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Unlearn A Few And Learn Some New

(Part-1)

EXPERT's Column

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Dr. K.R. Kranthi

"By Small and Simple Things, Are Great Things Brought to Pass" (Alma 37:6-7)

Great changes always have humble beginnings. Indian cotton is destined to be great, but India is waiting for that small beginning, whose time is just round the corner. There are some simple things that have made great changes to cotton production in a few countries. India must unlearn a few things and learn a few new things to be able to race to the top.

India has the largest share of 36-38% in the total global cotton acreage with 11 to 13 million hectares. Cotton is one of the main crops that, has been grown in the country for hundreds of years. Indian climate is ideal for the crop and so are the soils. India can race to the top comfortably by implementing simple changes that are derived from global experiences. This article is about a few simple things which can bring great things to pass.

Can we double Indian cotton yields? Can we double farmers' income? Can we half the production cost? Of course yes, we can. I have no doubt in my mind whatsoever. I affirm my belief that these things are eminently possible, much sooner than later. But we need to change.

Indian cotton production systems are radically different from rest of the world

Cotton production systems are very different in India compared to all other countries. We believe that long duration cotton is the best way to get higher yields. We believe that more bolls per plant is the best way to get more yields. We believe that big plants are better than small ones. We believe that hybrid cotton gives higher yields than pure-line varieties. The world thinks otherwise. Result -the yields of 'rest of the world' are double than that of India!!

Everything is different in India. All the differences in crop production practices of India with rest of the world are related to one major policy factor – hybrid cotton. India is now saturated with hybrid cotton. Rest of the world has rejected the concept of hybrid cotton. There was a general belief that hybrid-cotton technology could lead India towards high yields. Efforts were made from 1970 to develop high yielding hybrids. In 30 years of intensive efforts, about 30 new intra-hirsutum hybrids were released for commercial cultivation and the area under cotton hybrids reached 38 to 40% by the year 2000. With the introduction of Bt-cotton only in hybrids, the area under hybrid cotton reached 95% by 2011.

But, did the massive adoption of hybrid cotton technology make any difference to India's yields? The question assumes significance in light of the fact that, many jump into the bandwagon to credit only Bt technology for higher yields with no credit whatsoever attributable for the hybrid cotton technology.

In 2014-15, India's National average yield was 510 kg per hectare compared to the 'rest of World's average yield of 931 kg per hectare. The yields in a few countries were 1500 to 2600 kg lint per hectare which is 3 to 5 times higher than India. A few years ago, yields in these countries were also at 500 kg lint per hectare. These countries used simple technologies to enhance yields progressively over the past two decades. Generally, every year, 34 countries across the globe cultivate cotton in more than 50,000 hectares. Five of these have been able to achieve National average yields of more than 1500 kg lint per hectare, which is three times more than India's average. The five countries are Australia (2619 kg/ha), China (1508 kg/ha), Brazil (1601 kg/ha), Turkey (1574 kg/ha) and Mexico (1577 kg/ha). All these countries cultivate pure-line varieties. Turkey has only non-Bt varieties. Brazil has less relevance for Bt cotton because of negligible problems with bollworms.

National average yields in Australia, China, Brazil and Turkey have been increasing steadily over the past two to three decades, specifically over the past 10-15 years despite having large cotton acreages. This could be possible either because these countries have the best climate for cotton cultivation and/or because of the technological advances in production practices. But, the increasing trends in yields of these countries indicate that technological advances, mainly in plant breeding of improved varieties that were tailored to suit the local climatic conditions, actually contributed to higher yields. For example, historically, prior to 1994, Brazil's cotton yields never exceeded more than 440 kg lint per hectare. Technological changes appear to have pushed up the yields within 5 years after 1994 to more than 1000 kg lint per hectare with a consistent incremental upward growth trend in productivity until date. Similarly, yields in China were never higher than 500 kg/ha prior to 1980, and were always less than 1000 kg/ha before 1997. China's progress can be considered as most spectacular because of its steady increase of National average lint yields from 1000 kg/ha to 1500 kg/ha during 2003 to 2012 in a large acreage of 5.2 to 6.2 m hectares. Yield increase in Brazil, Turkey and China are identical with an increase from 1000 kg/ha in the year 2000 to 1500 kg/ha in 2015. Impressively, the yield enhancement in Brazil happened in a large area of 0.8 to 1.4 m hectares during the past 12 years. However, chemical usage has increased enormously to an extent of 40-50 chemical applications in a single season, despite large scale adoption of GM cotton which includes herbicide tolerant and Bt-cotton. Insecticides in Brazil are used to control boll weevils, nematodes and sucking pests. Herbicides and plant growth regulators are used very frequently. It is quite likely that such rampant usage of insecticides would lead to collapse of the crop sooner than later. In stark contrast, insecticide usage has reduced very significantly in Australia due to Bt-cotton and in Turkey due to organic cotton. Both countries present very different perspectives. The most significant aspect of Australia is its application of science and discipline in implementation. Yields were above 1600 kg /ha after 1999 and reached as high as 2500 kg per ha in 2014. Impressively, insecticide usage declined to just about 2-3 sprays per season over the past 15 years at least. Similarly chemical insecticides in Turkey are restricted to small areas and are not used in organic cotton. The science of organic cotton in Turkey is very impressive. Though cotton area in Australia increased steadily until 1999 to reach 0.53 m hectares, acreage fluctuated wildly between 0.065 to 0.65 m hectares during the period 1999 to 2016 mainly influenced by drought.

Simple technological changes have swept the cotton world over the past 20 years. Biotech cotton, water management, new selective herbicides and insecticides, mechanization and new varieties brought in major changes in production technologies. Indeed, yield increases in Australia, China, Brazil and Turkey were technology driven.

The unique features of Indian production system - Can we unlearn these?

The following aspects related to hybrid cotton are unique to India and differ completely with many advanced countries as listed in the table on the opposite page.

Unique features

- More bolls per plant: Hybrid cotton varieties are selected for bigger bolls and large number of about 100 or more bolls per plant.
- High boll numbers compromise ginning% and fibre strength: In the process of selecting plants for larger number of bolls per plant, ginning% and fibre strength are generally compromised. Further late season bolls are smaller and of poorer quality.
- Longer duration: To produce a large number of bolls each plant takes a longer time of 6-8 months. These bolls are formed in a staggered manner in 3-5 batches over 160 to 240 days, thereby resulting in 3-5 multiple pickings.

	India	Australia, Brazil, Turkey, China, USA and Mexico
Cultivars	Hybrids	Pure-line varieties
Crop duration: days	160-240	150-160
Flowering-fruiting duration: days	80-160	60-100
Plant population /ha	11,000	160,000
Bolls/plant	20-100	5-7
Number of pickings	3-5	1
Sowing and picking	Manual	Mechanised
Labourers employed per hectare	100 to 120	1-10
Harvest index (seed-cotton v/s plant-bio-mass)	0.2-0.4	0.4-1.0
Lint % in seed cotton (Ginning%)	32-34	38-44
Plant architecture	Bushy	Erect-compact
Plants in meter row	1 to 2	10
Seed rate kg/ha	2	12
Seed production	Cumbersome	Easy
Pink bollworm infestation in long duration crop	High	low
Non-Bt seeds in bolls	present	absent
Bollworm resistance risk	High	low
Area Lakh ha	119	224
Average lint yield kg/ha	500	>1500

- Longer reproductive phase: Flowering and fruiting stage extends over 80-160 days for the plants to produce more number of bolls.

- Need for more water and fertilizer: Since more than 80% of water and nutrients are required by the plants during flowering and fruiting phase, the extended reproductive window demands intensive irrigation and fertilizer management for high yields.

- Energy intensive hybrid-vigour of traits: Different hybrid varieties may show hybrid-vigour for different characteristics. Some hybrids may have hybrid-vigor for plant height, some for bushy nature, some for excessive vegetation, some for boll size, some for boll numbers, some for fibre length, some for duration, etc. All these traits are energy intensive and are expressed better under intensive use of fertilizers and water.

- Tall and bushy plants: To produce more number of bolls per plant, the hybrid-variety plants are selected to be big and bushy. The hybrid plants respond well to irrigation and fertilizers to grow tall and bushy under ideal conditions.

- Low harvest index: Hybrid vigour leads to more vegetative unproductive excessive biomass comprising of leaves and stems, thereby resulting in low harvest index.

- Low density of plants: Because they are bushy, the hybrid plants need space and light. Thus, plant population for hybrid cotton was optimised at a low density of 6000 to 16000 plants per hectare depending on irrigation and soil type.

- Wide spacing: To accommodate the bushy plants with hybrid vigour, a wide spacing up to 150 x 120 cm was adopted in irrigated regions mainly in Gujarat and 90 x 60 cm in rain-fed Maharashtra.

- Labour intensive seed production: Hybrid seeds are produced by crossing two different varieties through a cumbersome method of emasculating the flowers of one variety and pollinating it with pollen of the second variety, thus making seed production expensive and labour intensive. In contrast, varietal seeds are directly harvested from a single pure-line variety.

- Labour intensive production practices: Sowing in a wider spacing of 90 x 60 cm or more cannot be easily adapted to machines. The existing technology of spindle-type machine-pickers, are not suited for cotton picking of the bushy wide-spaced Bt-cotton hybrid crop. Weed problems are more in widely spaced crop. All these operations are labour intensive and make cotton cultivation in India, the most labour intensive as compared to other countries.

- Multiple pickings & inferior quality: Multiple pickings resulted in variable quality, generally with inferior quality in late picked cotton due to poor availability of soil moisture and nutrients in the terminal stages of the crop.

- Lack of seed sovereignty: Seeds harvested from a hybrid crop cannot be used subsequently for sowing, whereas varietal seeds can be saved and sown recurrently for several seasons. Farmers are required to procure freshly produced hybrid seeds every year from the market.

- High risk of bollworm resistance to Bt-cotton hybrids: Two factors accelerate resistance risk are, long duration crop and seed segregation for Bt-toxins in Bt-hybrids. Long duration crop provides an extended window for the pink bollworm infestation which occurs mainly in winter when the crop is extended beyond 150 days. Seed companies found hybrid-seeds as a convenient vehicle of 'value-capture' for Bt-technology. The F-1 (filial-1 generation) hybrid seeds were developed by crossing one Bt-variety with another non-Bt-variety. This would result in F-1 hybrid seeds, containing one copy of the Bt-gene inherited from one of the parents. Bolls produced in a Bt-hybrid crop produce seeds that segregate for Bt toxins. A proportion of seeds do not contain Bt-toxins. Both these factors create an ideal condition for bollworms to develop resistance to Bt-cotton.

The simple features of 'rest-of-the-world' –can we learn from these?

A summary of plant breeding policies and best practices that are being followed in China, Australia, Turkey and Brazil are listed below:

1. High 'harvest-index' short duration varieties: Compact architecture; sympodial in nature with short-internodes; suited for high density planting and machine picking; short duration (150-160 days); high harvest index of 0.4 to 1.0 and robust seedling and root vigour.

2. High density planting: Optimising plant populations at more than 110,000 plants per hectare with compact statured varieties. Spacing of plants is maintained for 10-12 plants per meter within rows and at 45 to 90 cm between rows.

3. Canopy management: Plant architecture is maintained through a combination of genetics and manual intervention (China & Turkey) or chemicals (Brazil and Australia) for better sunlight penetration into the crop canopy.

4. Legume-cotton based cropping systems: Cotton is either rotated or inter-cropped with legume crops for nitrogen-fixing.

5. Soil health management: Conservation tillage and crop residue management practices that enhance soil health with high residue cover, crop residue mulching, minimum tillage, etc.,

6. Eco-conscious pesticide usage: Least early season insecticide applications and careful choice of 'biological-control-friendly' insecticides in Australia and Turkey for highly efficient season-long pest management through conservation of naturally occurring biological control.

7. Input-use-efficiency: Enhancing water-use-efficiency (WUE), nutrient-use-efficiency (NUE) and pesticide-use-efficiency (PUE) by implementing INM (Integrated Nutrient Management), IWM (Integrated Water Management), IRM (Insect Resistance Management) and IPM (Integrated Pest Management) strategies by optimising application of water, manures, fertilizers, pesticides and biological resources.

Yield enhancing technologies in China, Australia, Brazil and Turkey are based on a combination of 'structured-varieties' in tandem with appropriate agronomy and efficient pest management. These systems deserve to be studied carefully so that lessons can be learnt for other countries. However, in some of these countries high yields were obtained due to intensive chemical usage, mechanisation, irrigation and labour-intensive crop management. For example, China deploys labour for nursery transplanting, sowing and canopy management, while Brazil moved towards high level of mechanisation, fertilizers and pesticides to obtain high yields. It is quite likely that these technologies will not sustain themselves in the long run only to lead production systems into perennial risks. Therefore there is a need to exercise proper discretion in choosing the most appropriate technologies that are suited for local needs and local conditions, with focus on sustainability. A few of the core technologies could then be adapted to India and other countries to establish sustainable production systems for high yields and low inputs costs.

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