growth and poor translocation of photosynthates are some of the physiological limitations for improving a plant's ability to produce more fiber. Floral bracts being close to the boll could provide more photo-assimilates for boll growth, but their rate of photosynthesis is very low. Balanced nutrition for the plant is important; the higher photorespiration rate in cotton causes consumption of much higher amounts of nitrogen than is actually needed. Solutions lie in minimizing nutrient deficiencies, triggering optimum use of available nutrients in the soil, enhancing the photosynthesis rate for improving leaf growth and extending the longevity of leaves. According to Dr. Barragan, challenges are complex due to intricate genetic controls and even some time-negative correlations among the desired features. Results can be expedited through national and international collaboration.

By the end of the 21st century, climate change is projected to increase temperatures, change rainfall patterns and increase drought. Dr. Derrick Oosterhuis of the University of Arkansas, USA, presented a paper on Global Warming and Cotton Productivity. Global warming will alter production management practices and geographical regions of suitability for cotton and other crops. Research has shown that higher levels of CO_2 are associated with increased photosynthesis, reduced stomatal conductance and increased water use efficiency. Cotton yields have shown positive responses to higher levels of CO_2 due to a higher photosynthetic rate. But, because cotton exhibits lower stomatal conductance, extreme weather like flooding or drought and a rise in average temperatures, will make cotton vulnerable to net losses in yields. High temperatures affect all stages of plant growth, and cotton is most sensitive during the reproductive stage when pollination and fertilization are occurring.

Dr. Dean Ethridge, a member of the Executive Committee of the International Cotton Researchers Association (ICRA) presented a report on the activities and programs of the Association. ICRA has been incorporated, an Executive Committee has been constituted, bylaws have been formed and a web page has been developed. The ICRA has applied for tax-exempt status with the US Government. The ICRA is functional and currently focused on web improvement and development of a strategic work plan. The mission of ICRA is to strengthen facilitation among cotton researchers and to serve as an international voice on cotton research.

Mr. Luiz Renato Zapparoli, President, Cotton Growers Association of the State of Goiás, Brazil, briefed the Committee on Cotton Production Research of the ICAC on preparations for the World Cotton Research Conference-6 (WCRC-6). The Conference will be held in the city of Goiânia, State of Goiás, Brazil, from June 20-24, 2016. The WCRC-6 will be a joint initiative of the Brazilian cotton research institutions, and the Conference will be held under the auspices of the International Cotton Researchers Association (ICRA).

The Committee on Cotton Production Research of the ICAC decided to hold the 2014 Technical Seminar on the topic of 'Enhancing the Mechanism of Input Interaction in Cotton Production.'

Round Table for Biotechnology in Cotton Executive Summary of the Report

Keith Menchey
Chairman of the Round Table for Biotechnology in Cotton, National Cotton Council of America, USA

The adoption of biotech crops continues to spread to more countries. Fifteen countries -- Argentina, Australia, Brazil, Burkina Faso, China, Colombia, Costa Rica, India, Mexico, Myanmar, Pakistan, Paraguay, South Africa, Sudan and USA – planted biotech cotton in 2012/13. Following South Africa and Burkina Faso, Sudan is the third African country to commercialize biotech cotton. Other countries in Africa have conducted trials and are close to commercializing biotech cotton.

From the 1960's to the 1990's, Australia relied almost exclusively on applications of insecticides, generally of limited modes of action. This limited range of chemistries inevitably led to pesticide resistance in key pests. Weeds were controlled through pre- and post-planting use of residual herbicides. Heavy reliance on chemical control by the cotton industry resulted in negative public perceptions, and Australia was in serious need of a technology that could reduce reliance on chemicals. Consequently, the Australian cotton industry moved to integrated pest management (IPM) techniques, and was one of the first adopters of biotech cotton in conjunction with IPM systems. Most varieties in Australia today contain the Bollgard II® and Roundup Ready

Flex® traits together, and a smaller percentage of Liberty Link® cotton stacked with Bollgard II® is also planted. Australia implemented a strict biosafety regulatory system that has evolved over the years with risk to public health and environmental safety as its core principles. The regulatory system also strongly supports preemptive resistance management strategies.

The success story of biotech cotton in various countries is similar – increased yields, reduced pesticide use, less tillage, increased worker safety - but critics continue to raise issues that cannot be proven scientifically. The crystal (Cry) toxins of Bacillus thuringiensis that were deployed in biotech cotton are safe for human consumption. The human stomach is acidic and contains proteases like pepsin, which degrade the Bt protein quickly. More importantly, the human intestine lacks the specific receptors to which the activated Bt proteins bind and initiate physiological effects.

Egypt has commercialized only biotech maize. However, biosafety regulations are in place in Egypt to commercialize biotech cotton and other crops. The Egyptian biosafety system includes legal authorities delegated to various agencies, assurances that the use of biotechnology products are safe, systematic reviews of biotechnology products, and a mechanism for public feedback. It is critical that an effective biosafety system includes mechanisms through which new information and accumulated experience can be incorporated into ongoing programs. It is important to encourage science-based decisions rather than politically motivated campaigns. Reinvesting in biotech research has an important bearing on moving biotech crops forward. Public awareness campaigns should explain economic and environmental benefits as well as the technical aspects throughout the chain of commerce including regulation, production, and trade.

The U.S. government decided against labeling food derived from biotech crops years ago as these products did not demonstrate safety concerns for humans or animals. The government has long held the policy that biotech food products are not «materially different» from conventional food products and, therefore, need no labeling. A number of surveys undertaken in the USA have shown that public opinion is in support of labeling biotech products if asked if they have a right to know about the food products that they buy. However, in other surveys with open-ended questions such as "what are your food safety concerns?" U.S. consumers consistently list biotechnology as a low priority. Opponents of labeling believe it would undermine both the labeling laws and consumer confidence. The European Union began requiring labeling for biotech foods in 1997 in response to consumers' concerns. Other countries including Russia, Japan, Australia, New Zealand, Turkey and China have also mandated labeling. In Australia, biotech foods and ingredients which contain novel DNA or protein that has come from an approved biotech food must be labeled with the words 'genetically modified'. However, foods that do not need to be labeled include highly refined foods, such as sugars and oils, where the process has removed DNA and protein from the food. In addition, labeling is not required where there is no more than 1% (per ingredient) of an approved biotech food unintentionally present in a non-biotech food. Labeling is not required in Canada.

Biosafety laws mainly focus, including the EU, on food and feed. Biotech cotton fiber is not included in Europe's biosafety regulations although cotton seed, meal, and oil are subject. While about one-third of world cotton fiber production is exported every year, only a small quantity of cotton by-products (seed, meal and oil) are exported. In terms of cotton fiber, Turkey's new Biosafety Law that became effective in September 2010, depending on its interpretation, could include fiber produced from biotech varieties. This law is probably the strictest among countries with biosafety regulations in place.

At the international level, Biosafety (Cartagena) Protocol, Codex Alimentarius, Food & Agriculture Organization of the United Nations, International Plant Protection Convention, Organization for Economic Cooperation & Development and World Health Organization have or claim a role in regulation of agricultural biotechnology and standard setting. Of these, the Cartagena or Biosafety Protocol (BSP) is most specifically focused on biotech crops and bears directly on the trade of biotech commodities. Adverse environmental impacts and risks to human health are the two most important clauses of the Cartagena or Biosafety Protocol.

Public perception of biotechnology is one of the critical issues in the further development, adoption, and free trade of biotech products. Public perception has resulted in a variety of regulatory restrictions among producing and consuming countries of biotech products. Anti-biotech groups have played a big role in stimulating public debate that is often times not based on science but on philosophical theories and fear. Apprehensions about the technology and stringent import restrictions in the EU are founded on the precautionary principle. In July 2010, the European Commission granted member states the authority to allow, restrict, or ban the cultivation of biotech crops on part or all of their territory. Consequently, a number of EU countries are planting biotech maize.

Given that importing countries have the right to ban any biotech product, technology developers play a crucial role in minimizing trade disruptions. Technology providers can make certain that legal approvals are completed in countries that are major and important markets for a biotech crop prior to commercialization. Governments can assist in this regard by diminishing the time between national and international approvals. With so many countries producing biotech crops and so many products and by-products coming out of biotech agricultural commodities, it seems unfeasible for importing countries to set a zero tolerance policy. Whatever the importing countries' policies are, they should be clear, and the industry must be aware of any such restrictions.

Experience with biotech cotton in Brazil, Colombia, Pakistan and South Africa has concluded that success of a biotech product could be hampered by local constrains and limitations. Although lepidopterans are very important in South and Central America, boll weevil is still the key pest in most of the countries in these regions, and the Cry insecticidal proteins present in biotech cotton do not affect the boll weevil or other sucking pests. The benefits of biotechnology in cotton observed in Africa, Asia, and the USA will only be achieved in Brazil and Colombia if boll weevil resistance is incorporated. The development of a boll weevil resistance trait is ongoing in public research institutes of Brazil and Argentina. In 2012/2013, *Helicoverpa ar*migera that caused damage in some cotton regions was detected for the first time in Brazil. When this pest results in yield reduction and environmental costs due to higher use of insecticides, the area with biotech cotton will probably increase in Brazil. In Pakistan, the Cotton Leaf Curl Virus (CLCuV) has curtailed the adoption of biotech cotton. Resistance to the virus disease is a more serious problem than controlling lepidopterans. Farmers need CLCuV tolerant varieties, and only the eradication of this disease could ensure that farmers would benefit from the plant's inbuilt resistance to bollworms. In South Africa, low yielding cotton producers have not made use of biotechnology in cotton due to higher prices for competing crops.

All biotech cotton producing countries have reported some unintended consequences. The most common problem is the development of secondary pests. As pesticide applications for lepidopteran species declines, secondary pests, which had previously been inadvertently controlled by these applications, have increased in numbers to become primary pests. A resurgence of mirid bugs, and other minor pests, was reported in India and China. Colombia reported that the incidence and severity of diseases, particularly ramularia (Ramularia areola), anthracnose (Colletotrichum gossypii) and boll rot (disease complex), is higher in biotech cotton than in conventional cotton varieties. A rise in the incidence of diseases could be related to changes in the plant canopy and fruit allocation on the plant in a biotech cotton variety compared to a parental conventional variety.

Most of the reports provided to the Round Table on Biotechnology in Cotton from countries expressed concerns over the development of resistance by target pests. Resistance is likely if appropriate measures are not taken to delay and avoid resistance to a specific toxin. However, refuge requirements as a resistance management tool are being relaxed or ignored in some countries. It is imperative that pest populations be monitored for early detection of increased tolerance to the Bt toxin and to permit the implementation of mitigation measures early enough to prevent the actual development of resistance. In this regard, it is also important to monitor the level of toxin expression at various stages of growth and in different plant parts. Sub-standard expression of Bt toxin in biotech varieties only accelerates the resistance development process. In Pakistan, breeders and biotechnologists have been urged to improve the Bt toxin level of their varieties to an effective dosage level. Gene stacks for a particular trait, but of unrelated modes of action, provide an excellent option for resistance management, apart from enhancing the trait efficacy. However gene stacking can add to increased seed costs.

Private companies charge a fee for the technology in biotech cotton. Most countries reported concerns about the cost of biotech seed, which is considerably more expensive than that of non-biotech conventional planting seed. Farmers have often expressed their opposition to the high cost of technology in cotton and, in some countries, measures were taken to lower the cost of planting seed. The cost of biotech cotton seed has been prohibitive in rainfed production areas in South Africa where yields are lower. Technology fees for the same event may differ among different countries and even in different regions of the same country. However, according to the owners of the events, the value is proportional to the benefits provided to farmers.

Biotechnology applications in agriculture provide tools to modify plants precisely with desired traits. Cotton farmers around the globe anticipate commercial availability of a range of new biotech traits in the near future. It is important to develop biotech cottons to assist in the prevention of the distribution of phytosanitary problems such as Fusarium and Verticillium wilt as well as important regional pests and diseases, especially the boll weevil in Latin America and Cotton Leaf Curl Virus in Pakistan and India. There is a need to strengthen the technology with additional genes through gene stacking to ensure long-term sustainability of various events. There are several sources other than Bacillus thuringiensis that have been used to isolate insecticidal genes.

Genes from endo-symbiotic bacteria of nematodes, Xenorhabdus and Photorhabdus have been actively considered for the development of transgenic crops. Amongst animal sources, anti-chymotrypsin, anti-elastase, chitinase, cholesterol oxidase, and anti-trypsin have been isolated from the tobacco hornworm and used to develop biotech cotton resistant to sucking pests and lepidopteran insects. Trypsin inhibitors and spleen inhibitors isolated from cattle, protease inhibitors from plants (soybean, barley, cowpea, squash, mustard, rice, potato, tomato), amylase inhibitor genes from beans and cereals and lectins from plant sources have been used to develop biotech crops resistant to insect pests. Other gene sources include chitinases, glucanases, peroxidase, and tryptophan decarboxylase from various plant sources may also be useful transgenes to develop insect and disease resistant cotton. Replicase genes and coat protein genes have been used to develop leaf curl virus resistant varieties through over-expression of the proteins or silencing of the genes through RNAi, especially for countries in Africa, India, and Pakistan. The technology carries huge potential. It is not only inserting foreign or intra species genes, specific targets can also be achieved by gene silencing through RNA interference.

A lot of work is also going on to deal with abiotic stresses that the cotton plant faces in the field. Drought tolerant cotton is among many new avenues being extensively researched and some of the new traits are close to commercialization. Many drought related genes have been cloned and characterized in recent times. A number of potential genes have been shortlisted for fiber quality improvement, including a gene from spinach, a spider silk gene, and a gene from the silk worm. Good progress has already been made to develop ultra low gossypol cotton thus increasing the nutritional value of cotton seed. Molecular marker assisted breeding will of course bring precision and certainty to cotton breeding.

Full report of the Round Table for Biotechnology in Cotton is available at:

https://www.icac.org/getattachment/mtgs/Plenary/72nd-Plenary/Presentations/os5_e_biotech_round_table_report.pdf