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Unlearn A Few And Learn Some New

(Part-1)

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

EXPERT's Column

Dr. K.R. Kranthi

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)

Production & Stock of Spun Yarn (SSI & Non-SSI)

(In Mn. Kgs.)

MONTH / YEAR	PRODUCTION				STOCK			
	COTTON	BLENDED	100% N.C.	G. TOTAL	COTTON	BLENDED	100% N.C.	G. TOTAL
2013-14	3928.26	896.19	484.99	5309.45	133.80	51.33	23.40	208.53
2014-15	4054.51	920.20	512.92	5487.64	140.60	48.30	22.48	211.38
2015-16 (P)	4137.83	972.50	554.79	5664.93	140.68	49.46	22.99	213.13
2016-17 (P) Nov.	2696.54	689.98	401.62	3788.14	165.80	70.21	31.15	267.16
2014-15								
April-14	328.68	73.84	41.41	443.93	142.80	50.06	21.20	214.06
May-14	332.92	74.77	42.71	450.40	139.60	46.20	20.80	206.61
June-14	330.69	74.03	42.95	447.67	151.05	47.99	22.56	221.60
July-14	340.00	78.51	44.85	463.36	160.20	51.30	24.18	235.67
Aug.-14	338.09	76.66	44.23	458.98	166.64	53.21	24.87	244.72
Sept.-14	334.03	77.91	42.55	454.49	167.53	51.73	24.02	243.28
Oct.-14	323.53	74.51	40.96	439.00	178.62	56.85	25.89	261.36
Nov.-14	335.66	71.42	41.50	448.58	171.13	55.01	25.21	251.36
Dec.-14	353.96	76.54	42.01	472.51	160.58	56.06	26.47	243.11
Jan.-15	349.83	80.16	43.25	473.23	161.61	55.80	24.17	241.57
Feb.-15	330.35	81.26	41.88	453.49	149.92	50.83	22.47	223.22
Mar.-15	356.79	80.59	44.62	481.99	140.60	48.30	22.48	211.38
2015-16 (P)								
April-15	349.38	77.11	44.07	472.51	141.19	51.45	21.33	213.98
May-15	348.14	80.02	44.74	472.90	153.07	52.34	23.79	229.21
June-15	346.72	79.68	45.27	471.66	158.57	55.72	23.93	238.22
July-15	356.36	82.15	47.48	485.98	160.33	61.25	26.62	248.20
Aug.-15	354.67	82.24	49.97	486.88	166.34	63.73	27.88	257.95
Sept.-15	338.53	79.51	45.41	463.45	165.96	62.33	26.16	254.46
Oct.-15	342.12	83.61	47.35	473.08	170.07	64.46	25.69	260.23
Nov.-15	320.06	77.67	43.27	441.01	173.96	61.59	24.17	259.72
Dec.-15	353.31	81.30	49.86	484.31	158.66	58.22	25.34	242.22
Jan.-16	343.98	83.34	46.84	474.26	158.52	57.55	25.10	241.18
Feb.-16	336.55	80.94	43.12	460.60	155.36	52.18	22.81	230.35
Mar.-16	348.01	83.87	46.35	477.03	140.68	49.46	22.99	213.13
2016-17 (P)								
April-16	334.30	80.55	46.49	461.35	127.63	48.99	24.26	200.88
May-16	360.75	85.95	53.50	500.20	132.43	54.79	26.25	213.47
June-16	352.08	89.10	50.87	492.05	131.10	50.84	21.46	203.40
July-16	343.97	88.21	49.06	481.24	137.04	56.57	24.36	217.96
Aug.-16	335.48	90.52	50.89	476.89	155.52	54.49	22.92	232.93
Sept.-16	328.39	87.62	52.95	468.96	153.48	57.74	24.20	235.43
Oct.-16	315.30	83.56	50.16	449.01	165.82	63.40	28.96	258.18
Nov.-16	326.26	84.48	47.71	458.45	165.80	70.21	31.15	267.16

P - Provisional *Source : Office of the Textile Commissioner*

CAI's December Estimate Places Cotton Crop for 2016-17 Season at 341 Lakh Bales

The Cotton Association of India (CAI) has released its December estimate of the cotton crop for the 2016-17 season beginning from 1st October 2016. The CAI has placed the cotton crop for the 2016-17 season at 341.00 lakh bales of 170 kgs. each. The projected Balance Sheet drawn by the CAI estimated total cotton supply for the cotton season 2016-17 at 404.00 lakh bales while the domestic consumption is estimated at 290.00 lakh bales thus leaving an available surplus of 114.00 lakh bales.

A statement containing the State-wise estimate of the cotton crop and the balance sheet for the cotton season 2016-17 with the corresponding data for the crop year 2015-16 is given below.

The arrivals of cotton during the ongoing 2016-17 crop year are estimated to be lower than those upto the same period last year due to holding back of seed cotton by farmers.

CAI's Estimates of Cotton Crop as on 31st December 2016 for the Seasons 2016-17 and 2015-16

(in lakh bales)

State	Production *		Arrivals As on 31st December 2016 (2016-17)
	2016-17	2015-16	
Punjab	9.50	7.50	4.50
Haryana	20.00	17.00	7.50
Upper Rajasthan	6.50	5.50	2.00
Lower Rajasthan	11.00	10.50	6.00
Total North Zone	**47.00**	**40.50**	**20.00**
Gujarat	92.50	88.00	23.00
Maharashtra	86.00	78.00	31.00
Madhya Pradesh	20.00	18.75	5.00
Total Central Zone	**198.50**	**184.75**	**59.00**
Telangana	47.00	58.00	15.00
Andhra Pradesh	18.00	24.00	6.00
Karnataka	19.00	18.50	5.00
Tamil Nadu	5.50	7.00	0.50
Total South Zone	**89.50**	**107.50**	**26.50**
Orissa	4.00	3.00	1.50
Others	2.00	2.00	1.00
Total	**341.00**	**337.75**	**108.00**

*Note: (1) * Including loose*

(2) Loose figures are taken for Telangana and Andhra Pradesh separately as proportionate to the crop for the purpose of accuracy

The Balance Sheet drawn by the Association for 2016-17 and 2015-16 is reproduced below:-

(in lakh bales)

Details	**2016-17**	**2015-16**
Opening Stock	45.00	67.25
Production	341.00	337.75
Imports	18.00	22.00
Total Supply	**404.00**	**427.00**
Mill Consumption	256.00	275.00
Consumption by SSI Units	24.00	25.00
Non-Mill Use	10.00	10.00
Exports		72.00
Total Demand	**290.00**	**382.00**
Available Surplus	**114.00**	
Closing Stock		**45.00**

Developments and Opportunities in Cotton Breeding

Breeding is the development of superior varieties/cultivars/ genotypes/germplasm lines, and even hybrids, for commercial production or utilization in breeding programs. Cotton breeding has been going on for centuries and is certainly much utilized/more widely explored than any other scientific approach to agriculture. Contributions from breeding are so immense that other disciplines have only endeavored either to recover the true value of breeding efforts or tried to protect achievements acquired from breeding. These are the breeders who domesticated cotton, though mainly through selection, to be grown as an annual crop and produce lint that has enriched consumption value. An examination of many cotton research programs shows that the initial efforts in breeding were upgraded into research stations and institutes, which emerged as multidisciplinary focal research centers on cotton. Instances where the inverse happened and the breeding of varieties was added to an existing entomological or agronomic research program may exist, but are rare. In cotton, breeding is the leader and at times was regarded as the central axis of any cotton research program.

Target plant breeding started about 10,000-12,000 years ago when man observed that if a seed falls on the ground it germinates and produces a new plant (Roupakias, 2014). Just one hundred years ago researchers were still struggling to accept the Mendelian Law of Inheritance and the Law of Independent Assortment. Mendelian genetics was ignored for almost 25 years due to hesitation in admitting the existence of genes or accepting that heritable characters are genetically controlled and cannot just be transferred as if acquired. The genes assort independently without any outside influence.

The extensive research done on cotton became more formal and was easier to understand after it was discovered that there are genes that carry a blueprint of the characters to be expressed under a given set of growing conditions. Such discoveries, unimaginable in the early years of cotton research, were severely questioned and remained shelved for about half a century. The theory of evolution did not satisfactorily address many concerns, and it was practically impossible to give up the long-held belief in the inheritance of acquired characters. Fortunately, however, the laws of inheritance of characters and the independent assortment of genes were rediscovered and applied. Thus began the science of formal breeding we know today.

The Cotton Breeding of Yesterday

Only three methods of breeding have been employed throughout the world, i.e. introduction, selection and hybridization. Varieties have been imported from other countries and directly adopted for commercial cultivation. This is probably the most obvious and easiest way to improve production based on improving the genetic background of cultivation material. Cotton production itself was initiated by introduction in the Indian subcontinent, it initially failed and then succeeded. The reliance on introductions has diminished since it has been understood that there is a science behind the carryover of characters and they cannot merely be manipulated based on production conditions. Introductions do not have an impressive history of success, although varieties developed in one part of the world do have a chance to excel in performance when grown under more suitable conditions within a country or across countries.

Selection from within a population, having not been produced directly through hybridization, has also proved successful in the past. The material from where selections were made often comprised adopted/commercially grown varieties. The major limitation to the selection method of developing varieties has been a lack of sufficient variability, as selection had to rely either an existing variability in the population resulting from natural out-crossing or natural mutations. Drastic deviations from existing populations were not expected and usually there was no fear of adaptation issues.

Because of the limitations described above, efforts were made to induce variability in the existing homozygous populations via mutagenesis. Chemical mutagens were employed without much success. However, radiation was extensively used in a hit and miss fashion in many countries in the 1960s and 70s. Gamma rays were more effective than other sources of radiation on cotton for desirable mutations. A number of different doses were tried, and it was found that 30 and 35 krad induced chromosomal changes with a minimum number of deleterious mutations. Pakistan probably benefitted the most from gamma radiation in the form of developing heat-tolerant varieties. The variety NIAB-78, developed through radiation was once planted on over two million hectares in Pakistan. Although the variety showed continuous segregation at low level, apart from commercial use, NIAB-78 provided a base for developing heat-tolerant varieties, which was the most important factor limiting yield until early 1980s. There are many different ways of using radiation to induce beneficial mutations, including radiating wet/soaked seed, pollen grains, using varying doses, and using different sources of radiation; all have been tried. Scientists have concluded that the high number of deleterious effects and undesirable linkages induced by radiation rendered this technique too costly and inefficient to continue.

The hybridization procedure has existed parallel to the other two approaches, but hybridization has not been employed on a large scale for several reasons:

- Hybridization is a long process involving the crossing of two parents, selection from segregating populations starting from F2 generation onward, and attaining genetically pure breeding lines before they are carried forward for commercialization.

- Populations that segregate starting from the F2 generation have to be grown in sufficient numbers so that the maximum number of combinations can express themselves. A small F2 population means that all the possible combinations cannot occur in the field, and subsequent generations will also be limited in the number of expressions they can exhibit, either through the bulk selection method or with progeny rows. Managing large segregating populations and various segregating generations of each population requires huge resources.

- Selection from segregating populations in the field requires vigilant breeders' judgment on what should be carried forward and what not. Fiber quality was used as a criterion for rejecting single-plant selections or bulk populations, but only when the rest of the material had been discarded. It was common that breeders always had difficulty in deciding which plants and progenies to reject, and it was easier for them to select more rather than fewer plants and lines. The cost of carrying huge populations from one generation to the next restricted attempts to try more combinations and crosses.

- Nevertheless, hybridization continues as a modern method of developing varieties, but the practice relies mostly on the experience and judgment of breeders, rather than science. In other words, breeding is practiced more as an art of selecting better plants that will continue performing better in subsequent generations and will become commercial varieties.

- Unfortunately, breeders lacked a precise test that would ensure success. However, a big team of breeders attempting a large number of crosses has a higher chance for success because they are screening more combinations. Nevertheless, there is no way to guarantee that large teams will develop a superior variety than a small group of breeders attempting a few crosses every year.

- Mutagenic control of various characters, negative correlations among desired characters, and other factors complicate and restrict the flow of varieties. There were gene combinations that every breeder desired to introduce into varieties, but they were not successful because they could not pick and choose genes carrying the desired characters.

Various efforts were made to overcome some of the constraints to successful breeding of superior lines. These included using backcrossing to retain or transfer a limited number of characters, the same technique now used to transfer biotech genes. Single crosses, double crosses, varieties crossing with segregation populations and many more options have been tried, but only back crossing proved its worth. The development of varieties with single, double and even triple biotech gene transfers is possible because of the experience learned from conventional breeding.

Variety Development and Seed Production

In spite of all the limitations it was unequivocally recognized throughout the world that comparative advantage in cotton production was in large part based on its superior seeds. This meant that farmers could purchase improved seed and imitate the innovation by planting and increasing it locally. The genetic superior hidden behind the seed was least acknowledged.

Development of a variety and seed production are two separate tasks. The role of seed production was recognized much after the impact of breeding was acknowledged. Then followed the importance of variety maintenance. A breeder could develop a good variety and it might be lost due to lack of a good seed production system. Once a variety is developed, it is necessary that varietal purity is maintained and high germination seed is provided to farmers. Grading, proper packing, instructions on the package, timely delivery, proper seed rate to be used, among others are linked to the success of a variety.

Many countries have realized the fact that variety maintenance and seed production should be separated, with the latter being transferred to private seed companies. Variety maintenance, that has a role from breeders, is the next task that private companies took over from the public sector. This change has just been completed in Australia, China, India, Pakistan and the USA. Turkey has joined the same system in the last few years. Among these countries, there is not any country where all the three stages i.e. variety development, maintenance and seed production, are in a single hand without any competition. In the USA, USDA breeders develop germplasm lines that could be used by the private sector in the development of varieties but university breeders are free to develop varieties for commercial adoption. They were doing so until the biotech genes became part and parcel of any commercial variety. In other countries the public sector competes with the private sector to develop and commercialize varieties.

What is Breeding Currently Going Through?

Breeding is increasingly conducted within the private sector, although it will take many more years until this shift is complete. The public sector in many countries see private sector breeding as a challenge to their authority and have sometimes been reluctant to cooperate.

Public sector breeding programs have often been judged in terms of the number of varieties released for commercial production and the area planted to such varieties. Some breeders fear that financial support from governments will dissipate if they surrender the right to commercialize varieties. However, the shift to private sector breeding is a reality, and this shift allows public sector resources to be better utilized in other areas of research that require higher attention than received in the past. Variety approval and seed certification are two aspects of the planting seed development chain that could stay with the public sector.

Breeding programs, whether in the private or public sector, are faced with issues that will have long-term consequences if proper measures are not taken. Constraints are often openly discussed, but solutions are not given, or if solutions are mentioned, pathways are not shown to resolve them. Hence the elimination of constraints is not expected soon, and the consequences are potentially severe and long lasting.

The major issues confronting cotton breeding programs are:

- The genetic base of current varieties is narrow. Only a limited circle of varieties are hybridized to produce newer varieties, hence the breeders end up with only a slight chance of achieving improvements over existing varieties. Individual companies or public sector breeding teams are using their own varieties for the sake of maintaining their known and accepted stylized series. They are doing so to have a higher success rate in commercializing new varieties than they would have if they attempted to cross two diverse genotypes. So, breeders themselves have fused this problem into their breeding programs, and they are the ones who must change their approaches. A breeding process can produce change in the composition of a population only if there is variation from which to select.

- Germplasm exchange has almost disappeared. Germplasm availability is the extent of freedom that a breeder has to obtain and use any genetic material that exists in or outside a country. The result of stringent plant variety protection in individual countries is restricting breeders' capacity to freely use any genetic material. These restrictions inhibit further development of innovations. It is true, to some extent, that while some countries have been collecting significant amounts of new germplasm, they are not reporting significant rates of providing germplasm beyond their own borders. No statistics are available to report in cotton, although CGIAR data show this trend in other crops.

- The advent of biotechnology and intellectual property laws has increased the market for improved seed. These changes made it easier for commercial breeders/ companies to be rewarded and to recover the cost of their investments, But, at the same time, intellectual property protections limit the ability of farmers or rival breeders to reproduce seed. Private seed companies have benefitted the most from the expansion of the seed industry, to an amount exceeding US$2 billion. Public sector breeders and programs have not been compensated for their work to the same degree as private programs, resulting in shrinkage of public sector breeding programs.

- The focus in cotton breeding has shifted to short-term objectives to achieve quick returns. Budgets for long-term fundamental scientific research are shrinking, which is not in the ultimate best interest of achieving breakthrough achievements.

- The rise of molecular genetics, particularly with the commercialization of biotech crops, has accelerated the shift toward private sector plant breeding. Many scientists believe that as conventional breeding is replaced by biotechnological approaches, public sector programs and institutions will retreat from classical plant breeding. This, in turn, has a negative effect on breeding education at universities and research work at public institutions (Roupakias, 2014). Biotechnology is relatively new and can be done in large centralized laboratories; there has been a rapid expansion of biotechnology research. This research is essential, but a reduction has also occurred in public sector plant breeding efforts, which could result in a lack of progress in the development of elite germplasm and effective commercial cotton cultivars (Constable, 2015). Conventional breeding and molecular genetics are complementary and both are needed to fundamentally improve cotton varieties.

The most relevant Plant Variety Protection related laws are Plant Variety Protection (PVP), the International Convention for the Protection of New Varieties of Plants ("UPOV Convention"), Intellectual Property Rights (IPR), Convention on Biological Diversity (CBD) and patents. Up until the 1960s, plant genetic resources were traditionally more openly shared, moved rather rapidly around the globe and rapidly utilized. Most sources of origination were in the public sector and, therefore, the plant genetic resources were conceived of, and treated like, public goods. The organizations and individual scientists were free to collect and use genetic materials from any part of the world in their breeding programs. Would that was not the case at the time of developing short duration fertilizer tolerant wheat and rice varieties, the occurrence of green revolution would have been delayed significantly. In the last fifty years, however, an increasing proportion of plant genetic resources have been subject to various forms of capture, as a result of advances in applied bioscience and the promotion of exclusive legal protections. As such, they have been converted into appropriated, private goods. International intellectual property rights are practically non-existent. The current intellectual property rights are mostly territorial in nature, and they are acquired and enforced on a country-by-country basis. The feeling among the stakeholders shows that no one took advantage over the others because of plant variety protection and other restrictions.

High Potential – A Challenge for Breeders

Since the acknowledgment of genetics as carrier of characters and furtherance of physiological understandings on how the cotton plant reacts to the biotic and abiotic factors, breeders have admitted that they have a high challenge of reaching near to the genetic potential. The genetic potential (sometimes referred to as theoretical yield) could not be assessed in quantitative terms. The plant morphology dictates that total number of bolls on the plant could be as many as the number of leaves minus the number of branches, but the question then arises of how big a boll (boll weight) will develop. The proportion of lint to the seed is another critical factor inhibiting the calculation of quantitatively accurate theoretical yield. It is undoubtedly admitted that only a portion of the real potential is realized. Realization of genetic potential is considered to be impossible or unreachable. The factors hindering the research to reach genetic potential are many, interdependent, complex and misunderstood or even insurmountable.

Breeders talk of recoverable potential, by which they mean how much potential can be extracted/realized under a given set of production conditions. While the genetic potential may be closer among cotton-producing countries, recoverable potential, which is influenced by the production conditions, varies hugely among countries and even among farmers within countries. The author does not agree with Constable (2015) who stated that the theoretical yield in Australia under best irrigated condition is about 5,034 kg lint/ha. According to him, Australia reached 3,500 kg lint/ha under best conditions in 2015. This means that breeding and all other allied disciplines together have a target of increasing yield by 44%. The author is of the opinion that the indeterminate nature of the plant does not permit us to quantify the upper limit.

Source: The ICAC Recorder, Vol. XXXIV No.1, March 2016

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) 2016-17 Crop JANUARY 2017					
Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Strength /GPT	16th	17th	18th	19th	20th	21st
1	P/H/R	ICS-101	Fine	Below 22mm	5.0-7.0	15	8464 (30100)	8464 (30100)	8633 (30700)	8773 (31200)	8858 (31500)	8830 (31400)
2	P/H/R	ICS-201	Fine	Below 22mm	5.0-7.0	15	8745 (31100)	8745 (31100)	8914 (31700)	9055 (32200)	9139 (32500)	9111 (32400)
3	GUJ	ICS-102	Fine	22mm	4.0-6.0	20	8717 (31000)	8717 (31000)	8745 (31100)	8802 (31300)	8858 (31500)	8858 (31500)
4	KAR	ICS-103	Fine	23mm	4.0-5.5	21	9617 (34200)	9617 (34200)	9617 (34200)	9673 (34400)	9729 (34600)	9729 (34600)
5	M/M	ICS-104	Fine	24mm	4.0-5.0	23	10629 (37800)	10629 (37800)	10629 (37800)	10686 (38000)	10742 (38200)	10742 (38200)
6	P/H/R	ICS-202	Fine	26mm	3.5-4.9	26	11417 (40600)	11473 (40800)	11585 (41200)	11726 (41700)	11867 (42200)	11838 (42100)
7	M/M/A	ICS-105	Fine	26mm	3.0-3.4	25	10714 (38100)	10742 (38200)	10770 (38300)	10798 (38400)	10882 (38700)	10882 (38700)
8	M/M/A	ICS-105	Fine	26mm	3.5-4.9	25	10939 (38900)	10995 (39100)	11051 (39300)	11107 (39500)	11220 (39900)	11220 (39900)
9	P/H/R	ICS-105	Fine	27mm	3.5.4.9	26	11585 (41200)	11642 (41400)	11754 (41800)	11895 (42300)	12035 (42800)	12007 (42700)
10	M/M/A	ICS-105	Fine	27mm	3.0-3.4	26	10826 (38500)	10854 (38600)	10882 (38700)	10911 (38800)	10995 (39100)	10995 (39100)
11	M/M/A	ICS-105	Fine	27mm	3.5-4.9	26	11164 (39700)	11220 (39900)	11276 (40100)	11332 (40300)	11445 (40700)	11445 (40700)
12	P/H/R	ICS-105	Fine	28mm	3.5-4.9	27	11642 (41400)	11698 (41600)	11810 (42000)	11951 (42500)	12092 (43000)	12063 (42900)
13	M/M/A	ICS-105	Fine	28mm	3.5-4.9	27	11304 (40200)	11360 (40400)	11417 (40600)	11557 (41100)	11670 (41500)	11585 (41200)
14	GUJ	ICS-105	Fine	28mm	3.5-4.9	27	11389 (40500)	11445 (40700)	11501 (40900)	11557 (41100)	11670 (41500)	11670 (41500)
15	M/M/A/K	ICS-105	Fine	29mm	3.5-4.9	28	11389 (40500)	11445 (40700)	11501 (40900)	11557 (41100)	11670 (41500)	11670 (41500)
16	GUJ	ICS-105	Fine	29mm	3.5-4.9	28	11473 (40800)	11529 (41000)	11585 (41200)	11642 (41400)	11754 (41800)	11754 (41800)
17	M/M/A/K	ICS-105	Fine	30mm	3.5-4.9	29	11529 (41000)	11585 (41200)	11642 (41400)	11698 (41600)	11810 (42000)	11810 (42000)
18	M/M/A/K/T/O	ICS-105	Fine	31mm	3.5-4.9	30	11670 (41500)	11698 (41600)	11754 (41800)	11810 (42000)	11923 (42400)	11923 (42400)
19	A/K/T/O	ICS-106	Fine	32mm	3.5-4.9	31	11867 (42200)	11867 (42200)	11867 (42200)	11923 (42400)	12007 (42700)	12007 (42700)
20	M(P)/K/T	ICS-107	Fine	34mm	3.0-3.8	33	15325 (54500)	15466 (55000)	15466 (55000)	15607 (55500)	15691 (55800)	15691 (55800)

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