of cotton where its fibers are considered the longest type of staple fibers in ranging between 1/4 inches to 19/16 inches making Pima cotton fiber to be considered an extra-long staple cotton fiber in comparison to conventional cotton's fibers that measure to approximately 7/8 of an inch. The extra length of the cotton staples contributes into the creation of a much stronger yarn, softer and higher quality textile. *Pima cotton* is typically grown in California, Arizona, Texas and New Mexico. On the other hand, *Egyptian cotton* is luxurious and desired as it contributes to high-quality set of sheets usually offered by five star hotels. *Egyptian cotton* states that the cotton is grown in Egypt regardless of its fiber length. However, *Egyptian cotton* is known to have an extra-long staple fiber. In most cases can fiber's length exceed the length of *Pima cotton* that can result in a very soft and silky textiles [10].

4 THE INFLUENCE OF SALLY FOX ON THE COLORED COTTON INDUSTRY

Sally Fox has been an innovator of organic farming methods, rediscovering the ethics of the naturally colored cotton and her contributions to this industry have been appreciated as she cared to protect and save the environment. Fox began breeding brown and green cotton by choosing the best seeds to be able to produce the longest staple fibers and cultivate them year after year. Ultimately, Sally Fox succeeded in creating two major colored cottons that were able to be spun on a machine, as she was able to purchase a small land to grow the two naturally colored cottons. Sally was the recipient of Plant Variety Protection Certificates, which are equivalent to a patent. During the year 1988, only one acre of organically grown cotton existed in the United States and today over 20000 acres of organic cotton are available. Sally Fox received prestigious awards including the UNEP Award awarded to her in the year 1993 [11] and the Discover Magazine Award in 1994 for the sake of technological innovation. Green Housekeeping Award was given to Fox for Environmental Leadership

5 ADVANTAGES OF NATURALLY COLORED COTTON

The cotton that does not have the usual yellowish off-white color is usually referred to as colored cotton. It is mainly bred to have a different color than the traditional commercial one. The most popular colors grown are green, red and various shades of brown. The cotton's natural color is not likely to fade [9]. The naturally colored cotton is supposed to have originated in central and south America about 2000 years ago. Especially, the Mochica Indians can be credited with growing naturally colored cotton of many various hues that are preserved on the northern coast of Peru [12]. Not many colors are grown naturally today, mainly in addition to the green, red, light shades of brown, gray and chocolate brown may exist. The utilization of the naturally colored cotton has been blocked, mainly because of the industrial revolution, as the commercial off-white cotton was much cheaper to produce for mass production clothing items. Today, people have become more aware about the harm chemicals causing to both humans and the environment. The trend to use the naturally colored cotton has been revived and is being favored because of his low impact on harming the environment. If the colored cotton is already colored naturally, then there is no need to use synthetic dyes or harmful chemicals during processing and production. An important fact is that the natural colored cotton is unlikely to fade with the wash, like the fabrics colored with synthetic dyes.



Figure 7 Naturally colored cotton

Naturally colored cotton without any chemicals, synthetic dyes or any other treatments has been increasingly in demand and is becoming more popular mainly for being safe and environmentally friendly. The commercial off-white cotton is known to be the most pesticide-dependent crop in the world. Even though it only occupies around 3% of the world's farmland, but it consumes over 25% of the insecticides and 12% of the pesticides consumed worldwide. Around fifty-five countries rely upon cotton for a substantial percent of GDP. The residues after using the dyes are usually thrown into nearby rivers causing the contamination of the water and soil. Artificial dyes are eliminated when using the already colored cotton saving the environment. The World Bank predicts that 20% of water pollution originated because of the chemicals used from textile dyes. Seventy-two toxic chemicals in our water solely were identified to be related to textile dyeing. Using naturally colored cotton not only saves the health of humans, including farmers, but also saves to the environment and communities and in addition to reducing production cost. In comparison to the white cottons, naturally colored cotton fibers are shorter and economically less profitable. Even though the dying process cost is omitted from the cost of colored cotton production, but the cost of it is much higher than the cost of white cotton. Mills producing cotton using artificial dyes have reported cases of antagonistic effects on the skin and human health, such as allergies and itching of the skin and even cases of cancer. Furthermore, the washing after effects of the natural colored cotton is quite different from the synthetic dyed colors, as the dyed fabrics

have tend to fade much faster while some naturally colored cotton improve in intensity with each wash.

5.1 Types of lint color

The main lint color of commercial cotton cultivation is often white. Brown and green colors are most common in the cultivated species. However, it was reported that some of the genotypes of USA and Russian Republics cotton collection included colored lint with shades of pink, red, blue, green and also dark grey close to black. Even though Sally Fox of Verses Ltd. Has claimed to developed multicolored lint with more than one color on the same lint strand. Genotypes with multi colored lint have not yet been made available to the researches and nor were produced on a large scale. The two main lint colors are green and shades of brown.

Brown color is considered the most common color among the colored cotton. It is available in different shades and ranges from light brown almost mocha color to an intense mahogany red. The names are given to the colors based on the intensity of the shades. For example: khaki, camel, brown, dark brown, chocolate brown, dirty grey, tan and red. Interestingly, the brown colored cotton stable fibers are longer than green. With intense exposure to sunlight the brown colored cotton fades but gradually and at a very slow rate [5].

Green colored cotton is the second significant commonly used lint color in cotton. The green color is not as common or available as the brown and comes only in two shades, light green and green. The green color fades much faster than the brown color with exposure to sunlight. The prolonged exposure to sunlight during the boll opening may lead to fading of the shade of green color and it may turn to white or off-white. An important finding by the central institute for cotton research Nagpur discovered that the colored cotton genotypes are poor in yield as they hold weak fiber properties in comparison with white linted cotton.

Wild species are considered a significant source of colored lint. Many of the wild species of genus *Gossypium* including assumed donors of present-day tetraploid cotton *G. herbaceum* race *africanum* and *G. raimondii* have colored lint. In addition to lint color some of wild species possess the ability to resist drought, insect pests' diseases and poses fineness and extra strength of their fibers.

Table 2 Major economic and fiber characteristics of colored upland cotton

Lint color and accessions	Seed cotton yield [g/pt.]	Durations [days]	G.O.T. [%]	2.5% span length [%]	Maturity coefficient	Micronaire value	Strength '0' gauge [g/tex]	Uniformity ratio [%]
Dark Brown								
LC-1-1	50.2	165	33.2	23.4	0.89	3.1	38.0	54
Red 5-7	46.5	170	19.5	21.3	0.81	3.6	40.7	46
Conark (DB)	45.6	160	31.1	24.1	0.62	2.7	40.7	46
Medium Brown								
Extreme Okra Leaf	54.3	160	28.3	15.1	0.83	3.9	38.0	49
Parbhani American	68.7	165	35.1	14.8	0.83	4.5	35.0	53
Hirsutum Tashkent	39.2	160	32.3	20.0	0.78	3.6	36.5	51
Light Brown								
Kampala Colored	24.9	160	30.9	22.9	0.64	2.8	37.4	44
Nankin brown	63.7	160	31.5	20.0	0.76	3.4	34.6	51
LL 55-68-2	34.6	170	29.8	19.8	0.66	2.8	36.0	48
Khaki Color								
Khaki Colored	37.4	165	30.5	20.0	0.65	3.0	35.0	46
Light Green								
Arkansas Green	46.5	160	19.5	18.5	0.59	2.6	32.0	50
Green								
Intense Red Green	31.5	160	20.7	21.7	0.56	2.8	32.2	47
Commercial White								
LRA 5166 (Check)	126.0	165	35.0	25.5	0.71	3.6	44.5	51

Table 3 Economic and fiber characteristics of brown linted germplasm of desi cotton

Sl. No.	Accessions	Seed cotton yield/plant [g]	Duration [days]	G.O.T. [%]	2.5% span length [%]	Fibre strength [g/tex]	Micronaire value	Uniformity ratio [%]
G.arboreum								
1	Light brown	32.0	176	36.2	20.6	17.5	3.2	48
2	SP 3936 (A)	30.5	182	38.0	21.1	18.1	5.4	50
3	Malvensis	49.0	195	30.7	23.0	16.4	4.8	47
4	7869 Brown	28.0	186	37.5	24.0	19.0	4.9	50
5	Khaki color 8631	32.1	195	38.0	20.0	17.1	5.3	50

Table 4 Lint colours found in *Gossypium* species

Continent	Species	Genome	Lint color
America	<i>G.aridum</i>	D ₄	brown
	<i>G.armourianum</i>	D ₂₋₁	brownish
	<i>G.darwinii</i>	AD	brownish
	<i>G.mustelinum</i>	AD	brownish
	<i>G.gossypoides</i>	D ₆	greyish
	<i>G.harknessii</i>	D ₂₋₂	greyish
	<i>G.laxum</i>	D ₉	tan
	<i>G.lobatum</i>	D ₇	tan, white
	<i>G.trilobum</i>	D ₈	tan
	<i>G.lanceolatum</i>	AD	white
	<i>G.tomentosum</i>	(AD) ₃	red brown
Africa	<i>G.hirsutum</i>	(AD) ₁	brown, tan, white, green
	<i>G.barbadense</i>	(AD) ₂	creamish, white
	<i>G.anomalum</i>	B ₁	brownish
	<i>G.capitis-virdis</i>	B ₄	brownish
	<i>G.somalense</i>	E ₂	brownish
	<i>G.herbaceum</i>	A ₁	greyish, white
Afro-Asia	<i>G.longicalys</i>	F ₁	greyish
	<i>G.triphyllum</i>	B ₂	tan creamy
Arabia	<i>G.arboreum</i>	A ₂	brown, tan, white
	<i>G.stocksii</i>	E ₁	brownish
Australia	<i>G.arenarium</i>	E ₃	brownish, grey
	<i>G.incanum</i>	E ₄	tan
Australia	<i>G.austroale</i>	C ₃	brownish
	<i>G.sturtianum</i>	C ₁	brownish
	<i>G.robinsonii</i>	C ₂	greyish
	<i>G.sturtianum</i> var. <i>nandewarensis</i>	C _{1-n}	greyish

6 DISADVANTAGES OF NATURALLY COLORED COTTON

Some of the major disadvantages of naturally colored cotton include the limitation of colored cotton availability, in addition to the low yield potential, poor fiber characteristics and limited colors with the instability of colors and low market demand. The yield potential for colored cotton is currently very low, almost half of the white linted variations. Because of low demand, naturally colored cotton did not become as popular as the white cotton to be produced commercially. In fact, the low yield has acted as a blockade in the expansion of its cultivation and the cultivation of colored cotton has been limited to tribal areas and small lands only. Another major factor that makes the colored cotton undesirable is the poor fiber properties it processes compared with white cotton. The fibers are usually shorter in staple length and weaker. They also have low fiber maturity compared to white cottons. The weakness of the colored cotton fibers makes it difficult for spinning the fibers into yarns. In addition to the weakness of the fibers, colored cotton is available in limited lint colors, while the white cotton can be colored into any shade using the chemical dyes. The ability of the natural colored cotton to stay bright and intense is low, as the extensive exposure to sunlight fades the colors, especially the green, and turns it into almost white fiber. The brown colored cotton fades but slower than the green. Another disadvantage that the colored cotton processes is contamination. Growing of colored and white cotton in the vicinity will increase the chance of contamination of white linted genotypes with colored genotypes and vice-versa. For this reason, growing of white cotton in the field in which colored cotton was grown in the previous year may also lead to contamination. Colored cotton should be restricted to small areas only. Low market demand is another reason that limits the cultivation of colored cotton on a big scale. However, the demand of naturally colored cotton has increased in some European countries. It is recommended to develop marketing facilities before starting the cultivation of colored cotton on commercial scale. For example a written agreement should be drafted between the purchaser and the producer in order to facilitate the production of naturally colored cotton, as its demand is fairly limited.

7 CONCLUSION

Fibers can come from different sources, natural or synthetic. The natural textile fibers are extracted from either animal sources like mohair, wool and silk or from vegetable sources like cotton, kapok, linen, ramie, hemp, jut and sisal. The man-made fibers, such as acetate and viscose, are usually extracted in the lab and their polymer is generated from

a cellulosic source such as wood and linters. For example, silkool from *Glycine max*, kazein from milk, ardil from peanut, zein from maize, are all obtained from natural sources, however they're not generated in a traditional fiber structure but with special treatments applied they can be extruded into fibers and then they will be known as regenerated-fibers.

Cotton is a very desirable fiber, as it has a wicking ability that makes the wearer feels cool and comfortable to wear during the summer. According the Daily Records report of January 2019 [8], the top ten countries in the world that produced white cotton are India being ranked at number one with 5879 thousand metric ton, China, United States of America, Pakistan, Brazil, Australia, Uzbekistan, Turkey, Turkmenistan, and ranked as number ten, Burkina Faso with 283 thousand metric ton.

Cotton in its natural state and never dyed at all, can be identified as entirely organic. And since the naturally colored cotton is natural, and more desired than the chemically died one, naturally colored cotton has been gaining popularity in recent years as companies started seek more sustainable solutions. However, to grow natural cotton many factors need to be taken into consideration, since the utilization of the naturally colored cotton has been blocked, mainly because of the industrial revolution, as the commercial off-white cotton was much cheaper to produce for mass production clothing items.

Today many companies are becoming aware of the concept of sustainability, since no chemical dyes are involved in the process. In Brazil the organic colored cotton is produced without any synthetic fertilizers and pesticides by the Natural Cotton Color Group NCC Ecobrands in the city of Juarez Távora (PB). The plantation takes up 18 hectares of land and the production system relies on a guaranteed purchase agreement between the NCC and the local farmers. In India, the Central Institute for Cotton Research of Nagpur and several State Agricultural Universities have taken up breeding programs for improvement of colored cotton.

Sally Fox, the American lady has been an innovator of organic farming methods, rediscovering the ethics of the naturally colored cotton, and her contributions to this industry have been appreciated as she cared to protect and save the environment. Fox began breeding brown and green cotton by choosing the best seeds to be able to produce the longest staple fibers, and cultivate them year after year.

Even though natural colored cotton is becoming more desirable by the consumers and many clothing companies, and fashion designers are going sustainable, natural colored cotton has many drawbacks, and limitations. Mainly naturally colored cotton has limited colors, shades of brown, green,

grey, and chocolate brown. Fabrics created from naturally colored cotton fade with washes. The green color fades from the exposure of the sun, but improves its fastness and color intensity with each washing. Colored cotton fibers are weaker, shorter staple fibers than white cotton, which makes it difficult to spin into yarns, and if planted with the white cotton, will make the white cotton subject to contamination, that is why naturally colored cotton must be planted in separate small areas exclusively.

Because of short productivity per unit area, poor quality of fiber physical appearance, and uneven distribution of colors, colored cotton is not produced commercially. Even though, the demand of naturally colored cotton has increased in some European countries, and is desirable because of its natural color properties, without the chemical dyes, it is recommended to develop marketing facilities before starting the cultivation of colored cotton on commercial scale.

A written agreement should be drafted between the purchaser and the producer in order to facilitate the production of naturally colored cotton, as its demand is considered fairly limited in comparison to white commercial cotton that is a better quality, and can be dyed in any color following the fashion trends.

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