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Disruptive Innovations in Transformation of World Agriculture and Cotton Scenario: - Biotech Crops (Part 2)

GUEST COLUMN

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Agricultural systems science, as we know it today, has evolved over the last 50 or more years with contributions from a wide range of disciplines. Generally during this same time period, appreciation for and acceptance of agricultural systems science has increased, as more scientists, engineers and economics graduates from universities are engaged in training in systems modeling, analytical approaches and information technology (IT) tools. Over this time period, there has also been a corresponding increase in demands for agricultural systems science to address questions faced by society that transcend agriculture.

The relevant basic question today is that how to better manage the systems for higher and more efficient production. Also, what changes are needed in the farming system for higher profitability, without harming the environment and what policies are needed to help farming systems evolve to meet broader societal goals. Still more critical questions are, what systems are needed to adapt to the continual changes that agriculture faces, including climate change, changes in demand for agricultural products, volatile energy prices and limitations of land, water and other natural resources. Agricultural systems models are being challenged to move beyond just including economic and sustainability issues

Meeting the food and fibre demands of a burgeoning population depends on increasing the output of crops and the efficient and environmentally responsible use of resources such as land and water. This is where role of disruptive innovations starts because of the following reasons:-

- Farmers need help to develop climate-smart agricultural practices that not only can adapt to and mitigate the impacts of climate change, but also have the potential to increase food production.
- Natural resources, such as land, water, soil and genetic resources, must be better managed so that more productive and resilient agriculture can be achieved.
- Conservation agriculture, which can yield many positive benefits: reduced soil erosion; better soil water retention and nutrient availability for crops; increased soil organic matter accumulation; and higher crop productivity.

Disruptive Technologies identified and being used in different parts of the world to foster world agriculture with special reference to cotton have been illustrated below:-

A. Innovations in Gene Technology -Biotechnology

- By the mid-1980s, insects had begun building up resistance to the insecticides that were currently available. At the same time, many researchers had begun to understand the environmental impact of those pest deterrents. A new type of insecticide was needed; one that would protect crops without damaging the environment. As a natural protein, Bt was a promising option that targeted specific pests, but its traditional application presented challenges to its efficacy.
- "Cotton Incorporated" sponsored research at notable research institutions such as Texas A & M. Scientists found that through molecular biology, they were able to move the gene that encodes the Bt crystal directly into a plant. Bt cotton was introduced in 1996.
- Modern biotechnology is the science of altering the genetic makeup of living organisms to achieve production improvements such as increased quality and volume, and reduced environmental impact. As a tool for agriculture, biotechnology is a proven means to help in meeting the challenges of future generations. Biotechnology is being used successfully for more than 20 years.

B. Global Biotech Crop Highlights

Since 1996 when Bt cotton was introduced, other biotech crops like peas, maize and canola were also cultivated. More information about biotech crops at the global level is given below:-

a. Global Area of Biotech Crops, 1996 to 2017: By Crop (Million Hectares, Million Acres):-

In 2017, the 21st year of commercialisation of biotech crops, 189.8 million hectares of biotech crops were planted by up to 17 million farmers in 24 countries (Figure-1). From the initial planting of 1.7 million hectares in 1996 when the first biotech crop was commercialised, the 189.8 million hectares planted in 2017 indicates ~112-fold increase Thus, biotech crops are considered as the fastest adopted crop technology in the history of modern agriculture.

FIGURE 1. GLOBAL AREA OF BIOTECH CROPS, 1996 TO 2017 (MILLION HECTARES).
Source: ISAAA, 2017

b. Biotech Crops in Industrial and Developing Countries:-

For the past six years, developing countries have planted more biotech crops than the industrial countries (Figure 2). In 2017, 19 developing countries planted 53% (100.6 million hectares) of the global biotech hectares, while 5 industrial countries took the

FIGURE 2.
DISTRIBUTION OF BIOTECH CROPS IN DEVELOPING AND INDUSTRIAL COUNTRIES IN 2017
Source: ISAAA, 2017

47% (89.2 million hectares) share. This trend is expected to continue in the upcoming years due to the increasing number of countries in the southern hemisphere adopting biotech crops and the commercialisation of new biotech crops such as rice, which is mostly grown in developing countries.

c. Global Area under Biotech Crops, 1996 to 2017 (Year Wise)

Year wise area (hectares / acres) under biotech crops in 24 countries starting from1996 to 2017 (Table 1) shows a multi fold increase.

Year	Hectares (Million)	Acres (Million)
1996	1.7	4.3
1997	11	27.5
1998	27.8	69.5
1999	39.9	98.6
2000	44.2	109.2
2001	52.6	130
2002	58.7	145
2003	67.7	167.2
2004	81	200
2005	90	222
2006	102	250
2007	114.3	282
2008	125	308.8
2009	134	335
2010	148	365
2011	160	395
2012	170.3	420.8
2013	175.2	433.2
2014	181.5	448
2015	179.7	444
2016	185.1	457.4
2017	**189.8**	**469**

Source: ISAAA, 2017

d. Distribution of Biotech Crops (Country Wise)

Rank	Country	2016	2017
1	USA*	72.9	75
2	Brazil*	49.1	50.2
3	Argentina*	23.8	23.6
4	Canada*	11.6	13.1
5	India*	10.8	11.4
6	Paraguay*	3.6	3
7	Pakistan*	2.9	3
8	China*	2.8	2.8
9	South Africa*	2.7	2.7
10	Bolivia*	1.2	1.3
11	Uruguay*	1.3	1.1
12	Australia*	0.9	0.9
13	Philippines*	0.8	0.6
14	Myanmar*	0.3	0.3
15	Sudan*	0.1	0.2
16	Spain*	0.1	0.1
17	Mexico*	0.1	0.1
18	Colombia*	0.1	0.1
19	Vietnam	<0.1	<0.1
20	Honduras	<0.1	<0.1
21	Chile	<0.1	<0.1
22	Portugal	<0.1	<0.1
23	Bangladesh	<0.1	<0.1
24	Costa Rica	<0.1	<0.1
25	Slovakia	<0.1	0
26	Czech Republic	<0.1	0
TOTAL		185.1	190

***Rounded-off to the nearest hundred thousand. (Source: ISAAA, 2017).*

Of the 24 countries that planted biotech crops in 2016, 18 countries were considered as biotech mega-countries, which grew at least 50,000 hectares. USA remained as top producer of biotech crops globally, which planted 75 million hectares in 2017, covering 40% of the global biotech crop plantings. Brazil landed on the second spot, with 50.2 million hectares or 26% of the global output.

e. The Global Value of Biotech Crops
According to "Cropnosis Ltd", the global market value of biotech crops in 2017 was US$17.2 billion. This value indicates that there was a 9% increase in the global market value of biotech crops from 2016, which was US$15.8 billion. This value represents 23.9% of the US$70.9 billion global crop protection market in 2016, and 30% of the US$56.02 billion global commercial seed market. The estimated global farm gate revenues of the harvested commercial "end product" (the biotech grain and other harvested products) are more than ten times greater than the value of the biotech seed alone.

C. GLOBAL BIOTECH COTTON: HIGHLIGHTS

Genetically engineered cotton, like other crops, can also fight diseases and pests so as to produce enough quantities of lint for mills that will ultimately meet the fibre requirements of the growing population in the world. In genetically modified (GM) cotton, a bacteria is transferred, which naturally produces a crystal protein toxic to many pest insects, but allows farmers to use fewer and in some instances, no pesticides.

a. Introduction of Biotech Cotton:- Cotton Incorporated identified Bt, a bacterium formally known as Bacillus thuringiensis, which had been used as a topical pesticide by organic cotton growers since 1920, primarily to kill flour moths. As a liquid spray, the product was not widely used because it was easily and negatively affected by the weather; rain rapidly washed it away and the sun de-generated its beneficial properties. Farmers instead turned to synthetic pesticides, which were prevalent and effective.

Prior to commercialisation, the United States Environmental Protection Agency (USEPA), United State Department of Agriculture (USDA) and the Food and Drug Administration (FDA) subjected Bt cotton, like every other biotech product, to a rigorous regulatory evaluation. Comprehensive environmental and human safety studies were conducted, ruling out the possibility of harm to existing plants, non-target organisms, and humans.

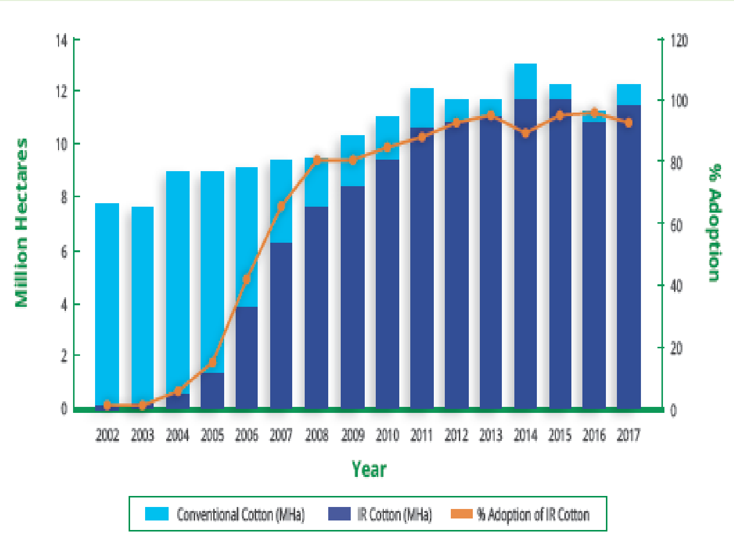
b. Success Stories of Biotech Cotton:-
There are many well-documented examples of biotechnological success.

- The eradication of the boll worm in the U.S.
- Research by Cotton Incorporated, in conjunction with the USDA and cotton growers across the country, reduced the threat posed by tobacco budworms, cotton bollworms and pink bollworms and costly infestations through the introduction of biotech cotton varieties that were better able to defend against the boll weevil.
- From 1996 to 2007, 23% less insecticide active ingredient was used in Bt-adopting countries,
- Environmental Impact from reduced insecticide use has fallen by 28% as measured by Environmental Impact Quotient (EIQ).
- Since the introduction of Bt cotton, the number of insecticide applications in the U.S. has been reduced by half.
- Not only has Bt cotton improved lint yield, but it has also decreased costs for insecticide supplies, equipment and labour and lowered the quantity of chemicals that enter the environment.

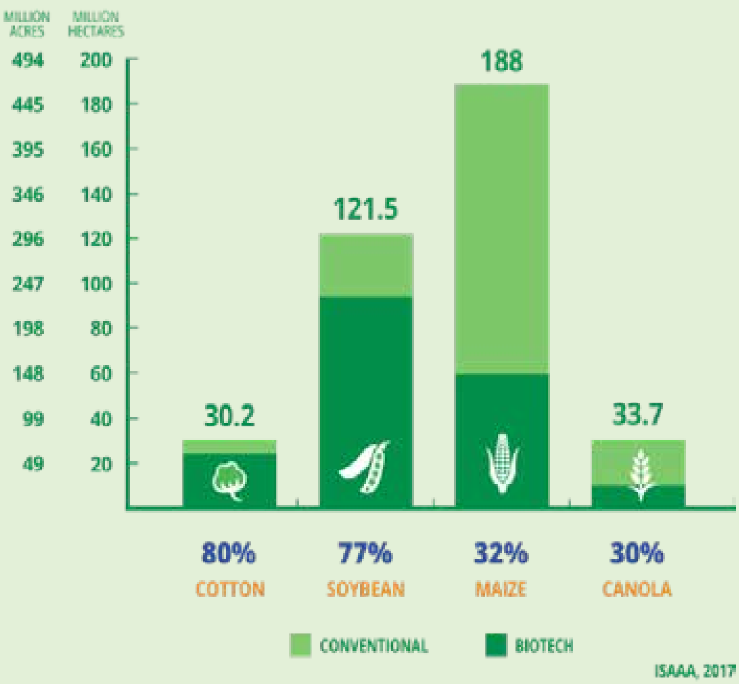
The benefits of Bt cotton are recognised around the world by cotton growers, who have seen their income increase significantly, by up to US$ 250 per hectare. Moving forward, the industry seeks to leverage biotechnology to develop plants that are resistant to an even wider variety of insect pests

c. Global Adoption of Biotech Cotton (Million Hectares, Million Acres):-
As per reports available, global area under biotech cotton has been adopted beyond 95%.

A graphic view of global adoption of biotech cotton from 2002 to 2017 has been presented below:-



The graphic presentation given below indicates that during a period of more than 20 years, starting from 1996 to 2017 global adoption of biotech cotton was highest (80%) among top four biotech crops viz. soybean, maize, peas and cotton.



D. Indian Biotech Cotton: Highlights

1. Gene Revolution in India

- Yields increased from 186 kg/ha in 2001-02 to 532kg/ha in 2013-14 which has come down in subsequent years due to various reasons,
- Gm cotton made India the largest producer and 2nd largest exporter of cotton,
- Ninety five per cent of cotton acreage (111m ha) under Bt cotton and
- Pesticides use declined by >50 per cent.

2. Commercial Biotech Cotton Traits

Various commercial biotic cotton traits:- rDNA Technology, Insect Resistant Trait, Single gene, Multiple Genes, Herbicide Tolerant Trait, CP4EPSPS/Bar gene (HT), Stacked IR/HT Trait, Single gene/HT and gene(s)/HT.

3. Biotech Cotton Under R&D in India, 2016

➢ Various Private and Public Sectors engaged:- MMB, Dow Agro Sciences, Bayer Crop Sciences, JK Agri Genetics, Monsanto, Mahyco, Nuziveedu. Rasi, CICR, DU, TNAU, NRCPB, NBRI etc.

➢ Technologies being used in India:- RRF, BG-IIRRF & IIIRRF, Wide Strike, Twin Link/ Glytol, etc.

E. Future Prospects Of Biotech Crops

The continuous growth in the adoption of biotech crops is attributed to the technology's positive impact on the environment, human and animal health, as well as on the improvement of socio-economic conditions of farmers and the general public. However, critics continue to spread non-scientific allegations about biotech crops that affect regulations and approvals. Studies have confirmed that delays in biotech crop approvals have led to immense economic losses and opportunity costs.

The benefits of biotech crops to farmers and consumers will only continue to be available if there is continuous implementation of science-based regulations, which focus on the benefits such as agricultural productivity with consideration to environmental conservation and sustainability, and most importantly to the large portion of the world population undergoing poverty and malnutrition, who are waiting for improvement in their state of living.

(The views expressed in this column are of the author and not that of Cotton Association of India)

Update on Cotton Acreage
(As on 22.08.2019)

(Area in Lakh Ha)

Sr. No.	State	Normal Area (DES)*	Normal Area as on Date (2014-2018)	Area Covered (SDA)					
				2019-20	2018-19	2017-18	2016-17	2015-16	2014-15
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Andhra Pradesh	6.56	5.002	5.450	4.730	5.320	3.778	4.890	6.291
2	Telangana	17.00	16.183	17.616	17.606	18.240	12.500	16.330	16.240
3	Gujarat	26.04	26.850	26.287	26.908	26.580	23.654	27.300	29.810
4	Haryana	6.06	6.078	7.010	6.650	6.560	4.980	5.810	6.390
5	Karnataka	6.47	5.056	4.947	3.840	4.500	4.640	4.840	7.460
6	Madhya Pradesh	5.65	6.012	6.100	6.880	5.990	5.990	5.470	5.730
7	Maharashtra	41.48	39.927	43.636	40.623	41.700	39.000	38.020	40.292
8	Odisha	1.31	1.376	1.695	1.578	1.450	1.360	1.250	1.240
9	Punjab	3.56	3.630	4.020	2.840	3.850	2.560	4.400	4.500
10	Rajasthan	4.76	4.412	6.445	4.961	5.031	3.847	4.060	4.162
11	Tamil Nadu	1.61	0.091	0.065	0.058	0.167	0.056	0.103	0.070
12	Others	0.43	0.230	0.271	0.172	0.286	0.170	0.210	0.310
	All India	**120.930**	**114.847**	**123.542**	**116.846**	**119.674**	**102.535**	**112.683**	**122.495**

** Directorate of Economics & Statistics, Ministry of Agriculture and Farmers Welfare, Krishi Bhavan, New Delhi*
Source : Directorate of Cotton Development, Nagpur

UPCOUNTRY SPOT RATES

(Rs./Qtl)

Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)]								Spot Rate (Upcountry) 2018-19 Crop August 2019					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	19th	20th	21st	22nd	23rd	24th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	11473 (40800)	11473 (40800)	11473 (40800)	11473 (40800)	11473 (40800)	
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	11614 (41300)	11614 (41300)	11614 (41300)	11614 (41300)	11614 (41300)	H
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	9308 (33100)	9308 (33100)	9308 (33100)	9308 (33100)	9308 (33100)	
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	10742 (38200)	10742 (38200)	10742 (38200)	10742 (38200)	10742 (38200)	O
5	M/M (P)	ICS-104	Fine	24mm	4.0 – 5.5	4%	23	11304 (40200)	11304 (40200)	11304 (40200)	11304 (40200)	11304 (40200)	
6	P/H/R (SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	12092 (43000)	12120 (43100)	12120 (43100)	12148 (43200)	12092 (43000)	
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	11220 (39900)	11220 (39900)	11220 (39900)	11220 (39900)	11220 (39900)	L
8	P/H/R	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	12176 (43300)	12204 (43400)	12204 (43400)	12232 (43500)	12176 (43300)	
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	26	11360 (40400)	11360 (40400)	11360 (40400)	11360 (40400)	11332 (40300)	I
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	11642 (41400)	11642 (41400)	11642 (41400)	11642 (41400)	11614 (41300)	
11	P/H/R	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	12260 (43600)	12288 (43700)	12288 (43700)	12317 (43800)	12260 (43600)	
12	M/M(P)/ SA/TL	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	11782 (41900)	11782 (41900)	11782 (41900)	11782 (41900)	11754 (41800)	D
13	GUJ	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	11810 (42000)	11810 (42000)	11810 (42000)	11810 (42000)	11782 (41900)	
14	M/M(P)/ SA/TL/K	ICS-105	Fine	29mm	3.5 – 4.9	3.5%	28	12092 (43000)	12092 (43000)	12092 (43000)	12092 (43000)	12063 (42900)	A
15	GUJ	ICS-105	Fine	29mm	3.5 – 4.9	3.5%	28	12035 (42800)	12035 (42800)	12035 (42800)	12035 (42800)	12007 (42700)	
16	M/M(P)/SA/ TL/K/O	ICS-105	Fine	30mm	3.5 – 4.9	3%	29	12317 (43800)	12317 (43800)	12317 (43800)	12317 (43800)	12288 (43700)	
17	M/M(P)/SA/ TL/K /TN/O	ICS-105	Fine	31mm	3.5 – 4.9	3%	30	12654 (45000)	12654 (45000)	12654 (45000)	12654 (45000)	12626 (44900)	Y
18	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.9	3%	31	12963 (46100)	12963 (46100)	12963 (46100)	12963 (46100)	12935 (46000)	
19	M/M(P)/ K/TN	ICS-107	Fine	34mm	3.0 - 3.8	3.5%	33	15213 (54100)	15213 (54100)	15213 (54100)	15213 (54100)	15157 (53900)	

(Note: Figures in bracket indicate prices in Rs./Candy)