NOVEL TECHNOLOGIES FOR COTTON, Today and tomorrow

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WHY COTTON IS IMPORTANT?

- There are nearly 7 million cotton farmers, mostly small.
- Cotton & textile account for 1/3 of total foreign exchange.
- Cotton provides employment to 43 m people, 7 million farmers + 36 million employed in textile industry.
- There are > 1.8 M registered looms, 1600 spinning units and 290 composite mills.
- Cotton, therefore has livelihood security attach to it.
Uniqueness of King Cotton

- India - four species of cotton
- Cotton - 9 to 12 million hectares
- India - inter-specific diploid hybrids & intra-specific tetraploid hybrids
- Average cotton holding < 1.5 ha; 8-8.5 million cotton farmers

- Diverse cropping practices including hand dibbling to drip-based-precision-planting to technology-intensive-inter-cropping system

- A robust cotton value chain providing employment to roughly 50 million people
Value-addition to Cotton Plant By-produce

By-produce of Cotton

- **Cotton Seed**
  - 125 lakh tonnes per annum
- **Cotton Plant Stalks**
  - 30 million tonnes per annum

By-products of Cotton seed

- **Cotton Linters**
  - 5 lakh tonnes/annum
- **Cotton seed Hulls**
  - 34 lakh tonnes/annum
- **Cotton Seed oil**
  - 15 lakh tonnes/annum
- **Meal**
  - 4.4 million tonnes/annum
Value addition to Cotton Stalk

- Particle Boards
- Pulps & papers
- Corrugated boxes
- Briquettes as fuel
- Bio-enriched compost
- Growing Mushrooms

Particle Boards from Cotton Stalks
Pulps & papers
Corrugated boxes
Briquettes as fuel
Bio-enriched compost from cotton stalks
Growing Mushrooms
Advantages

• Additional income to farmers

• Rural Employment

• Avenues for Rural Industry

• New Raw Materials for industry

• Conservation of Natural Resources
Rich experience of growing cotton

Productivity then was less than 60 kg lint per ha

But processing technology fairly advanced

Cotton trade to Britain began in 1640 through Calicut and hence the name Calico

India was the largest exporter of textiles

Desi cottons, *G. arboreum* and *G. herbaceum* were largely grown by the farmers

Opportunities to be harnessed industry
COTTON: Post 1947

- Desi cottons were slowly but steadily replaced by American cotton, G hirsutum.
- Quality improvement was given impetus with yield in new cottons.
- Egyptian cotton, G.barbadense was also brought but due to high susceptibility not spread in to main cotton growing areas.
- Research was concentrated on the hirsutum cotton as it brought new problems like bollworms into prominence.
- The fight against bollworm ended with plethora of insecticide in to cotton cultivation.
- Opportunities to be harnessed industry.
## Technology Change in Cotton Growth

<table>
<thead>
<tr>
<th>Period of change</th>
<th>Technology change</th>
<th>Production change (m bales)</th>
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</thead>
<tbody>
<tr>
<td>1952 – 1962</td>
<td>Arboreums to hirsutams</td>
<td>6.80 (+2.61)</td>
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<td>1962 – 1972</td>
<td>Hirsutam quality improvement</td>
<td>7.23 (+0.43)</td>
</tr>
<tr>
<td>1972 – 1982</td>
<td>Hybrids adoption (Inter and Infra-species)</td>
<td>9.90 (+2.67)</td>
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<td>1982 – 1992</td>
<td>Pyrethroid Protection</td>
<td>14.00 (+4.10)</td>
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<td>1992 – 2002</td>
<td>Technology fatigue (Bollworm resistance to Pyrethroid, sucking pest epidemic)</td>
<td>13.60 (-0.40)</td>
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<tr>
<td>2002 – 2012</td>
<td>Bt cotton era, hybrid expansion, Newer insecticides and IRM</td>
<td>32.00 (+18.19)</td>
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*In 1952, the production was 4.15 m bales with productivity of 105 kg lint / ha as against the production of 31.5 m bales with productivity of +500 kg lint / ha*
PHASES OF YIELD STAGNATION IN INDIAN COTTON

- Introduction of improved germplasm
- Introduction of *G. hirsutum* hybrids & pyrethroids
- Introduction of single gene and multiple genes Bt technology cotton hybrids

Source: Analyzed by SABC, 2017
PHASES OF YIELD STAGNATION IN INDIAN COTTON

- **Yield levels**
  - (kg lint /ha)
  - 88-110
  - 125-140
  - 150-180
  - 180-220
  - 250-320
  - 450-570

- **Period of stagnation**
  - when range limited
  - 1951-60
  - 1961-70
  - 1971-80
  - 1981-90
  - 1991-03
  - 2011 onwards
How to break the stagnation scene

- Yield stagnation broken by many countries from 600 kg /ha to 2600 kg (Australia), 1600 kg (Brazil), 1500 kg (China, Mexico and Turkey).

- This was achieved by using Biotech mode, Water, micro-irrigation use, Mechanization, IPM, INM and use of technologies.

- Can India regulate the ever-expanding number of hybrids in eco-based cultivation?
The yield of cotton was stagnant for 15 years from 1989 till 2003. The barrier of stagnation was removed by adopting the BT cotton in 2002, the first and only biotech product. And it changed the Indian cotton scenario.
Why Biotech Cotton?

• Bollworm developed resistance to pyrethroids
• Cotton became highly susceptible to Lepidopteran pests
• Frequent occurrence of the outbreak of Helicoverpa armigera resulting in crop losses up to 80%
• Cotton consumed 46% of total insecticides valued at US$504 million in 2001
• Farmers suffered losses- annual yield as low as 300 kg/ha, and often <154 kg/ha in rain-fed areas
• Indiscriminate usages of chemical insecticides
• Increasing import of raw cotton to meet textile need

Source: ISAAA, 2016; ISCI 2013; Kranthi, 2012; Manjunath 2011; Mayee, 2013
Adoption of Biotech Cotton, 2002-2016

Source: ISAAA, 2016
Adoption of Biotech Cotton by Farmers in India and USA, 1996 to 2015

Source: SABC, 2016
Cotton Transformation Cotton Hectarage and Production in India, 2002 to 2015

Source: CAB, 2015; ISAAA, 2016
Cotton Transformation Growth of Long Staple Cotton in India, 2002 to 2012

Source: Cotton Advisory Board (CAB), 2013; Cotton Corporation of India, 2013
Cotton Transformation Export and Import of Cotton in India, 2002 to 2016

Source: Cotton Advisory Board (CAB), 2017; Cotton Corporation of India, 2017; Analyzed by SABC, 2017
Cotton Transformation: Distribution of World Cotton Market Share by Top Five Countries, 2002 & 2016

Source: ICAC, 2016; USDA, 2016
FUTURE HOPE: Genomics and Biotechnology

- Cultivars suitable for HDPS
- Cultivars suitable for mechanical picking
- Salt and drought resistant varieties /hybrids
- Gene mining for quality fibre specially strength
- Indian cotton can make edge through this
PRECISION FARMING

- Water management is key issue both in rain fed and irrigated system.
- Micro-irrigation use essential in dry land area covering 60% area.
- Drainage improvements in irrigated area and controlled irrigation.
- Use of fertigation technology with INM.
- Careful use of growth promoting chemicals during growth.
- Improvement of organic carbon content.
PRECISION PLANT PROTECTION

- IPM SYSTEM FOR REDUCING THE PESTICIDE USE. IT HAS TO BE BASED ON THRESHOLDS, CONSTANT MONITORING, USE OF PHORMONE TRAPS, SANITATION FOREWARNINGS AND NON CHEMICAL PESTICIDE USE AS FAR AS POSSIBLE
- SHORT DURATION CULTIVARS IN RAIN FED AREAS
- CRITICAL TIME OF SOWINGS FOR CONTROL OF PESTS AND DISEASES
A 3-row, self propelled check row planter with pneumatic metering. Cost saving over traditional was 75% due to proper placement of seed. Actual field capacity was 0.51 ha/h with 88% field efficiency. Cost of operation was Rs. 215/ha remarkable less than any other traditional method.

Self propelled Check row planter (CICR & DrPDKV)

Bullock drawn precision planter with an innovative vertical rotor metering mechanism.

Reduced seed damage and uniform seed placement.
Germination percentage: 98% Seed rate: 4.2 kg/ha.
The field capacity of the implement is 4.5 ha.

Solar Knap Sack Sprayer

Patent F.No 1559/Mum/09
Rs 8000. 15-18° tilt. Light weight and works non-stop.
Cotton Picking is Highly Labour Intensive and expensive

Scarcity of Labour is making it increasingly difficult for farmers to rely on manual picking of cotton

With the advent of Cotton high density planting system there will be an increased need for mechanization of cotton picking
Hybrids - More bolls per plant

4 g boll x 100 bolls per plant x 10,000 plants/ha = 40Q/ha
Ideal Plant Type for Mechanical Picking

- Ideal Plant type for Mechanical Picking
  - Height: 105-135 cm
  - Monopodia: 0-1
  - Sympodial length: 20-25 cm
  - Plant growth habit: Erect
  - Boll bearing and Bursting: Synchronous
Experience with High Density Planting

**Early sowing**
The crop escapes bollworms & moisture stress
Overcomes Flooding

Coragen & Fame control bollworms effectively

Less weed infestation – less cost of weeding
Less crop foliage - less nutrients needed
Early & single picking – less labour needed

Less labour cost on sowing, weeding and picking

Low production cost Rs 15,000/ha
The alarm pheromone for many species of aphids, which causes dispersion in response to attack by predators or parasitoids, consists of the sesquiterpene (E)-farnesene (Ef). High levels of expression in *Arabidopsis thaliana* plants of an Efsynthase gene cloned from *Mentha piperita* were used to cause emission of pure Ef. These plants elicited potent effects on behavior of the aphid *Myzus persicae* (alarm and repellent responses) and its parasitoid *Diaeretiella rapae* (an arrestant response).

Insects release chemicals called alarm pheromones when they are scared by their enemies. This warns their colonies to escape. New biotech crops express alarm pheromones that scare the specific insect pests.
Herbicide-resistant plants: Giving plants the ability to inactivate the herbicide

Herbicides: Bromoxynil, Glyphosate and Glufosinate

- Resistance to bromoxynil (a photosystem II inhibitor) was obtained by expressing a bacterial (*Klebsiella ozaenae*) nitrilase gene that encodes an enzyme that degrades this herbicide.
- Resistance to glyphosate was obtained by over-expressing EPSPS gene from bacteria.

![Chemical structures](image)
Over expression of the gene encoding a Na+/H+ antiport protein which transports Na+ into the plant cell vacuole has been done in plants allowing them to survive on 200 mM salt (NaCl)

Figure 18.22  Schematic representation of ion transport in the plant A. thaliana showing the Na⁺ ions being sequestered in the large vacuole.

Spider silk: 5 times stronger than steel, twice as elastic as nylon. Water proof and stretchable.

Silkworm silk: 5-10 times more extensible than cellulose. Better thermal properties.

A pencil thick spider silk strand can stop a Boeing 747 in flight!!
Genes from **Spider, Bacteria & Spinach** improve cotton fibre traits

**Cotton fibrocyte expression vector plasmid of spider silk gene.**  

**Bacterial genes for improvement of cotton/flax fiber quality.**  

**Polyhydroxy butyrate synthesis in transgenic flax.**  
Polyhydroxy butyrate from bacterium *Alcaligenes eutrophus* when introduced in cotton fibres enhanced thermal insulation in the resultant fabric.

**Transgenic cotton with improved strength, length, micronaire and fibre weight.**  
Sucrose phosphate synthase gene was isolated from spinach and introduced into cotton. The resultant GM cotton pushed fibre quality to the premium range.
Engineering cottonseed for use in human nutrition by tissue-specific reduction of toxic gossypol

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A. T2 seeds from line LCT66-81-5

B. Seeds from wild-type plant

10 µg/mg
Challenges: 2015 onwards (cont)

B. Social and Economical

1. Public acceptance of new technologies like transgenic products
2. Patenting and nationalism

C. Political and Policy

1. Exim policy of raw cotton and textiles
2. Investments in Processing technology
3. Value creation through byproduct Utilization
A farmer near Jalna in Maharashtra examining his freshly sown cotton field. Express photo

ACREAGE SHIFTS

King Cotton’s comeback

The fibre crop, along with maize, seems the most attractive planting option for farmers this kharif

HARISH DAMODARAN

BHASKARAO MORE Last year towed tur (pigeon pea) and mung (green gram) on four acres and cotton in the rest of his eight-acre holding. In this kharif season, he has already planted seven acres under cotton, leaving a salai (rice) for monsoon.

“I grew mung and tur last year because prices were Rs. 3,000-3,500 per quintal. But having got a rate of only Rs. 500-450 per quintal for my five quintal of tur and three quintal of mung, I this year have gone back to cotton,” notes this farmer from Tugrewadi village in Radhanpur taluka of Maharashtra’s Jalna district.

The same goes for Ramshankar Vishnu Gadhane from Hinwan Khurd in Janjulnath, who, like many farmers here, cultivates cotton as an inter-crop with cotton or soybeans. “I usually plant tur and beans (in the same field) under cotton on each acre. Last year, the tur crops led me to raise the tur planting to 10 rows and reduce the cotton rows to 14. But I found it was better to do it in the previous year,” he adds.

Cotton is typically a 175-180 day crop, with the first harvest of “pecking” taking place some 120 days after sowing towards the second week of June. Subsequent pickings—there could be four or five— Within every 55 days or so a normal monsoon year, farmers with access to basic irrigation (piped water conveyed to fields through a three-horsepower motor pump) can harvest around 12 quintals per acre. With drip irrigation, which allows an extra picking, this could go up to even 15 quintals.

For farmers, the biggest cost is that of picking. At Rs. 600 per quintal for 12 quintals, it works out to Rs. 7,200 per acre. The second major expense is that of pesticides. About six sprays of branded insecticides such as ‘Cotigard’, ‘Acarac’ and ‘Palo’—mainly against sucking pests like thrips, jassids, aphids and whiteflies—cost roughly Rs. 4,200 per acre, excluding Rs. 2,000 on labour for each round of spraying.

This is followed by weeding (four rounds costing Rs. 750 per each) and inter-culture (five times); a farmer not owning bullocks will have to hire these each time at roughly Rs. 600. Then, there is fertiliser. Gadhane applies one 50-kg bag each of 19:19:19 NPK complex fertiliser (currently retailing at Rs. 4,000 in the previous year), he adds.

Farmers sowed 16.67 lakh hectares (ha) under cotton as on June 16, against last year’s corresponding all-India area of 12.25 lakh hectares. Acreage which, on the other hand, has dipped from 3.63 lakh to 2.22 lakh

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Cotton’s total advantage is its relative hardness. Soybean can be washed out in rains heavily during seeding or harvesting times. Cotton, on the other hand, is picked four or five times. Even if the rains aren’t too good, the farmer is assured of at least two pickings. If the monsoon turns out good, he may get the plant more water and fertilisers for it to yield an extra picking of 2 quintals,” points out Usha Barve, state joint director of research at Maharastra Hybrid Seeds Company.

Cotton apart, the other “hot” crop this kharif season is soybeans. A poor crop last year courtesy drought in Peninsular India has meant that the ruling prices, at Rs. 13,500-14,000 per quintal, are above the Centre’s MSP of Rs. 12,55.

Since cotton, unlike soybeans, does not require irrigation, the switch to soybeans over cotton may come as a positive move. But not without drawbacks. The fields that the farmers plough for soybeans (per-acre yield of 600 quintals) are the same that they are using for cotton, and the wiping out of both may not be a viable option. The climate in these areas is not similar to soybean’s

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