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"THE NATURAL-FIBRE INDUSTRY HAS REINVENTED ITSELF TIME AND AGAIN"

An interview about important insights from a century of natural-fibre trading, persistent natural-fibre myths and why natural fibres have long been more than just an 'Eco-Alternative'.

When Hamburg's Wilhelm G. Clasen (WGC) natural-fibre trading company was founded in 1919, natural fibres accounted for almost 100 percent of the global fibre market. Since then, the market has changed beyond recognition. Today, natural fibres not only compete with synthetic fibres for market share but must also contend with downward pressure on prices, the consequences of climate change and new demands on their supply chains. At the same time, they are finding their way into a wide range of technical applications, including composites and drones. In this interview with Texpertise, WGC Managing Director Thomas Bressler talks about 100 years of natural-fibre trading, damaged natural-fibre cargoes, persistent industry myths and the future of the natural-fibre industry.

Mr Bressler, what exactly does WGC do – and how did you get involved with natural fibres?

We act as an interface between individual farmers who grow natural fibres, manufacturers and consumers. WGC was founded in 1919 and began with raw jute, later adding kenaf and sisal. Today, our portfolio also includes abaca, hemp, cotton linters, kapok, coconut and niche fibres, such as pineapple and nettle fibres. We source our fibres from all over the world, including India, Bangladesh, Ecuador, Brazil, East Africa and Indonesia. We also work to raise awareness of the importance of renewable natural fibres. I used to work in the spice trade and my first contact with natural fibres was through jute bags for chillies. Then, when I joined WGC in 2011 and realised how complex this field is, I became fascinated with natural fibres. Even after more than 14 years, I'm still learning something new every day.



WGC Managing Director Thomas Bressler examining kenaf fibres in Bangladesh. Source: Bildarchiv Clasen.

How has the trade in natural fibres changed over the last 100 years?

When WGC was founded, Europe still had a thriving textile industry that imported large quantities of raw natural fibres and processed them locally. Before 1914, Germany alone imported over 120,000 tonnes of jute every year. Over the years, many crises, such as hyperinflation, oil shocks and the Asian financial crisis, impacted the natural-fibre business. However, there were three main factors that changed everything: the switch from general cargo to container shipping in the late 1960s; the relocation of the textile industry to Asia; and the introduction of polypropylene in the 1950s/1960s, which led to a shift from natural fibre-based packaging materials to synthetic-fibre alternatives. This was more devastating than all the economic crises combined because it meant that a huge market for natural fibres was lost in one fell swoop.

What experience and insights has WGC gained in over 100 years of trading in natural fibres?

One key lesson is that there is a natural-fibre alternative for almost all applications – and sometimes even several – even though it used to be thought that only synthetic fibres were suitable. However, I would like to stress that the combination of natural fibres, recycled fibres and man-made fibres will be crucial if we are to meet the major challenges of the coming years and develop more sustainable products. This is why, if we are to be successful together, strategic partnerships were and continue to be of great importance in the world of natural fibres.

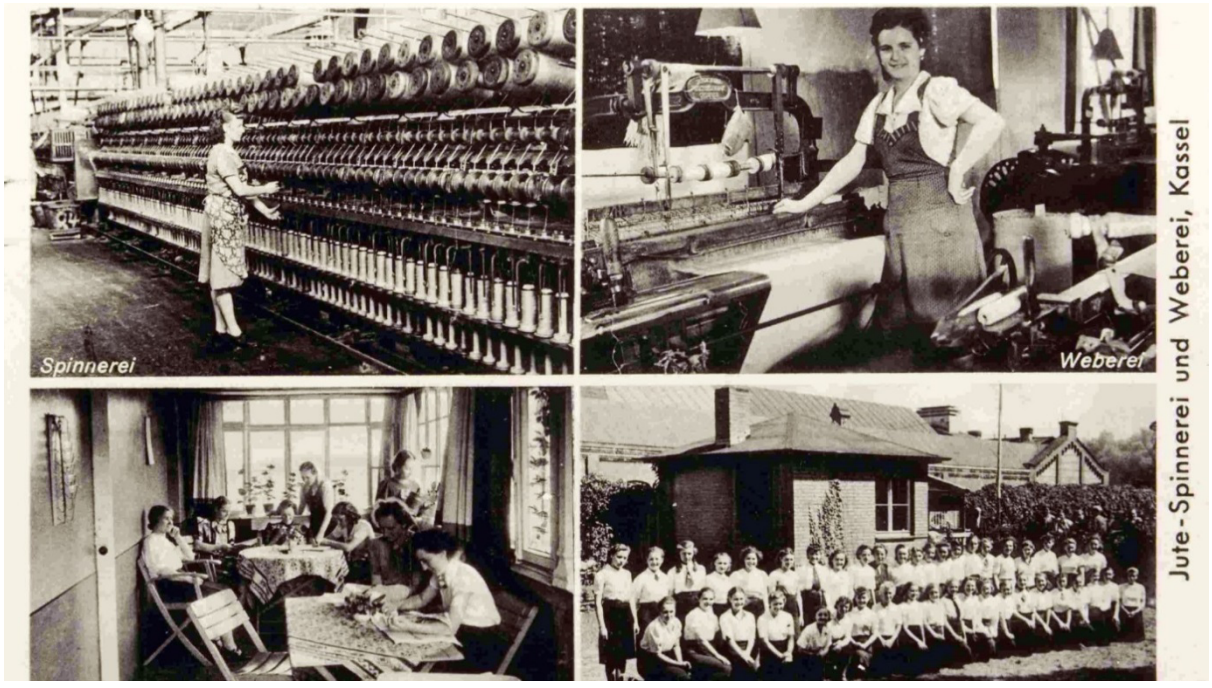
WGC has a special relationship with 'damaged shipments' – can you tell us more about this?

Damaged goods are natural fibres that originate from shipping accidents or have

suffered transport damage. Our company founder Wilhelm G. Clasen and, subsequently, his son and successor Peter Clasen were adept at taking possession of salvaged cargo, processing it and reintroducing it to the market. This complex process involved sorting, drying and inspecting the goods to determine their suitability for alternative uses.



Company founder Wilhelm G. Clasen inspecting a batch of raw jute around 1930. ***Source: Bildarchiv Clasen.***



Inside a jute spinning and weaving mill in Kassel – a symbol of the gradual decline of industrial natural-fibre processing in Germany from the 1960s onwards.
Source: Bildarchiv Clasen.



Company founder Wilhelm G. Clasen in his Hamburg office during the 'golden age' of the natural fibre trade in the early 1950s, before the synthetic-fibre boom.
Source: Bildarchiv Clasen.

Which customers does WGC currently supply with natural fibres?
Our customer base reflects the wide variety of applications for natural fibres and ranges from small businesses to global corporations, from manufacturers of decorative items to pulp producers. We have been working with many of them for decades. However, we also have many new customers, including start-ups that develop natural-fibre composites for agricultural drones. However, there is one thing that all our customers have in common – a passion for natural fibres.

Which industries traditionally use natural fibres and where do you see the strongest potential for growth?
Traditional users who are still loyal to natural fibres include the rope and carpet industries and the packaging sector – coffee and cocoa beans, for example, are still packed in jute sacks, even though many products are now transported in container liners. Natural fibres also continue to be sold in large quantities for use in agriculture, for example, as harvest and binding twine.

"The most important growth market is probably the building-materials industry. Customers are already asking us to work on developments in which natural fibres are to supplement or replace synthetic fibres. "Thomas Bressler
Basically, however, I see a potential for natural fibres in all industries that want or need to improve their carbon footprint. The automotive, composites, pulp production, cosmetics and medical sectors are also becoming of ever greater interest.

What role do natural fibres play in modern automobiles?

In the past, natural fibres such as coconut were mainly used in automobiles as insulation materials or for seat upholstery. In the 1970s, under the influence of the global oil crisis, most of the fibreglass in motor vehicles was replaced by hemp and flax, as well as, later on, increasingly by jute and kenaf with the aim of saving weight and reducing fuel consumption.

Even today, many moulded parts, such as dashboards and door panels, are made using natural fibres such as jute, kenaf, hemp and flax. Virtually all well-known manufacturers use natural fibre composites in most of their vehicles. We are proud to be an important part of this supply chain and, via our customers, indirectly supply our natural fibres to leading OEMs in Europe, the USA and Asia.

What challenges do natural fibres face in technical applications, such as composites?

Harvest-related fluctuations in price and quality remain the biggest challenge for all companies that process natural fibres. Strict quality control before the production process begins is therefore very important because, ultimately, natural fibres are always in competition with synthetic fibres, which are not subject to challenges of this kind. It is also increasingly important to respond to the growing labour shortage and to further automate processes. In my opinion, this is the biggest challenge we will face over the coming years. In India and Bangladesh, for example, the jute industry has been struggling to find workers for many years. On the one hand, more and more people are moving from rural areas to urban centres while, on the other hand, the physically demanding work to be found in the factories is not particularly attractive as there are plenty of alternatives. Given the extremely high population density, this may come as a surprise, but it is nevertheless a major challenge.

How have natural-fibre supply chains changed over the decades?

Most natural fibre markets are traditional markets and not much has changed here over the last 100 years. Natural fibres often pass through several hands before reaching the manufacturer. And this meant we faced some major challenges when the Supply Chain Due Diligence Act came into force, which calls for greater supply-chain transparency. Many middlemen in the countries of origin were not particularly enthusiastic about our efforts to source natural fibres directly from producers. However, we have now managed to bypass them and meet the requirements for a transparent supply chain, something that is extremely difficult in the case of natural fibres, most of which are grown by small-scale farmers.





Left: A hard and robust fibre, sisal is traditionally used for ropes and carpets. Today, however, it is also finding its way into modern applications such as dartboards, composites for automobiles and decorative stucco work. Right: Drying processes such as those used in this case with raw jute are crucial to prevent the dreaded 'heart damage' caused by excess moisture, which leads to the bales rotting from the inside out.
Source: Bildarchiv Clasen.

What is so special about trading in natural fibres, a sustainable raw material?

From my point of view, there are three main factors: firstly, the complete dependence on weather conditions, which makes the market particularly challenging because you must always adapt to new and ever-changing situations; secondly, the variety of applications and, thirdly, the fascinating interaction between agriculture and large-scale industry. In many cases, this may seem like an impossible balancing act. However, we have found that large-scale industry is demonstrating an increasing interest in natural fibres and is willing to adapt to take account of their special characteristics.

What distinguishes people who work in the natural-fibre sector?

More than 40 million households around the world earn their living from natural fibres, from micro-farmers to multinational companies. With so many people involved, as well as their diverse cultural backgrounds and countries of origin, it is difficult to single out any one particular characteristic. However, there is one thing that unites everyone I know who works with natural fibres: their great commitment and identification with the industry. Of course, some people mourn the golden age of natural fibres, but we are now dealing more and more with the second, third and even fourth generations. This has created a new dynamic and openness to exploring new paths with natural fibres. Ultimately,

it is evident time and again that once you have committed to natural fibres, it is difficult to switch to anything else.

How is climate change affecting the trade in natural fibres?

The effects are many and varied. They include shifting harvest cycles, crop failures due to heat, insufficient rain, storms and flooding. The Global South, where most natural fibres come from, is particularly hard hit. Farmers in the producing countries are therefore faced by the need to make the cultivation of natural fibres profitable despite these changing climatic conditions. And this means it is all the more important to provide them with modern agricultural technology and modified seeds, to respond to these climate changes and strengthen the agricultural sector.

What role does digitalisation play in the global natural-fibre trade?

In many areas, our industry still has some catching up to do in terms of digitalisation, particularly with regard to harvesting technology, statistical analysis, harvest monitoring and traceability. There are now some apps that enable more accurate harvest control, as well as permit each batch to be traced back to the producer. However, there is still a great potential for development here, which must be exploited given the increasing demands for transparency in the supply chain and better harvest analysis. Moreover, physical work with fibres remains important, for example, in sorting and grading the goods. This requires significant expertise, which cannot simply be replaced by digital technology. Although automation has long since found its way into processing, natural-fibre production is and remains a labour-intensive industry.

"The combination of natural fibres, recycled fibres and man-made fibres will be crucial if we are to meet the major challenges of the coming years." Thomas Bressler

How do EU regulations and sustainability goals affect the natural-fibre market?

Regulations have a considerable impact on the natural fibre market. Much of it is positive, even if the large number of new directives initially causes a great deal of additional administrative work. Unfortunately, however, natural fibres have often been neglected in the overall analysis, are not considered in sufficient detail, and are consequently incorrectly classified in many regulations. In principle, however, greater supply-chain transparency ensures that the needs of producers are more visible, which will hopefully lead to them being better rewarded for their hard work. Overall, the subject of sustainability is more important today than ever before and is opening up numerous new opportunities for using natural fibres.

What myths and misconceptions about natural fibres do you repeatedly encounter, even within the textile industry?

Many people still see natural fibres as a simple and technically unsound 'eco-friendly alternative' to synthetic fibres. This dates back to a time when methods were simple. However, against the backdrop of advanced processing methods, this is no longer the case. Although questions about deforestation are also

raised, they do not apply to most natural fibres because many areas of cultivation, for example, in the case of jute or kenaf, are traditional fields that are farmed all year round with different crops. There are certainly exceptions, but I am not aware of any natural fibres for which forests have had to be cleared. We also hear time and again that natural fibres cannot compete with other raw materials in terms of security of supply. However, it is important to look at the entire spectrum and not just individual fibres. There is no single fibre that can be used as a substitute or supplement for man-made fibres – it is the variety that counts.

How will the international market for natural fibres develop over the next few years?

The natural-fibre trade is in flux. In recent years, a large, future-oriented market has opened up for natural fibres, far removed from established areas of application. Much will depend on how successfully natural fibres can be incorporated into branches of industry that do not use them at present. If this goes well and general awareness of the need for sustainable raw materials remains high, I see a very positive future for natural fibres.

If WGC could share a single insight with the textile industry based on over 100 years of trading in natural fibres, what would it be?

Undoubtedly, it would be the fact that the natural-fibre industry has reinvented itself repeatedly over the decades – sometimes out of necessity but mostly driven by its own spirit of innovation. This ability to adapt in times of success as well as in difficult times demonstrates a high level of resilience and a raison d'être that will still exist a century from now.

Mr Bressler, thank you very much for speaking with us.

AN ERA OF TRANSGENIC COTTON (*GOSSYPIUM L.*); PROS AND CONS

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Abstract

Cotton is the major fibre crop in Pakistan and worldwide. Grown in tropical and subtropical locations throughout over 80 nations worldwide, it covers over thirty million hectares and produces over 20 million tons annually. Major cotton producing countries include China, U.S.A, India, Pakistan, Uzbekistan, Australia, Brazil, Greece, Argentina, and Egypt.

During its evolution, cotton have gone through many phases. Basically, it is a tree with deep root system and hard woody stem. It was domesticated from wild ancestors. Its different characters are improved by natural and artificial cross pollination inter and intra species. Genetic modification in cotton have played a massive role in its evolution. By using genes from soil bacterium *Bacillus thuringiensis,* insecticidal resistant cotton is developed, which is the one of the major factors in cotton evolution. Herbicide (roundup ready/glyphosate) resistant cotton is also developed by genetic engineering technology. That is why it is known as Bt cotton. Research is going on in China and some other countries for disease resistant cotton which will improve its resistance ability against different diseases specially both wilts (Fusarium and Verticillium). In this paper we will discuss different benefits as well as drawbacks or risk factors of using transgenic cotton and the role played by genetic engineering in cotton modification

Introduction

Cotton is the main cash crop for agriculture in Pakistan (GoP, 2015). Pakistan is currently the fourth largest producer and third largest consumer of yarn in the world. Approximately six million acres, which is about fifteen percent of the country's agricultural area, are cultivated by five million farmers, 1.3 million of whom are involved in cotton farming. In Pakistan, this significant cash crop which adds 5.2% to the value of agriculture and accounts for 0.8% of GDP. Cotton brings in 51% of total foreign exchange earnings for the country.

As cotton is the cash crop for farmers and government, so its cost benefit ratio is the major factor in its cultivation or usage. Along with increasing its yield/production or the output, scientists must work to reduce the expenditures or the inputs. It also will eventually increase the outcome or benefit of crop at the end. Main expenditures of cotton include Fertilizers, irrigations and chemicals. Most of the percentage of total inputs is carried out by chemicals to control insect pests. So, if we can reduce its expenses, the profit ratio would automatically increase.

Genetic modification or transgenic modification is a great step towards better agriculture. Different engineering techniques are being used for gene editing. Some major techniques which are used are particle bombardment, use of gene gun, CRISPRcas9, TALENS, and ZFNs etc. (Khan et al., 2023). GM cotton was made by using soil bacterium *Bacillus thuringiensis*. (Shar et al., 2021) GM cotton synthesizes crystalline proteins called as endotoxins, which are highly toxic to certain insects. This feature improves the insecticidal resistance ability of cotton as these endotoxins harm the insects by attacking on the gastrointestinal tract. These proteins are classified on the bases of their insecticidal activity (Cry 1, Cry2, Cry3, Cry4). Different strains of transgenic cotton produce about 25 or more different but related ICPs. These crystal proteins work well to destroy the larvae of numerous dangerous insects, such as disease-carrying insects and numerous other agricultural pests. Cotton bollworms (*Helicoverpa armigera* etc) belong to the order lepidoptera and are responsive to Bt Cry1 and Bt Cry2 protein which are specific to them. Useful bugs are not damaged or killed by these proteins (Abdullah, 2010).

Why Transgenic Cotton?

There are several issues which became the reason of transgenic cotton production (Marral et al., 2023). First of all, pest infestation reduces the cotton productivity very badly as more than 160 pests attack at different stages of crop(Kouser et al., 2019, Naeem-Ullah et al., 2020). Cotton farmers spend huge amount of money on pesticide to cope with these pests (Kouser and Qaim, 2013). Pakistan spends about 300 million dollars annually on pesticides, from which about 80% are being sprayed on cotton crop (Arshad et al., 2007, Khan et al., 2015). Along with the heavy budget, human health and environment was also being compromised greatly (Tooker and Pearsons, 2021, Ziółkowska et al., 2021). In addition to it, Many of insects also had developed resistance among them against the widely used insecticides, due to which the results of insecticides were not sufficient (Dhivya et al., 2016).

Use of this genetically transformed crop is getting great attention due to its ability to resist against different insects and herbicide (Rana, 2021). Due to its

resistance, it can lower the effect caused by insect such as bollworms (Lv et al., 2022). Its natural resistance will also lower the use of insecticides on cotton, which will increase the benefit-cost ratio and will also help in environment improvement (Kumar et al., 2008, Klümper and Qaim, 2014).

In this frame of reference, genetic engineering presents a vast opportunity to enhance the genetic diversity of crop plants by introducing foreign genes from various sources, such as bacteria. Bacillus thuringiensis (Bt) stands out as a crucial supplier of insect resistance genes. Employing Bt genes for insect resistance has proven to be a highly successful strategy in advanced agriculture, with genetically modified (GE) crops covering 175.2 mha globally in 2013 (James, 2003a). Notably, with the incorporation of Bt insecticidal proteins, transgenic cotton has quickly emerged as one of the most popular genetically engineered crop globally. (James, 2003b, Lu et al., 2012). Growing Bt transgenic cotton has significantly decreased the need for chemical pesticides, which has reduced pollution to the environment and reduced exposure of humans to toxins. (Bennett et al., 2004). Moreover, Bt toxins exhibit high specificity against insect pests, sparing predators and beneficial insects (Christou, 2005). Recognized for these benefits, Bt cotton varieties are considered a valuable element of integrated pest management systems.

Techniques for Genome editing

Gene editing tools, including ZFNs, mega-nucleases, TALENs, and CRISPR/Cas9, have gained prominence for targeted gene alteration in plants (Aziz, 2021). CRISPR, a well-known bacterial immune defense , introduced CRISPR-Cas9 as a groundbreaking tool for biotechnologies (Singha et al., 2022). These GenEd tools enable precise editing of DNA sequences in the genome to enhance genetic traits in organisms (Table 1). Designing and mapping GenEd tools in accordance with the target sequences are feasible. Although the design, cloning, expression vectors, and transformation techniques of ZFNs, TALENs, and CRISPR/Cas vary, they all work on the same concept of forming double-strand breaks (DSBs) at the target site.

The effective use of DSBs depends on the chosen genome editing technology. DSBs can create targeted heritable mutations, including insertions and deletions (Indels), with the potential for gene insertion, correction, and replacement using a donor template (Lo et al., 2013). However, these methods are found to be less efficient in plants. Additionally, gene deletion can be performed by creating two DSBs in the flanking regions of the gene.

The design and in silico assembly of GenEd tools are made easier by a variety of offline and online software programs. You can also obtain clones and plasmids from researchers or from charitable plasmid libraries such as Addgene. Other endonucleases (ENs) such meganucleases or homing endonucleases (DADGILAGLI) have been recognized for targeted genome changes, even though ZFNs, TALENs, and CRISPR/Cas are commonly utilized for genome editing (Roth et al., 2012). However, the applicability of Meganucleases has limitations in comparison with other Ens.

Table 1. Characteristics of various gene editing tools

Characteristic	ZFN	TALEN	CRISPR/Cas9	References
Binding principle	Protein-DNA	Protein-DNA	RNA-DNA	(Cui et al., 2022)
Ease of design	Moderate	Easy	Very Easy	(Buljung et al., 2022)
Assembling	Difficult	Easy	Very Easy	(Li et al., 2022)
Time for construction	5–7 days	5–7 days	1–3 days	(Li et al., 2022)
Cost	High	Moderate	Low	(Khan et al., 2022)

Bollgard-1 and Bollgard-2

Cotton plant modified genetically by incorporating gene conferring Cry1Ac protein is known as Bollgard-1 (BG-1). It contains delta-endotoxins which was very affective against lepidoptera insects (Kumar et al., 2008). It was approved for commercial use in 1996 in Australia and USA. This was the starting of new era in production of cotton. In Pakistan, Bt cotton seed was illegally imported during 2001-2002, but its approval came very late. Its official approval was given in 2010 by National Biosafety Committee.

1st generation Bt cotton (BG-1) failed in safety during the whole entire crop season from bollworms that developed in the later stages of crop. Cry1Ac was efficient against major insect pest such as American, Spotted and Pink bollworm but it was susceptible to other insects of order lepidoptera. So in order to solve out this problem, second generation Bt cotton or Bollgard-2 was introduced which contained two genes known as Cry1Ac + Cry2Ab (Chitkowski et al., 2003). This combination of two genes boosted up the resistance mechanism against bollworms or lepidopteran insects (Katta et al., 2020). Working on Triple genic cotton is also carrying out in the world and Pakistan as well. In a nutshell, this newly developed triple gene having Cry1Ac + Cry2Ab + EPSPS construt showed valuable mortality and protein expression of all these 3 genes in GM cotton (Puspito et al., 2015).

Economical effect

Whenever we are discussing an agricultural crop, main concern is with the ultimate profit to the farmers. Near to 160 different species of insects attack on cotton plant at different stages during crop season (Naeem-Ullah et al., 2020). About a dozen of these are significant, and half of them constitute the main obstacles to output reduction. Along with different management practices, costly chemicals are used to save crop from these insects otherwise production would be greatly reduced or even zero production could be the end result (Noman et al., 2016). *Pectinophora gossypiella* (PBW), *Earias vitelli* (Spotted bollworm), *Helicoverpa armigera* (ABW) *are the key insects of lepidoptera order* , can cause loss in yield

upto 80% (Zehr, 2010). With the introduction of transgenic cotton, the input or expenditure on cotton cultivation has been reduced greatly. As Bt cotton is resistant against insects of order lepidoptera so farmers don't have to buy and use those insecticides and their input cost is reduced by great extent (Di Lelio et al., 2022). Although the seed of Bt cotton is little bit costly than the non-Bt , and Bt cotton have more requirement of water but their ratio to savings from chemical expenses is much lower. Approximately 7 to 8 sprays of chemicals to control these lepidopteran insects are reduced. That's why Bt cotton spread and being adopted by most of the farmers even before its official approval by authorities related to biosafety.

Transgenic cotton and farmers health

In the last twenty years, the widespread and worldwide adoption of Bt cotton have gained much attention (Kouser et al., 2019). As this genetically modified cotton have gene from bacterium Bacillus thuringiensis to produce endotoxin which protect it from lepidopteran insect which can cause reduction in yield more than 80 %, hence not using such chemicals will be economical as well as eco-friendly. Pesticides have negative impact on beneficial insects and biodiversity, soil and water pollution and health issues to the labour and end-consumer which are both human as well as animals (Damalas and Eleftherohorinos, 2011, Gesesew et al., 2016, Hu et al., 2015). Pakistan being a developing country, have more negative health effects of chemical as here pesticide regulations are neither followed nor imposed vigorously by authorities. Symptoms of different diseases like Allergic, neurological, respiratory and gastro-intestinal may appear to the labour, spraying chemicals on cotton (Bourguet and Guillemaud, 2016, Lee et al., 2012).

Many studies have documented that those farmers using non Bt cotton have more incidence of acute and short-term pesticide poisoning than those using transgenic cotton (Kouser and Qaim, 2014, Abedullah et al., 2015). There is also drawback in these studies as it only includes numbers of incidence and not the severity of chemical. So, these studies don't tell us that weather these incidences were acute or chronic, there was need to consult a doctor, proper medication or only first-aid was sufficient. Researches used cost-of-illness approach for evaluation of the benefits of transgenic cotton adoption (Kouser et al., 2019). This study considered both direct and indirect losses due to incidence. Direct loss includes cost of medication, travelling and other expenses of treatment while on the other hand, opportunity of labour, and farmer's crop loss due to rest recommendation was included in indirect.

Studies also have conducted to checkout weather the bacterium gene could be dangerous or harmful to the end users. These endotoxins or proteins that are responsible for the toxicity and resistance against insect pests are not found to be incorporated into human and animals' body or having harmful effect on their bodies. No risk till now have been found in use fibre and oil of cotton by humans and in the seed cake, being used in animal feed. Transgenic cotton also has positive correlation with the environment. As significantly less use of chemicals is done

in Bt cotton, so there is low risk of polluting resources of soil and water, chemical contamination in the bodies of poor female labour picking the cotton and beneficial insects (Prabhakaran et al., 2023).

All these studies concluded that cost of illness, risk of exposure to chemical and number of incidences are significantly less in Bt cotton even the expression of Bt gene is low or moderate. Hence use of transgenic cotton should be promoted by government and other in-power authorities, but laws & rules should be imposed vigorously.

Genetic variability & heritability

As cotton is known as white gold in Pakistan, so gradual improvement in its varieties and germplasm is necessary. As genetic variability & heritability is the base of plant breeding so variability and heritability for its qualitative and quantitative characters is important for breeders (SAHAR et al., 2021). The reduction in quality and quantity is noticed in this crop due to loss oof genetic diversity in current germplasm (McCarty Jr et al., 2013). Several studies and experiments have been conducted to find out the genetic variability for different characters such as yield, fiber length, fiber strength, drought tolerance etc (Ali et al., 2017). During research there conducted an experiment to assess genetic variation and diversity for fiber quality and yield related traits in transgenic cotton and analyzed the association among them. Their analysis showed significant variation among all the characters under study, except height to node ratio and total number of nodes. The following traits had a high heritability: height, lint & seed index, number of monopodial branches, number of bolls per plant, and seed cotton output. Correlation analysis showed significant positive association of seed cotton yield with number of bolls, number of monopodial and sympodial branches, GOT, number of seeds per boll, plant height, seed index and uniformity index (SAHAR et al., 2021). Similarly, a two years study was conducted by Eldessouky and his team for genetic variability and association between oil and economic traits. It was conducted for evaluation of some genotypes for their oil contents and other parameters concerned with fiber yield. Genotypes under study showed high significant differences for different traits except boll weight. Experimental results showed positive correlations between seed index and embryo index, seed cotton yield and lint cotton yield, embryo index and embryo index oil%, seed Index and embryo index oil% and oil% and embryo index oil% (Eldessouky et al., 2021). Carvalho also observed genetic variability of cotton seed oil% in *Gossypium hirsutum* cultivars. So, from all above references and studies, we can definitely say that significant variability is present for almost all traits and improvement can be achieved through selections and crossing in transgenic cotton (Carvalho, 2017).

Genetically modified cotton and sustainability

Hereditary change of living beings and the idea of sustainability have drawn in much interest in the media and in the political field over the last 30 years (Morse and Mannion, 2008). The ability to alter the fundamental building blocks of life, such as the sequence of deoxyribonucleic acid

(DNA) genes, is a potent tool and, similar to all technologies, has expected weaknesses as well as benefits (Bell and Morse, 2012). In agriculture field, genetic engineering (or GM) can address crop issues like weed, infection and pest issues, as well as natural limits to the maximum efficiency of crops like soil salinity, waterlogging and dry season. This capacity to change the hereditary of plants so beneficial characters are shifted through the plants' own reproductive cycles appears to correspond with the idea of sustainability (Rigby and Cáceres, 2001). Bt cotton with artificial protection from the Heliothiscus infection, boltworm and bollworm was created by Monsanto, globally known agrochemical organization in the last part of the 1980s (Morse and Mannion, 2009). The mutated plants included a Bt trait that binds to the right receptor on the outer layer of the gut's epithelial cells to trigger the production of an endotoxin that is effective against pests. It appeared in all cells of the cotton plant, although it is especially significant in the leaves, as these give food to bollworms, and so forth. Midway through the 1990s, this Bt cotton underwent field trials in the US. With EPA approval, the development of Bollgard, the Bt cotton trademark, commenced in 1996 in the USA and in 1997 in China. Not long after Bollgard was supported by 13 different nations, including South Africa, it was acknowledged in India in 2002 following administrative examinations that started in 1995. These are the primary transgenic cotton creating nations today. Other business items have been developed, like Roundup Ready (herbicide safe) cotton, which has been economically accessible starting around 1997 and is cultivate exclusively in the USA. Bollgard II is a superior adaptation of the first Bollgard cotton; contains two qualities from B. thuringiensis that present protection from a more extensive resistance against pests, including Heliothis virescens, bollworms, and bollworms, in addition to bollworms and cotton leaf drills. It was supported in the US in 2002 and first planted in 2003. Hence, stacked GM varities of cotton were created. These are created with insect and herbicide resistance using Bollgard in addition to Roundup Ready and Bollgard II in addition to Roundup Ready Flex cotton (the latter option has further increased herbicide blockage).

There are the two up-sides and negatives to consider, and the period of GM crops is under 20 years of age, so extrapolating into what's to come is dangerous because of unusual factors. As frequently occurs in the utilization of the idea of sustainability develop, important to arrange and think twice about contrast altogether between partners (Morse and Bennett, 2008). In this way, a few partners are more able to acknowledge the expected dangers of Bt cotton, particularly if they are not prone to bear the results straightforwardly contrasted with others.

Prospects

The cultivation of cotton has reached the most outstanding bloom story over past few years. But here arises the question that how transgenic cotton is contributing in our production growth and whether it is satisfactory for us or not. So, now in present if we look for the prospects or benefits of transgenic cotton in future, we need immeasurable investigation and surveys related to different characteristics

of cotton production globally. Genomic alteration is well known for cotton breeding and considered as an authoritative tool for cotton production with a role in empowerment and betterment in current yield and related fabrics.

Bt cotton of transgenic cotton is considered as a miracle solution. That is why, its important to know that transgenic cotton will improve irrigation systems and also amplify the production quantity and quality.

Tohidfar, Mohammadi, and Ghareyazie have so far shown some degree of success in creating transgenic cotton that is more resistant to Verticillium wilt. Crude leaf extracts from transgenic cotton that expresses the chitinase gene have been shown to be able to suppress V. dahlia. *(Tohidfar et al., 2005)*. The creation of resistant GM cotton plants with strong resistance to Alternaria and Fusarium was another goal accomplished in this series of work.

Transgenic cotton has demonstrated efficacy in mitigating environmental fluctuations. It also focuses as an economically beneficial trait. In many countries' agricultural systems, cotton holds a significant place in the ecological realm due to its natural fiber source. Cotton having the fiber characteristics likes the quality, flexibility, durability, and strength which make it the most important and most feasible material for textile industry.

The results of our investigation shed insight on the last 20 years of success for cotton genetic engineering as well as likely future developments.

Conclusion

Cotton is the main fiber and cash crop in Pakistan. So, cost-benefit ratio for both, farmers and the government is the central point in its development or use. Alongside expanding its yield or the outputs, researchers need to attempt to decrease the consumptions or the inputs of cotton. Genetic modification is an incredible step towards better farming. Transgenic Cotton consolidating Cry1Ac protein is known as Bollgard-1 (BG-1) contains delta-endotoxins which was exceptionally good against lepidoptera insects. 1st age Bt cotton (BG-1) flopped in security as Cry1Ac was proficient against significant bug nuisance like American, Spotted and Pink bollworm however it was vulnerable to different bugs of order lepidoptera. So to tackle out this issue, second era Bt cotton or Bollgard-2 was presented which contained two *Bacillus thuringiensis genes* known as Cry1Ac + Cry2Ab. *Pectinophora gossypiella* (PBW), *Earias vitella* (Spotted bollworm), *Helicoverpa armigera* (ABW) are the critical bugs of lepidoptera request, can cause yield also upto 80%. With the introduction of transgenic cotton, the consumption on cotton development has been diminished enormously, that expense of disease, hazard of openness to substance and number of occurrences are altogether less in Bt cotton even the declaration of Bt quality is low or moderate. As no harmful effects of its consumption by animals as well as human are narrated by any study or experiment so rumors about its negative effects are just useless. Moreover, due to less use of chemicals, it is beneficial for environment. Variability is available for practically all traits and improvement can be accomplished through selection and

crossing in it. Consequently, utilization of transgenic cotton ought to be advanced by government and other in-power specialists however regulations and rules ought to be forced overwhelmingly.

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