M. SABESH

Training Manual on

Long Staple Cotton Production

भा.कृ.अनु.प.
ICAR

Trainers' Training Programme

September, 23-24, 2005

Organised by

Directorate of Cotton development
Mumbai – 400 038
&
Central Institute for Cotton Research
Regional Station, Coimbatore 641 003

Preface

The two-day training programme on Long Staple Cotton Production organized by the Directorate of Cotton Development, Mumbai at Central Institute for Cotton Research, Regional Station, Coimbatore on 23rd and 24th September 2005 is very timely. The country has witnessed a record production of 230 lakh bales during 2004-05 and the current indications are that the country will witness a bumper harvest during the current year also. However, as long as the extra long staple cotton production is concerned the country will be in a piquant situation. With the requirement of seven lakh bales, the country's production is about 5 lakh bales. The rest of the requirement is usually met from the imports especially from USA and Egypt. There is a growing apprehension that due to liberalization of world trade and reduction of subsidy to the farmers, the foreign cotton would become prohibitively costly and the mills may be left with no option but to source their requirement locally.

The southern states because of its soil and climate are ideally suited to cultivate extra long staple cotton. Hence, all out efforts are needed to extend the cultivation of extra long staple cotton in the southern states. Contract farming offers a new hope for meeting the extra long staple requirement of the textile mills. The tripartite agreement entered into by the Tamil Nadu Government, the textile mills and farmers will hopefully meet the challenge of extra long staple production in the country.

A series of twelve lectures covering all aspects of cotton cultivation like selection of varieties, agronomic manipulation, pest and disease management, role of private industries, contract farming, quality parameters and economics of long staple cotton production will be delivered by eminent cotton scientists of the country during the training programme. I am sure that the knowledge gained by the trainees during the course of the programme will help them to carry the message of quality cotton production to the farmers in different parts of the country.

A brief not of all lectures delivered during the training programme is reproduced in this report for the benefit of the trainees and I am sure that it will serve as a reference material for the cotton extension workers too.

Project Coordinator (Cotton Improvement) & Head (i/c)

Central Institute for Cotton Research
Regional Station, Coimbatore – 641 003

CONTENTS

Development of Extra Long Staple Varieties and Hybrids in *G. hirsutum*

S. Manickam

Scientist – Senior Scale

Central Institute for Cotton Research, Regional Station, Coimbatore – 641 003

Cotton is the most important commercial crop of India cultivated mainly for its fibre and other bye products. Qualitative and quantitative transformation has taken place in cotton production in India ever since Independence (Table 1 & 2). The production increased from a meager 2.29 million bales in 1947-48 to a record of 23.2 million bales in 2004-05. At the time of independence, mostly short and medium staple cottons were produced. Today, India produces the widest range of cottons from 6^s to 120^s counts, from non-spinnable coarse to medium, long, extra long and superfine cotton.

Table 1. Quantitative change in area and production of cotton in India

Period	Area (million ha)	Production (million bales of 170 kg each)
1947-48	4.3	2.3
1966-67 (AICCIP started)	7.8	5.3
1996-67	8.9	17.8
2004-05	9.0	23.2

Table 2. Qualitative change in production of three staple length group of cotton

Period	Production in Million bales (170 kg each)			
	Long	Medium	Long	Total
1947-48	--	1.53 (67)	0.76 (33)	2.29
1961-66	0.92 (17)	3.70 (68)	0.82 (15)	5.44
1995-96	10.53 (65)	4.38 (27)	1.36 (8)	16.27
1996-97	11.43 (64)	4.94 (28)	1.42 (8)	17.79
1997-98	10.89 (69)	3.96 (25)	0.95 (6)	15.80
1998-99	11.43 (69)	4.04 (25)	0.98 (6)	16.15

Only in India, all the four cultivated species of cotton are cultivated under commercial scale. Apart from the varieties of different species, hybrids are also cultivated to a larger extent in India. The species wise area under cultivation is furnished in Table 3. The cotton productivity has been enhanced remarkably especially after the establishment of AICCIP. The productivity has been increased from a mere 90 kg lint/ha during 1947-48 to as high as 438 kg/ha during 2004-05. The consumption of cotton fibre by the mills under different staple length category and projected requirement for the year 2006-07 are given in Table 4. It clearly indicates the additional demand of one lakh bales in extra long staple category and at least five lakh bales in case of long staple category in the next two years.

Table 3. Species wise area under cultivation in India

Species	Area (million hectares)					
	1947-48	(%)	1965-66	(%)	1999-2000	(%)
G. hirsutum	0.14	3.0	3.21	41.0	2.70	30.0
G. arboreum	2.79	65.0	2.84	36.0	1.62	18.0
G. herbaceum	1.39	32.0	1.78	23.0	1.08	12.0
Intra-hirsutum hybrid					2.52	32.0
Inter specific hybrid (H XB)					1.08	8.0
Total	**4.32**	-	**7.83**	-	**9.00**	-

Table 4. Staple wise consumption and requirement of cotton fibre

Staple group	Consumption 2002-03	Requirement during X Plan (lakh bales)		
		2004-05		2006-07
		CIRCOT	SITRA	Projected
Medium (upto 24.5 mm)	47.9 (35.2)	88 (46)	78 (38)	94 (42)
Medium long (25.0 – 27.0 mm)	27.3 (20.5)	23 (12)	39 (19)	35 (16)
Long (27.5 – 32.0 mm)	57.0 (41.9)	73 (38)	80 (39)	85 (38)
Extra Long (> 32.5 mm)	3.0 (2.4)	8 (4)	8 (4)	9 (4)
Total	136.0	192	205	223

History of Fibre quality improvement in India

1917: Indian Cotton Committee set up under the chairmanship of J. MacKenna, Agricultural Advisor to Government of India with six other members to investigate the possibility of extending the cultivation of long staple cottons in India. The committee observed that the Madras Province growing Cambodia cotton, Punjab where American cotton was making rapid headway, and Sind Province (Pakistan) were considered potential area for growing Egyptian and American Cotton.

1921: Central Cotton Committee was established at Mumbai.

1923: Central Cotton Committee became a statutory body for promoting agricultural and technological research in cotton.

Egyptian Cotton Production to Meet the Extra Long Staple Requirement in the Country

K.N.Gururajan

Project coordinator and Head i/c
Central Institute for Cotton Research, Regional Station, Coimbatore – 641 003

Cotton is an important commercial crop of India. Of the two thousand five hundred textile mills in India, eight hundred textile mills exist in Tamil Nadu. These mills along with the small scale sector consume around 70 lakh bales of cotton per annum. The extra long staple cotton requirement of these mills is around 7 lakh bales. The current production in the country is around 5 lakh bales. The balance is being met through imports.

The long and extra long staple cottons are normally used to produce high quality yarns of 60^s and above counts. Most of the 60s count yarn in India is from *G.hirsutum* species varieties MCU5, MCU5VT and Surabhi are the major source of 60s cotton in India. The 80^s count yarn is mostly derived from interspecific (*G.hirsutum X G.barbadense*) hybrids especially DCH 32 and TCHB 213. The super fine counts of 120^s yarn is exclusively produced from *G.barbadense* cotton.

G.barbadense, commonly known as Extra long staple (ELS) or Egyptian cotton is grown in about 10 % of the cotton area and supplies about 4 % of the world production.

Table 1: World Extra long staple cotton production (2002-03).

Country	Production (lakh bales)
USA	8.7
Egypt	16.9
Sudan	2.7
Australia, Israel, Peru	1.3
China	4.1
USSR	4.1
India	3.9
Total (ELS)	41.7
Total world production	**1135.0**

1 bale= 170 kg lint

World Cotton Situation, Nov.2004, ICAC, USA

ELS Cotton is generally roller ginned and used in the manufacture of high quality ring spun yarn. The common end uses are sewing thread, lace yarn, blend with polyester and high quality fabrics. The major ELS producing and exporting countries are USA, Egypt and Sudan.

United States of America

Egyptian Cotton is grown in about 1.8 l.ha. The annual production is about 8.9 lakh bales.(2003-04), with an average productivity of 850 kg lint/ha. The major varieties are Pima S6, Pima S7, CH 253 and Conquistador.

Sea Island Cotton was first introduced into USA in 1786 and flourished till 1900. By 1920, due to boll weevil infestation, the Sea Island industry collapsed. By around 1900, the Egyptian cultivar 'Mit Afifi' was introduced and by reselection the first American variety Yuma was released in 1903. This was followed by regular breeding work, which resulted in the release of series of Pima varieties viz., Pima S1 to Pima S7. The other commercial varieties include CH 253-6 and conquistador, which currently occupy about 11% of the ELS area in United States.

Table 2: Fibre Quality Attribute of important USA varieties

Attribute	Pima S6	Pima S7
Yield (Q/ha)	30.8	34.8
Boll Weight(g)	3.2	32
Ginning %	40	39
2.5% span length(mm)	34.0	34.5
Micronaire	3.9	3.9
Strength(g/tex)	42.9	44.9

Egypt

G.barbadense varieties are grown in an area of 2.1 l/ha. Egypt is perhaps the only country in the world to grow both long staple and extra long staple Egyptian cotton. While most of the long staple cotton are consumed by the local mills, the ELS cottons are exported. Thirty percent of the *G.barbadense* area is occupied under ELS varieties while the rest of the area is covered under long staple varieties. The ELS production during 2003-04 was about 3.5 lakh bales, while the long staple production was around 8.0 lakh bales. The productivity was 851 and 887 kg/ha respectively. Giza 70 and Giza 88 are the major ELS varieties. Giza 86, Giza 80 and Giza 85 are the major long staple varieties.

The original barbadense cotton grown in Egypt was probably Sea Island cotton. Later, the Peruvian barbadense cotton was introduced in Nile valley by a French Engineer Jumel and came to be known as Jumel cotton. By cross fertilization, the first Egyptian variety Ashmouni was developed in 1860. They had brown lint. They were first crossed with Sea Island cotton and various grades of cotton were developed. One such grade was called Mit Afifi. This further led to the development of varieties like Sakel and Karnak and through to the present day Gizas. The successful utilization of inbreeding between 1910 and 1940 led to the gradual development of the Egyptian Cottons with exceptional quality.

Table.2 Important Giza varieties and their Fibre Quality Attribute

Attributes	Giza 70	Giza 88	Giza 86	Giza 80
2.5% span length(mm)	36.8	35.9	33.1	31.5
Micronaire	3.3	3.9	4.4	4.2
Strength(g/tex)	45.4	44.9	42.0	37.5
Elongation %	6.4	6.5	7.1	7.8
CSP @ 60s	3245	3340	2850	2400

Sudan

G.barbadense is cultivated in an area of 1.3 l.ha with an annual production of 2.5 lakh bales. Productivity is low with around 420 kg/ha. Barakat and Shambat are the popular varieties.

Inspite of proximity to Egypyt, with river Nile as the common source of irrigation, varietal specificity in Sudan is totally different. To combat Bacterial blight and leaf curl virus diseases, Sudan cotton has gone remarkable change in respect of introgression of genes from the *G.hirsutum* and *G.herbaceum*. The Egyptian Sakel was introduced in 1913 from which Sudan Sakal was developed later. The current varieties are Shambat abd Barakat.

Table 3: Fibre properties of Sudan varieties

Attributes	Barakat 90	Shambat
2.5% span length(mm)	35.0	31.5
Micronaire	3.6	3.7
Strength (g/tex)	34	28

Peru

Till 1997-98, Peru used to produce about 3 lakh bales of Egyptian cotton.Peruvian Pima and Tanguis are the major varieties. While Tanguis cotton is mostly consumed by the local industry, Peruvian Pima is mostly exported. Since then, there is a reduction in area and production of barbadense cotton in Peru.

India

G.barbadense cotton was first introduced in India in 1931 by the East India Company. The initial attempts failed, mainly because of the harsh climate under which it was tested, long crop duration and heavy pest and disease infestation. During 1905, American, Peruvian, Egyptian and Sea Island varieties were experimented in the then Madras Province, but without success. Extensive trials conducted in the canal irrigated tracts of Mysore province gave an indication that barbadense cotton could be grown in at least certain pockets of Southern India. Systematic work was started during 1960s to assemble the germplasm resources available throughout the world and evaluate them. Reselection in the Egyptian variety Karnak resulted in the development and release of first barbadense variety **Sujata.** Later, Sujata in 1969 was crossed with a West Indies variety St.Vincent and variety Suvin was released in 1975. During 1975-80, this variety was cultivated in 25,000 ha with an annual production of 30,000 bales. However, the variety occupies less than 2000 ha.

Table 4: Fibre Quality attributes of Sujata and Suvin

Attributes	Sujata	Suvin
2.5% span length (mm)	32.3	40.6
Micronaire	4.0	3.4
Fibre Strength (g/tex)	31.6	32.3
CSP 100s count (combed)	2421	2830

Improvement in Indian Barbadense Cotton

Productivity of barbadense varieties should be viewed in terms of seed cotton yield, ginning percentage and earliness. Varieties Suvin, the only barbadense cotton under cultivation in India has the longest duration of 210 days and has the lowest per day productivity. Further, it has the lowest ginning percentage among the cultivated varieties. In contrast, barbadense varieties in Egypt and USA have a ginning out turn ranging from 35 to 38 per cent with high productivity. Average lint yield of Suvin across locations in India, when compared to the high ginning, high yielding, medium duration hirsutum varieties and hybrids, are the lowest and the offered higher price for barbadense does not adequately cover the cost of production. Hence, increased productivity in barbadense cotton should collectively address the problem of earliness, higher ginning out turn and seed cotton yield.

Germplasm offers the basic genetic source material. Proper evaluation and utilization to broaden the genetic base is a prime requisite for any improvement programme. Both conventional and modern technologies may be required to develop new varieties that have the ability to adapt to conventional stress and have high genetic potential to take varieties to new levels of sustainable and more stable yield improvement.

Quality Seed Production in Extra Long Staple Cotton

K.Rathinavel

Senior Scientist (Seed Technology)
Central Institute for cotton Research,Regional Station, Coimbatore-641 003

Cotton, the "white gold" is grown in India under diverse agro-climatic conditions in about 8.3 m.ha with a production potential of 160 lakh bales, which constitute about 20% of the cotton growing areas in the world with a share of 12% of the global production. However, area wise, India ranks first in global scenario, it ranks third next to USA and China with regard to production. Nearly one third of foreign exchange (Rs. 50,000 crores) is earned by cotton and textile export. To sustain the export potential via enhancement of its productivity, a comprehensive approach on the production system inculcating all the factors causing cut down of cotton productivity over years is needed at present. Seed being the basic and vital input for cotton production its critical role in cotton productivity and quality has been emphasized in the recent years. Consequences of the release of high yielding varieties and hybrids; the concept of quality seed usage has assumed greater importance. The high quality seed should possess true characteristics of a particular variety and should possess at least the minimum quality standards of seed certification. In this paper, attempts have been made to furnish a complete package of practices for quality seed production including the principles of seed production, processing and certification.

ELS varieties: MCU5, MCU5VT, Surabhi (*G.hirsutum*), Suvin (*G. barbadense*),

ELS hybrids: DCH.32, TCHB213, Sruthi, DHB 105 (*G. hirsutum* x *G. barbadense*)

Field preparation

The land marked for seed production should be ploughed deeply for three to four times and harrowed two to three times for the attainment of fine tilth. Make the soil well pulverized and level the field evenly for uniform irrigation and drainage of excess rainwater. Remove all the stubbles and trashes of previous crop and open up ridges and furrows of 5 m long at a distance of 120 cm.

Presowing seed management

Before sowing, treat the delinted/fuzzy seeds with chemicals or bio inaculants individually or in combination, as per the requirement. The recommended seed treatments are Carbendazim @ two g/kg of seed, Thiram @ two g/kg of seed, Talc formulatian of *Trichoderma viride* @ 4 g/kg of seed, Delinted seeds may be slurry treated or coated with polymers along with Imidachloprid or thiamethoxam @ 5-10 g/kg, Delinted and fungicide treated seeds may be treated 600 g of *Azospirillum* inoculant and sown immediately for the maximum beneficial effect.

Season of planting: August in winter irrigated tracts of Tamil Nadu. Middle of September to first week of October in black soil area.

Sowing

Dibble two to three seeds at a depth of three cm in the furrows where fertilizers have applied, maintaining the correct spacing suggested for that variety and then cover seeds with top soil. Irrigate the field on the same day of sowing followed by life irrigation on third or fourth day. Gap sowing should be taken up on or before ten days of sowing. Retain only one healthy and vigorous seedling per hill and thin out the rest between fifteenth to twentieth days of sowing. Intercultural operations may be carried out to reform the ridges and furrows on 45th of sowing. This operation may be combined with first top dressing of fertilizers. The ridges are formed in such way that the plants are on the top of the ridges and well supported by soil. This may prevent lodging of plants in the event of excess bearing of squares and bolls.

Fertilizers

Basal application of inorganic fertilizers Nitrogen, Phosphorus and Potassium @ 120:60:60 Kg/ha may be suggested in addition to Farm yard manure @ 12.5 t /ha. Nitrogen may be applied in two or three split doses such as 1/2 at sowing, 1/4th at squaring and 1/4th at flowering. Foliar application of 1 to 2 % potassium (Muriate of potash) can be combined with pesticide application. Foliar application of Diammonium phosphate @ 1.0 to 2.0% thrice on 7Oth, 80th and 90th day after sowing may be advocated for good seed filling. Foliar application of zinc sulphate @ 0.5% at flowering stage or soil application @ 25 kg/ha or both, Foliar application of Borax @ 0.3% at boll development stage may correct the deficiency of zinc and boran, respectively.

Buds and bolls shedding

- To avoid shedding of pre mature fruiting bodies, foliar spray 40 ppm NAA (40 mg of NAA dissolved in one litre of water will give 40 ppm) on the crop during square formation and boll setting stage.
- Repeate the same after one month to prevent such shedding and to increase the yield.

- Application of NAA may be alternated with foliar application of DAP @ 1-2% once or twice during flowering.
- To reduce excessive vegetative growth spray application of growth retardant CCC, Lihocin (Mepiquat Chloride) or PIX @ 50 ppm at 85 days after germination.

Water management

Water requirement of cotton crop depends mainly on variety duration of crop, soil type, agro-climate conditions and quality of water used for irrigation. Water requirement of cotton is found vary in the ranges of 60 to 120 cm in different regions. In clay and clay loam soils of South India, it is about 75 cm and in sandy loam soils it ranges from 75 to 85 cm.

Weed management

- For sowing, use good quality cotton seeds free from weed seeds,
- Application of well-decomposed compost, farm yard manure etc., free from seed, stem, runners, stolon and bulbs of weed plants.
- Intercultivation of cotton fields with junior hoe followed by earthing up with ridge plough will eliminate most of the weeds besides providing good aeration and anchorage to the root system.
- Fluchloralin/ Basalin 48 % EC @ 1.0 to 1.5 kg/ha or Pendimethalin / Stomp 30 % EC 1.25 to 2.00 kg/ha may be applied as pre-emergent soil incorporation for the control of broad leaved weeds.

Harvest

The time of picking of matured bolls is an important aspect for maintaining seed quality. Delayed picking of matured bolls may affect the seed quality. The picking should commence when the cotton is fully matureand the bolls begin to open. Picking of bolls more than once at a specific interval depending up on the weather condition may be required, since bolls ripen over a period of two to three months. The crop maturity and weather decides the number of pickings in a seed crop. The following steps may be considered while harvesting.

- Seed cotton from first five pickings in winter crop and first four pickings in the summer crop alone may be ginned for seed purpose.
- The bolls may be harvested at frequent intervals and the duration of inerval should not be less than 7 days.

- Picking should not be done at high level of humidity or rain. Bolls at high moisture content in any manner need not be picked and stored. The occurance of heat at moisture content may cause damage to seed. Further, exposure of high moisture seed to ginning may cause more mechanical damage.
- As soon as seed cotton is harvested, the unopened locks from the good puffy ones may be separated.
- Harvesting of seed cotton may be restricted to morning hours upto 10 to 11 am only so that dry leaves and bracts do not stick to the kapas.
- Bolls spoiled due to rains or damaged by insects or otherwise damaged, should be picked separately and discarded.
- The kapas should be shade dried immediately after each picking to reduce the moisture content.
- The picked cotton when it is completely dry should be stored in a dry place and covered if ginning is delayed.
- Faulty ginning may causes seed injury which may go upto 6.5%.
- Immediately after ginning the fuzzy seeds obtained should be air-dried. If heaped, heating would cause loss in viability.

Post harvest processing

Following steps needs to be followed for effective seed processing

1.Raw cotton, 2. Pre-cleaning, 3.Ginning, 4. Fuzzy seed cleaning, 5.Delinting, 6.Fuzzy seed, Delinted seed cleaning and upgrading, 7.Gravity separation, 8.Seed treatment, 9.Seed packaging & labeling.

Ginning seed Cotton

The seed cotton is ginned when the moisture is 15-17% to avoid mechanical damage to seeds. The fuzzy seeds received from the gin were shade dried before being forwarded for cleaning. The ginneries engaged for ginng cotton seed were evaluated for their performance and seed quality. The saw gin is found effective for ginning seed cotton (Kapas) as compared to roller gins. The results revealed that about 1 to 1.5% seed gets damaged on saw gin and 7 to 8% lint remain with seed compared to 3 to 4.5% seed damage obtained from roller gin and 12 to 14% lint remaining with seed.

Fuzzy seed cleaning

Majority of the fuzzy cotton seed is screened manually and the broken, ill filled, insect damaged are hand picked from the screened seeds. The hand picking efficiency of a person is below 12 kg per day for hybrid cotton and 15 kg per day for improved cotton.

Delinting of seeds

The cotton seeds obtained after ginning have 8 to 10% of lint attached on the seed coat (fuzz), which make them cling together during sowing. Delinting is a process by which the fuzz remained in the seed coat is removed so that seed flow freely during sowing. The advantages of delinting are

- Free flowing of seed makes the processing machinery easy, used for cleaning, upgrading, treating and packing.
- Acid delinted seed can be planted very precisely.
- In the process of delinting seed coat is disinfected, hybernating pink bollworm larvae inside the seed if any are killed, hence no need for fumigation.
- Germination rate of delinted seed is enhanced by 2 to 3 days
- The process of delinting aid for removal of illfilled and immature seeds, which hinder the establishment of vigourous seedling and uniform crop stand followed by better yield.
- High level of field emergence could be obtained in problem soils.
- The volume of seed is reduced and hence occupies less space in storage godown.
- The cost of seed treatment is reduced.

Delinting methods: 1.Mechanical delinting, 2.Wet sulphuric acid delinting, 3.Dilute sulphuric acid delinting, 4.Foam delinting, 5.Dry Hydrochloric acid gas delinting

Acid-delinting procedure

- Choose either plastic or enamel coated bucket for delinting of seeds.
- Use earthenwares, metal vessels, and porcelain wares for delinting are not advised, as sulphuric acid will corrode them.
- Place the required quantity of seeds in the container and add commercial grade sulphuric acid @ 100 ml / kg of fuzzy seed.

- Stir the seeds along with acid, vigorously and continuously with a wooden stick for 2 to 3 minutes until the fuzz sticking on to the seeds is completely digested and the seed coat attains a dark brown colour.
- After three minutes, add water to fill the container and stir with wooden stick once or twice.
- Drain the acidic water and repeat the washing 4 or 5 times so as to remove even the trace of acid.
- Remove the floating, ill filled, damaged, diseased and insect attacked seeds while retaining the healthy and good seeds, which remain at the bottom.
- Drain the water completely and dry the delinted seeds in shade to the required level of seed moisture.

Hybrid Seed Production

India is the only country to grow hybrid cotton in a commercial scale to the extent of nearly 50% of its area under cotton cultivation. This is mainly because of large-scale production of hybrid seed adopting hand emasculation and pollination technique.

Planting of parents

The parents of the hybrids are generally grown in separate blocks side by side and are raised in 2:1 or 3:1 or 4:1 ratio of female: male, depending upon the flowering behaviors and ability to produce pollen grains in the male parent. Both parents should be planted in isolated regions with an isolation distance of five meters between plots. The planting dates of two parents should be appropriately adjusted for synchronization of flower opening. The parental purity in the hybrid seed-producing plot should be maintained and inspected thoroughly for the removal of off type plants, if any. Once the emasculation and pollination is completed, the male parents are removed. The female plot alone is maintained with all the management practices until the picking of the final set of crossed bolls.

Increase of flower

Soil application of zinc sulphate (50 kg ha^{-1}) followed by foliar spray (0.5% at 75 and 90 DAS enhanced number of flowers $plant^{-1}$, maximum pollen production and higher percentage of viability. Number of flowers produced $plant^{-1}$ up to 130 DAS will be more if three foliar sprays of 0.5 %, $ZnSO_4$ at 70, 90 and 110 DAS is given in the summer. In the winter crop soil application of $ZnSO_4$ (50 kg ha^{-1}) alone and three foliar applications of 0.5%, Borax may produce more flowers/plant in TCB 209 (male parent of hybrid TCHB 213).

Seed setting

Depending on the species involved in the crossing program and management practices, setting percentage varies. Generally, it ranges from 40-50% in *G. hirsutum* x *G. barbadense* crosses under good management. Physical disturbances during daily crossing, insufficient pollen dusting, incorrect time of crossing and pollen parent incompatibility etc. may reduce setting percentage. Even under normal circumstances, ratio of final boll set to total flowers or squares produced is only 25-35% due to physiological, environmental and pest induced shedding.

- Treatment of the gynoecia with gibberellic acid 50 or 100 ppm for all or part of the crossing season improve percentage boll setting and seed yield.
- The boll setting was observed more in the early period of crossing i.e. from two to five weeks of initiation of flowering.
- The seed soaking treatment succinic acid @ 0.2 % given to female parent before sowing and subsequently foliar application of boron @ 0.1 % at 60 and MgSO4 @ 1.0 % at 75 days after sowing resulted higher boll setting, more cross boll weight, with seeds having high viability and seedling vigour.
- In inter specific seed production Lakshmi x SB 289 E, removal of 1, 2 or all 3 bracteoles at the time of emasculation of the female parent adversely affected boll set percentage.
- Production of hybrid seed in the cotton hybrid Varalaxmi rubbing the anthers around the stigmatic lobes was found superior than to dusting the pollen on the stigma, in terms of better boll set, seed weight and seed number/boll.

Pollination Techniques

Cotton is an often cross-pollinated crop with 3 to 20% cross-pollination, depending upon the insect activity and environment in which the parents are grown. The flowers are solitary in to axils of leaves. The pollen grains of cotton are heavy, sticky and warty leaving little chance for wind pollination, hence, emasculation and pollination are essential, which makes hybrid seed production a tedious, costly and difficult process. Even if genetic or chemical method of emasculation are practiced in specific crosses, physical transfer and dusting of pollen grains on stigma of each emasculated flower is essential and has not been circumvented by pollination employing honey bees or other effective techniques. The problem of nicking is not there in cotton since the flowering extends over a period.

In commercial seed production, emasculation and hand pollination is a daily activity, extending for a period of 30 to 60 or even 90 days. For obtaining good quality seeds, it is advisable to restrict the pollination to 30-40 days of effective flowering.

Being an indeterminate crop, cotton has a continuous flowering habit and flowering starts 50 to 60 days after sowing. The effective flowering interval in a growing season ranges from 45-90 days, depending upon the variety/species. The flowers are produced in regular intervals of 3 and 5 days, respectively, on horizontal and vertical axes of sympodial branches of the main stem. The opening of flowers follows a spiral course in acropetal and centrifugal succession. Among the various systems to produce hybrid cotton the traditional hand emasculation (Doak's method) of female parent in the evening hours followed by pollination in the next morning has been widely adopted for commercial seed production. Before starting emasculation in commercial hybrid seed production plots, all the opened and uncrossed flowers are removed completely from the female parent plots to avoid mixing of crossed boll with naturally set bolls. In the process of emasculation, first the bracts are removed from the selected fully grown flower bud. Then the petals together with androceum, which along with anther sac are removed gently, and smoothly by cutting them with thumb nail without damaging the stigma, style, ovary or even the white covering of the ovary. After emasculation, the flower buds are covered with red tissue paper or straw tube to avoid the contamination of the emasculated flower by exotic pollen. The emasculation in the female parent bud is done during the evening hours from 3.00 to 6.00 p.m.The following care must be taken during emasculation

- Cutting from the external layer of the calyx into the internal perianth layer should not be too deep in order to prevent damaging the ovary, and the white membrane covering the outer wall of the ovary.
- Do not strip off the bracts. To avoid breaking the stigma, the calyx and perianth should not be pulled off too violently.
- To emasculate completely, be sure that no anthers are left on the pistil.

The stigma of the emasculated female flower is highly receptive from 8 to 10 a.m. of the subsequent day of emasculation. At this time, pollination has to be carried out using pollen from the male flower, for which the flower about to open are to be collected, the bracts and petals removed and kept open under sun in a plastic tray in the morning hours (8 to 10.0 a.m.) of the day of pollination. Normally, one flower from male parent can be used to pollinate 5-8 emasculated buds depending upon the parental species, genotypes, season of crop growth, etc. During pollination, the flower is held in right hand, with exposed androecium shaken gently or rubbed on the stigmatic receptive surface of the emasculated bud. Dusting of sufficient pollen must be ensured on all the stigmatic lobes for the proper development of all the locule. The emasculated flower should be handled with care to avoid snapping.

Soon after pollination, the red bag or tube in the female flower is replaced with white bag or tube, to get protection from foreign pollen. The uncrossed flowers left in female parental plots are removed and destroyed on each day after completion of pollination. A trained labour can emasculate nearly 300-400 flowers in the evening and pollinate the same number of flowers in the morning hours of the following day, depending upon the age group, skill and supervision. In this method, successful boll setting ranges between 30 and 80 % depending on the hybrid, stages of crop, crossing efficiency and crop husbandry.

To produce a high yield of hybrid seeds with high purity, proper attention should be paid to the following aspects.

- Plan the time for pollination effectively and strive to pollinate in the morning. During rainy period, when pollination cannot be done in the morning, pollen should be kept in an ice bottle or refrigerator and used after the rain is over.
- Sufficient pollen should be exerted while pollinating
- Pollen should be smeared on the stigma very gently to avoid any damage to the stigma and affecting the boll setting rate. Care must be taken to smear on all the stigmatic lobes for the proper development of seed on all the locules. The beak shaped crossed boll on to female plants indicates improper dusting leading to non-development of one or two locules.
- Any unemasculated flowers should be picked off immediately and taken out of the field.
- After pollination has been finished, pluck off all the ineffective buds. Inspect the field daily and if there are any remnant buds or flowers, pluck them off. At the same time, topping and pruning should be practiced.

- Inspection should be done in the field plot-by-plot, row-by-row, and plant-by-plant. After emasculation and before pollination, pluck off all the remaining flowers. One week after pollination, the bolls may be identified as selfed or crossed. A sharp boll bottom characterizes crossed bolls. The selfed bolls should be picked off to ensure the purity of hybrid seeds.

Methods of hybrid seed production

The problems faced during hand emasculation and pollination forced to develop an alternate method of hybrid seed production using male sterility systems. Based on the mode of inheritance male sterile lines are classified into Genetic Male Sterile System (GMS) and Cytoplasmic Genetic Male Sterile System (CGMS).

Genetic male sterile system (GMS)

In this system, nuclear genes govern sterility. Gregg MS 399 conditioned by two pairs of recessive genes, ms5ms5ms6ms6 is the most stable and promising. The merits are conversion only for male sterile lines, no change in the morphology of plant except anther size, less labour in hybrid seed production, high genetic purity of seed obtained. The demerits are removal of 50% fertile plant in seed plot, less hybrid seed yield per unit area, maintenance of male sterile line needs hand pollination, conversion of male sterile line is tedious.

Cytoplasmic Genetic Male sterility System (CGMS)

In cotton, CGMS system is developed by introgressing cytoplasm of one species into the nuclear background of another species. The nuclear genome of G. hirsutum variety, designated as 'B' line is transferred by repeated back cross into the male sterile cytoplasm (CMS) source 'A' line, to get its CMS A counterpart, as an isoline. The lines A and B are isolines, except that 'B' is normal, while 'A' line has sterile cytoplasm from the basic source. The 'A' line is maintained by pollinating with 'B' line, while 'B' line is maintained by selfing. By crossing the 'A' line with 'R' line with fertility restorer gene, fertility is restored in F_1 hybrid grown as commercial crop. The merits are easy and quick conversion of 'A' line, less hybrid seed production cost, high genetic purity of hybrid seeds, high boll setting in hybrid seed production, more than two parents can be used in hybrid development and the demerits are reduced flower size in female parent, conversion of 'R' line is tedious, need for maintenance of 'A','B' & 'R' lines, 'A' line multiplication needs hand pollination.

Steps to increase efficiency in hybrid seed production

- Emasculate and dust as far as possible all buds appearing during the first six weeks of reproductive phase to ensure good setting and development of bolls,
- Restrict your emasculation to each day evenings to 3 PM to 6 PM and pollination to morning between 10 AM to 1 PM to ensure highest purity of hybrid seed. Emasculation should be complete and perfect.
- Choose optimum size of bud and avoid too young or too old buds for emasculation,
- Cover the male buds with paper packets previous evening for their use next day. Emasculated buds may be covered preferably with buffer paper packets,
- Do not forget to tie a thread to the pedicel of the bud immediately after pollination.
- Close your crossing programmes after 9th week (from commencement of crossing) and remove all buds and flowers appearing subsequently to facilitate the development of crossed bolls.
- Nip the top and side shoots at the stalks to stop further vertical and horizontal growth.
- Light irrigations should be given as and when required. Excessive, scanty, or inadequate irrigations should be avoided especially during crossing and boll development period.
- Continue irrigation until last pick of the crossed bolls. Frequency of irrigation depends on weather factors like rainfall, temperature and wind velocity.
- Pick up the ripe and completely opened bolls along with brackets and threads on and collect in baskets for second sorting. Bolls without threads may be bulk harvested as Laxmi seed cotton.
- Crossed bolls collected in baskets may be sorted out for second time to verify that they are crossed bolls, then collect the crossed seed cotton and store in gunny bags carefully marked as crossed bolls.
- Rain touch cotton or hard locks should be picked and kept separately to avoid poor germination of hybrid seeds.
- Store the crossed seed cotton in a cool dry place until it is handed over to processing unit.

- Seed producers are required to keep a clear accqunt of the cost of production of hybrid seed.

Ginning, storing and certification

- Gin the crossed kapas in separate gins erected in seed processing units or farm gins under the close supervision of the authorities concerned to ensure purity and avoid seed damage.
- Sieve the seed in two types of mesh to remove small-shriveled seeds, broken seeds and clean perfectly from any dirt or dust.
- After ginning, the seeds should be dried well and cleaned by hand picking. After cleaning, certification agency will take sample for testing germination and genetic purity test. Minimum germination - 65%, Genetic purity - 90%
- Certified seeds would be bagged in one kg bag, sealed and specified regarding its origin, germination per cent, physical purity per cent and genetical purity per cent, besides season of production and passed on to sale agencies or respective producers for commercial sale at the specified rate.
- The concerned Department or Agency would procure uncertified seed at the market rate for the ordinary cotton seed for further destruction. This step is essential to avoid unauthorized sale of substandard uncertified seed.
- The seeds when put into potable water will separate into sinkers and floaters. Dead seeds become buoyant and float.
- Sinkers may be soaked in double the volume of 3.59 g of Disodium phosphate in 100 lit.water for 2 h (Fuzzy seeds 1 h). The soaked seeds should be air dried to original moisture content. The mid storage correction improves the planting value of old seeds.

Seed certification

The land to be used for production of cotton seed must be free of volunteer plants of cotton. Cotton is mainly a self-pollinated crop but natural cross-pollination has been recorded in all the species. The actual isolation requirements for cotton vary according to the extent of natural cross-pollination. In India, a minimum isolation distance of 50 meters for foundation seed class and 30 meters for certified seed class production from fields of other varieties of the same species, other species and fields of the same variety not confirming to varietal purity requirements for certification is necessary.

In cotton three types of seed production is followed

1. Parental line seed multiplication
2. Hybrid seed production
3. Varietal seed production

If male-sterile lines are used for producing hybrid seed, following eligibility requirements are to be considered

- An inbred line to be eligible for certification shall be from a source such that its identity may be assured and approved by the certification agency.
- Hybrid seed to be eligible for certification shall be the progeny of two approved inbred lines, one of which shall be male-sterile
- An inbred line shall be a relatively true breeding strain resulting from self-pollination with selection.
- The foundation class seed shall consist of an approved male-sterile line to be used as a female parent and an approved inbred line to be used as a male parent for producing hybrid seed.
- A male-sterile line shall be a strain carrying cytoplasmic-genetic male sterility, which sheds no viable pollen and is maintained by the normal sister strain, which is used as a pollinator.
- The certified-class seed shall be the hybrid seed to be planted for any use except seed production.

Breeder's seeds for raising foundation seed crop, foundation seed for raising certified seed crop, parental line seeds for producing hybrid seeds should be obtained from an approved source. The seed is usually treated with the appropriate recommended chemicals. If not it should be treated with captan, thiram or carbandazim @ 2 g kg^{-1} of seeds before sowing.

Sowing of cotton seeds for seed production should be informed to the Seed certification agency within 35 days from the date of sowing. Seed field inspections are carried out by the Seed certification agency in two stages one at 75 days after sowing i.e. during flowering and the second in 105 days i.e. at crop maturity stage. In both the stages of inspection, the seed certification authority verifies the seed crop isolation and assesses the presence of off-type plants. Off-type plants are assessed by entering and observing the seed field at a randomly selected site from any side and start moving in the direction of the rows or start at random from any point in any row and count ten consecutive plants in that row. Count the number of off-types, inseparable other crop plants, objectionable weeds, and plants affected by designated diseases with in these ten plants.

In case of hybrid cotton in female parent, take counts for off-types in addition observe selfed bolls (often selfed bolls non-bagging before pollination and improper emasculated) in every 50th, 100th plant of each count. Count the total number of bolls (crossed bolls, selfed bolls, open flower, non-bagging before pollination and improper emasculated flowers) from the aforesaid plants and arrive percentage. Observe for off-types in male rows separately. Crossover the pre determined number of rows and again start counting ten consecutive plants from a point nearly parallel to the last plant counted in the previous row. Count the factors mentioned above. Repeat the process eight more times until total 100 plants have been examined and the factor counted.

In general wherever the plant population is lesser than the actual number to be counted take entire population, study and arrive the purity of the field. Wherever the counting procedure could not be adopted as per the above said procedure, take entire populations study and arrive for the purity of the field.

Seed standard

The seed standards prescribed for certification is as follows

Factor	Varieties		Hybrids	
	Foundation	**Certified**	**Conventional**	**Ms based**
Physical purity				
Pure seed (Minimum)	98%	98.0%	98%	98%
Inert matter (Maximum)	2.0%	2.0%	2.0%	2.0%
Other crop seeds (Maximum)	5 kg	10 kg	5 kg	5 kg
Weed seed (Maximum)	5 kg	10 kg	5 kg	5 kg
Germination (Minimum)	65.0%	65.0%	65.0%	65.0%
Moisture (Maximum)	10.0%	10.0%	10.0%	10.0%
For vapour proof containers (Maximum)	6.0%	6.0%	6.0%	6.0%
Genetic purity				
Pure seed	99%	98%	90%	95%
Selfed female			8.5%	4.0%
Off-type	1.0%	2.0%	1.5%	1.0%

Agronomic practices to improve long and extra long staple Production in the country

C. S. Praharaj and K.Sankaranarayanan

Senior scientists (Agronomy)

Central Institute for Cotton ResearchRegional Station, Coimbatore-641 003

Cotton (*Gossypium* spp.), popularly known as "**white gold**" being a premier cash crop of the country enjoys tremendous potential in economic and trade related activities besides sustaining substantial employment generation. Nearly one-third of India's export earnings are from textile sector of which cotton alone constitutes 70 % raw material. Moreover, cotton, being the principal raw material for the textile industry, it provides livelihood to about 60 m people who includes traders to farmers. Grown in all the three distinct agro-ecological region of its cultivation (northern, central and southern zone), cotton productivity is highest in the northern zone and lowest in the central zone.

Thanks to all the stake holders as cotton production increased from 5.3 million bales (1 bale=170 kg *kapas*) during 1966-67 to an estimated 23.2 million bales in 2004-05 (from an area of 9.06 million hectares with a productivity of about 440 kg lint/ha). This was attributed to 15.2 % increase in area under cultivation particularly in comparison to last year, favorable weather conditions and spurt in hybrid cotton area. The sudden surge in the cultivation of hybrid cotton (40 % area) was on the sentiments of cultivating Bt hybrids although not released for even northern states. However, although our achievements are low against the world average of 558 kg/ha, yet it is within the limits of our agro-climatic situations. The quantitative changes in production and consumption pattern of the different staple lengths in our country indicate that there is shortfall of a clear cut huge 19 lac bales of long and medium staple cotton which has been met through imports. Here the importance of production practices is realized to gap the target.

Suitable agro-techniques viz., proper planting schedules (time and method of planting), optimum plant population and crop geometry, judicious and balanced fertilization / fertigation, use of improved and stable high yielding cultivars/hybrids, timely control of pests & diseases including weeds and effective irrigation scheduling for irrigated crop and proper water harvest cum management strategy for rainfed crop play a crucial role for achieving the higher productivity of quality cotton.

With reference to fibre quality, the micronaire of Indian cotton is invariably lesser than that of foreign countries even in the same length groups. For Indian cotton belonging to long and extra-long cotton (Table-1), ideally micronaire should be in the range of 3.8-4.2 (3.5-4.8 in US cottons). However, it is around 3.0 i.e., immature fibres lead to neps and uneven places during yarn processing. At the same time, too much of short staple but high micronaire & coarse cotton which makes it difficult for spinning and are used mostly for alternate use of cotton viz., absorbent cotton and non woven filters. Besides length, strength is also low in Indian cottons which deteriorated over time and needs to have a fill up. Even short staple varieties i.e. mostly diploids can be improved in length and micronaire to be spun easily keeping aside their weakness as under.

Agronomic practices to improve long and extra long staple production

Since fibre properties are primarily governed by the genetic make up of the cultivar, yet strong genotype and environment i.e. soil and climate including management interaction exists which modify the ultimate expression of fibre properties.

It is estimated that about 80 % of the variation on fibre length is governed by genetic factors. On the other hand, 60 % of the variability in micronaire and 80 % of the variability in colour grades are controlled by environmental factors. The measures that might ensure maintaining normal fibre quality characterized by of its own genetic make up without productivity decline include most agro-technogical practices including management interacting with environment. These practices are discussed herein as under.

Climate and soil constraints

The climate and soils are the pre-requisites for successful raising of the crop(s) in an Agro-ecoregion. The most essential climatic factors which influence fibre development are temperature and light intensity. Weather factors like cold, frost, drought etc. also have direct or indirect influence on boll maturation.

A minimum temperature of 15°C is required for successful germination of the seeds. The optimum temperature ranged for vegetative growth is 21-27° C although the crop can tolerate a temp. as high as 43° C but doesn't grow well if the temperature falls below 21° C. However, warm days & cool nights with large diurnal variations are conducive to good boll and fibre development.

Loamy sand to sandy loam soil with effective drainage system in north zone is highly suitable for good quality cotton where soil temperature is high at sowing while soils are low in nutrient status. However, deep *vertisols* (black loamy soil) are good for long and extra long staples viz., hybrid and *hirsutum* cotton. Red loamy soils in south zone pockets are also suitable for cotton. Normally, the pH ranges from 5.5 to 8.5 are suitable for cotton with soil depth up to at least 60 cm. Besides this, certain soil problems such as crusting, hard pan, salinity, water logging, acidity, moisture and nutrient stress may affect quality cotton production.

Fibre length was negatively correlated whereas fibre strength was significantly and positively correlated with the difference between maximum and minimum temperature. Field studies in India showed that fibres grown at 15°C took 3 to 5 days longer to reach 2 mm in length than did control fibres grown at 24°C. Studies also indicate that under controlled condition as temp increased from ambient to 7°C above ambient, the fibre length distributions became more uniform (Reddy et al. 2004). Fibre fineness and maturity increased linearly with increase in temp. up to 26°C but decreased at 32°C. Short fibre content decreased linearly from 17 to 26°C but was higher at higher temp. As the temperature Increased the short fibre mote content increased at ambient as well as elevated (720 ppm) CO_2 levels. The long fibre fluctuations were random at both the CO_2 levels. Similarly, compared to normal, under shaded condition, the fibre strength was reduced by 3 %, micronaire was reduced from 4.38 to 4.21 and fibre maturity was reduced from 85.1 to 83.6 % (Venugopal et al. 2005).

Planting materials

Selection of a specific varieties and hybrids suitable for a region is the key for success of a crop/commodity. Mainy varieties of *G. hirsutum* and *G.barbadense* and their hybrids are grown in all the cotton growing states. *G. herbaceum* varieties are taken up in some areas in Gujarat and Karnataka and that of *G. Barbadense* in Tamil Nadu and Karnataka. The major released and still sown varieties/hybrids under long and extra long staple grown in different zones are listed here. There exits variability in quality parameters at different locations (Table-3).

Some of the important long & extra long staple cultivars under cultivation in India

- *Hirsutum* varieties: Surabhi, MCU-5, MCU-13, MCU 5 VT, LRA 5166 (popular but medium)
- Intra-*hirsutum* hybrids: H-4, H-6, PKv Hy-2, G cot H-8, Savitha, NHH44
- Barbadense varieties: Suvin, DC 59-2, DC 58-14, K 3474
- Interspecific hybrids: Varalaxmi, DCH 32, HB 224, NHB 12, G cot DH-7, G cot DH- 9
- *Arboreum* varieties: Parbhani Turab, Jawahar Tapti, AHH-1, G Cot DH-9, PA 405
- *Herbaceum* varieties: G.Cot-21 & G. Cot-23, K7 K8, K9, K10, H511, LS 1, LS 2

Time of planting

Time of planting under an agro-climatic region is the most important non-monetary critical input affecting the growth and yield of the cotton crop. Thus, the decline in yield due to delay in planting may not be compensated fully by other agro-techniques including excess use of the costly inputs.

The optimum time of sowing varies with crop growth behavior, moisture need and heat unit requirement and is different in different agro-climatic regions under various growing conditions (irrigated/rainfed). Environmental modification of fibre maturity (micronaire) by temperature was most often identified in planting and flowering dates studies and delayed planting usually lowered micronaire values. (Porter et al.,1996).

Crop geometry

Crop geometry is the ultimate spatial arrangement in a particular field affecting growth, development and subsequent yield of a crop which is the deciding factor (along with required plants maintained per hill) for seed rate required for an unit area and has a bearing on plant density to be retained in the field.

Dwarf and compact varieties require closer spacing (high plant density) for better performance. However, earlier highly branched monopodial varieties and hybrids of cotton do require wider spacing over their non-branched sympodial and *desi* counter parts. Recent result indicating closer spacing and thus, higher plant population for higher yield has been reported in many cotton-growing areas of the country.

Weed control

The crop is highly susceptible to competition due to weeds from emergence to around 60 DAS (25-60 DAS being the critical period) when the crop covers the ground. Weeds remove available nutrients from the soils and compete with crop for light, moisture, nutrient and space, thereby render deterioration in crop performance in terms of quality and out put.

Besides manual weed control, use of suitable and appropriate herbicide provides a very pertinent role in timely control of weeds. Supplementing herbicide with use of modern tools/implements for row crops like cotton and effective crop management (crop rotation, mixed or intercrop and mulching etc) are crucial for an effective integrated weed control strategy. Application of Fluchloralin @ 1 kg/ha or pendimethalin @ 1.25-1.5 kg/ha or butachlor @ I kg/ha as pre-planting application followed by one interculture at 35 DAS has consistently performed better in control of weeds and increased cotton production in many areas of the country. Moreover, use of tractor drawn harrows for interculture and removal of weeds are more common in northern zone, while bullock drawn blade harrows are common in central and southern states. Sometimes, chemical weed control alone proves better especially in a black cotton soils and other heavy soils where incessant rains makes the mechanical weeding not feasible.

Nutrient management

Integrated nutrient management is the most efficient and practical way to mobilize all the available, accessible and affordable plant nutrient sources in order to optimize the quality/output of the crops/cropping systems and economic return to the farmer. Three years data collected from 267 sites in India under different crops convincingly show a 22 % increase in yield by following INM rather than farmer's practice (Govil and Kaore, 1997). This has happened because of balanced application of nutrients based on soil test as well as due to proper integration of organic sources with fertilizers.

Since cotton crop forages deeper (45 cm) into the soil and are thus, efficient in availing the native soil nutrients like P & K. Hence response to P & K is probable and the crop need is low in many cases. However, universal crop response to applied-N is reported in many locations in India. As per 2020 projection, we require around 23.0 m bales for which anticipated requirements of N,P & K is 1.2, 1.1 and 1.8 m tones respectively (Kairon and Venugopalan, 2000). Amongst secondary and micronutrients, S & Zn deficiencies are on the rise (Rattan et al., 1999).

Fibre property modulations due to the application nutrients are often contradictory due to the complex interactive effects of genotypes, climate and soils.

Thus, response of cotton bolls to the environmental ·al variables is essential for realizing yields with acceptability quality parameters.

Nitrogen

The quality parameters of cotton have a great significance in fetching good market price, have got direct relationships with the monetary gain. It is observed that the fibre quality is also adversely affected by the application of nitrogen. Contrary to it observed improved ginning percentage with application of nitrogen. Full genetic quality parameter potential of any particular cultivar is only realized when optimum atmospheric and nutritional environments are available.

Cotton uses very little N during the first 50 days of growth. As the crop approaches the square/early blossom stage, N uptake increased markedly. The peak rate of N use occurs between 75-135 DAS during which 3.5 kg N/ha/day may be used. Thus, it would be most desirable to add N at a time approximating as closely as possible to the peak requirement of the cotton crop.

The index of efficient use of fertilizer is higher yield per unit N applied and greater B: C ratio. Nitrogen application increased fibre length and strength but usually decreased micronaire from an optimum dose to higher one. Moreover, uniformity ratio, ginning out turn, lint-index and maturity co-efficient were not influenced by the variation in Nitrogen (Nehra et al, 2005). Span length was increased significantly up to 120 kg N/ha. From new south wales, Australia, it was concluded that N fertilizer generally increased fibre length and strength but decreased micronaire (Constables and Hearn, 1981). In a 5 yr study, micronaire decreased with increasing n application rates from 101 to 202 kg/ha (Reddy et al. 2004). Leaf N during boll maturation stage had a significant positive correlations with mean fibre length, fine fibre fraction and immature fibre fraction and negative correlations with fibre diameter, short fibre content, fibre cross sectional area.

Phosphorus and Potash

The application of P did not produce significant effects on quality of fibre (Table -1). The reason being that genetic and environmental factors apparently exert so much influence on fibre quality that little direct effect from phosphorus can be elucidated.

Potassium has a key role in improving quality of fibre and bundle strength besides hastening maturity of the crop. K application possibly increases the micronaire in cotton. Sometimes K supply increased fibre length and strength besides enhancing maturity ratio (Table-2).

In Israel, applied K improved all the fibre properties except fineness. Its application increased fibre length and micronaire and fibre strength and fibre maturity index. Usually the over all effect of the K deficiency appears to be a reduction in the amount of photosynthates available for the reproductive sinks which promotes the yield and fibre quality reductions associated with production under K deficiency. Micronaire values of 3.5-4.9 are regarded most desirable in respect of fibre strength and moderate application of K not only improved boll size but also its fibre strength and micronaire (Table-3).

Table-1 Effect of P levels on quality parameters of cotton fibre (Multan, Pakistan)

P_2O_5 levels (kg/ha	2.5 % S.L. (mm)	UR (%)	Fibre strength (000'lbs/inch^2)	Micronaire (mg/g)
Control	26.1	46.4	94.9	4.68
100	26.4	46.4	94.8	4.58
150	24.4	46.7	95.3	4.65

Table 2. Effect of K fertilization on fibre quality of Stoneville(Venugopalan et al.2004)

K levels (kg/ha	2.5 % S.L.(mm)	Strength (KNm/kg	Micronaire (milli tex)	Maturity ratio	Elongation (%)	Perimeter (um)
Control	28.2	218	3.84	78.5	7.10	47.2
112	28.3	214	4.05	80.5	7.42	48.0
C.D. (0.05)	NS	3.00	0.07	1.2	0.09	0.40

Table-3. Effect of K levels on fibre parameters of cotton fibre (Multan, Pakistan)

K_2O levels (kg/ha	Bolls/ kg	Fibre length (UHM/cm)	Fibre strength (000'lbs/inch^2)	Micronaire (mg/g)
Control	243	0.42	1.49	3.70
70	176	0.44	1.50	4.80
140	163	0.44	1.57	4.28
280	163	0.43	1.47	4.23

Shanmugam and Bhatt 1991 observed at Coimbatore that application of 1/3 of the total K through foliar during flowering and the remaining through soil at sowing maintained 30-306 % K in the leaves during the reproductive stage, improved 2.5 %

span Length, uniformity ratio, fibre fineness, maturity coefficient and fibre strength. Moreover, application of 2/3rd of K dose through soil and the remaining as foliar spray improved fibre quality parameters compared to no application of K as well as application of the entire quantity (45 kg/ha) through soil (Bhatt 1996) (Table-4).

Table 4. Effect of soil and foliar K fertilization on Suvin (Venugopalan et al. 2004)

K levels (kg/ha	2.5 % S.L.(mm)	UR ratio (%)	Micronaire (milli tex)	Maturity coefficient	Strength (g/tex) 0gauge
Control	31.4	37.0	106	0.58	51.9
45 kg/ha soil	34.0	39.0	110	0.64	54.5
30 kg/ha soil + 15 kg/ha foliar	37.4	43.0	124	0.70	57.5
C.D. (0.05)	1.2	2.11	2.75	0.19	2.01

The treatment viz., NPK + K foliar at early and peak boll formation stage @ 5 kg K_2O/ha gave slightly increase in 2.5 % staple length and strength (g/tex), where as elongation percent and micronaire were higher in NPK + K foliar at peak boll formation stage @ 5 kg K_2O/ha. Uniformity per cent was slightly higher in NPK soil applied (Anonymous, 2003-04).

Secondary & micronutrients

Deficiency of Mg results in mostly reddening of leaves (red leaf systems (RLS) while Fe and Mn deficiency leads to chlorosis of leaves. On the contrary, Zn and B deficiency lead to the problem of improper bud and boll opening and subsequently in boll rotting and decline in fibre quality. For correcting these deficiencies, Mg as 1% $MgSO_4$ as foliar spray while others can be given 0.3-0.5 % SO_4 of Fe, Mn and Zn foliarly or 25 – 50 kg sulphates of these cations to soil per hectare. Since boron deficiency is associated with boll rot in cotton, spraying of borax @ 0.5% or boric acid @ 0.1% also beneficial.

Biofertilizers and green manures

Biofertilizers play a useful role in reducing cost of cultivation by way of decreasing fertilizer usage especially that of N to the tune of 20 kg N/ha. In cotton-chick pea sequential crop at Rahuri, maximum fibre yield was realized with combined application of FYM @ 5 t/ha, green manure dhaincha buried in situ, Azotobacter, Azospirillum and seed treatment with PSB (Phosphate solublizing bacteria); followed by combined application of FYM @ 5 t/ha & green manure dhaincha buried *in situ*.

Fibre Quality Index, an index based on span length, bundle strength and micronaire value was maximum (400) under the combination of FYM @ 5 t/ha, cotton whole residues @ 2.5 t/ha & sun hemp buried at 45 days which proved the importance of *in situ* farming on production of quality fibre (Praharaj et al, 2005b).

Table-5 depicts the correlations between fibre parameters and properties of soil. Fibre properties viz., micronaire, length, elongation, uniformity, strength are more strongly correlated with soil moisture and soil P. Soil pH and organic matter also increased fibre quality parameters. Fibre length, micronaire, strength and elongation were influenced by water supply. Moderate moisture stress increased fibre length but did not increase fibre strength and maturity. There was an increase in fibre length and a decrease in micronaire with increase in soil moisture regime on a sandy loam. Moisture stress reduced fibre length and increased micronaire.

Moreover, Johnson et al 2002 observed that a strong correlation between soil pH and micronaire, length, uniformity, strength and elongation in Florida, USA. Fibre finesses were negatively correlated with salinity whereas lint index, fibre length and fibre strength were less affected by salinity. Increasing the salt conc in a soil with 1.6 ds/m using 70,140,210 mol/m^3 NaCl increased GOT and fibre fineness where as staple length, fibre maturity and fibre strength decreased at higher salt concentration i.e., 140 and 210 mol/m3. Fibre strength and fineness decreased when salinity was lower than 5.43 mmhos/cm. Soil salinity results in differential uptake of cations, causing changes in cationic ratios in the plant tissues, which is responsible for alteration in fibre properties.

Thus, to sum up, although the quality of fibre is becoming importance in coming days because of premium involved, yet nutrient role on quality is not apparent. The fibre quality is adversely affected by the application of N . Contrary to it some observed improved GOT following N application. After certain level, successive decrease in fibre strength and fibre fineness was observed due to increase in N levels. In contrast, P didn't affect on fibre quality. So far K is concerned, when it is combined with NP is largely effective. K when applied on foliage at early and/or peak boll formation stages increased 2.5 % SL & strength and elongation % (Shanmugham and Bhat 1991) because of higher K (3.0-3.6 %) in the leaves during the reproductive phase.

Irrigation scheduling

Productivity of cotton is proportional to water availability during the growing season. Water requirement of the crop (WRC) depends on many factors viz., climate, soil type, soil moisture storage and stage of the growth and is largely location specific. Depending on the season and length of the growing period, WRC^{max} varies from 70 to 120 cm. Crop requires about 1/3rd of seasonal water use during initial growth till flowering and the rest during flower and boll development.

Quality parameters like staple length, uniformity ratio, micronaire value and tenacity were not affected by any of the irrigation methods and scheduling of drip irrigation (Patil et al ., 2004).

Table-5.How fibre Quality is related to parameters in soil (Venugopalan et al. 2004)

Soil Property	S.L. (mm)	Micronaire	Elongation	Uniformity	Strength
Moisture	-S**	-	-S***	-S***	-S***
Phosphorus	-S***	S**	-S**	-	-S*
Potash	-	-	-	-	-
Sodium	-	-	-	-	-
Calcium	-	-	S*	-	S*
Magnesium	S**	.-	S*	-	-
pH	S***	S***	S*	-	-
Organic manure	S**	S*	-S*	-	-S*
CEC	-	-	S**	S**	S*

*= 0.05,**= 0.01, ***= 0.001, S = significant and - = NS

However, Fibre length, micronaire, strength and elongation were influenced by water supply. Moderate moisture stress increased fibre length but did not increase fibre strength and maturity. There was an increase in fibre length and a decrease in micronaire with increase in soil moisture regime on a sandy loam. Moisture stress reduced fibre length and increased micronaire. Similarly, early termination of watering combined with heavy application of N decreased fibre length, micronaire and yarn strength. Frequent watering coupled with heavy N application decreased uniformity of length, micronaire and yarn strength.

The effect of irrigation on fibre fineness was inconsistent, however, mulching improved fibre fineness. Even irrigation was applied at branching, flowering and seed formation stage, the best quality of fibres in terms of short fibre per cent, maturity and fineness was obtained. Stress induced by temporary drought increased the strength of cotton fibres. The fibre quality parameters of LRA 5166 like 2.5 % S.L and fibre quality index were significantly influenced due to polymulching up to 30 micron. The GOT although enhanced through such a mulching did not reach to the level of significance (Nalayini et al. 2005) (Table-6).

Table-6 Quality traits as under different treatmantrs Polyethylene mulching

Polyethylene mulch	SCY kg/ha (10 yrs)	2.5 % SL. (mm)	Micronaire value (ug/inch)	Strength (g/tex)	FQI LxS/|_M
100 micron	2039	29.5	3.78	23.8	361.2
75	2113	29.9	3.89	24.4	370.4
50	2104	29.4	3.88	24.2	361.3
30	2010	30.0	3.74	23.9	371.3
Mean	2067	29.7	3.82	24.1	366.1
Control	891	27.8	3.77	23.6	338.5
C.D. (0.05)	284.4	0.78	NS	NS	22.24

Problematic soils and salinity

Irrigation scheduling has to be modified as per soil and water salinity and this condition warrents certain precautions not followed under normal condition. Majority of yield and fibre parameters were increased up to moderate EC of 4 dS/m and declined beyond. However, fibre bundle strength increased up to 8 dS/M. FQY [(2.5 % span length x bundle strength)/ square root of micronaire], an index of fibre quality declined after a maximum value at EC 6 dS/m.

It is convincingly proved in many trials that beyond 8 dS/m there is decline in physical characteristics of fibre and its yield that might play a key determinant for application of poor quality of water to cotton crop.

Cotton based cropping systems

Amount and distribution of rainfall, length of the rainy season and type of the soil decides the kind of cropping systems to be taken under a location. Under normal condition, monocropping, intercropping and sequential cropping is followed in the rainfall ranges of 500-600 mm (with soil moisture storage of 100 mm), 600-800mm (with 150 mm of storage) and above 900 mm (>200 mm storage) respectively.

In order to assess and refine a cropping system, both stability index (i.e. sustainability yield index based on variability in productivity in relation to maximum yield over the years) and production efficiency (productivity per day in the whole cropping system calculated on the basis of total yield of the system from equivalent yields) should be taken into account. For example, the most important cotton based cropping systems in south zones viz. cotton-jowar has both higher stability index and production efficiency over cotton- fallow system in hot semi-arid areas of the south zone and many regions all over India, thereby signifying the sustainability and profitability of the system without deterioration in fibre quality (Table-7)(Praharaj et al. 2005a).

Table-7 Quality traits as under different treatments (3 yrs pooled data)

Treatments	SCY q/ha (10 yrs)	2.5 % SL. (mm)	Micronaire value (ug/inch)	Strength (g/tex)	Elongataion (%)
Varieties					
Savita	12.47	32.1	3.76	23.3	5.84
Surabhi	12.21	32.5	3.67	23.5	5.75
C.D. (0.05)	NS	NS	NS	NS	0.05
Cropping system					
Cotton-Fallow	10.17	32.3	3.60	23.4	5.78
Cotton-Jowar	14.50	32.3	3.83	23.5	5.80
C.D. (0.05)	0.502	NS	0.059	NS	NS

*N, P & K in kg/ha and FYM in t/ha

Use of growth regulators and defoliants

Application of defoliants viz., drop or Ethrel had no adverse effect on the quality of cotton. Similar findings are obtained at central and southern zones where both the defoliants performed equally well and can be used for areas where double cropping is practiced.

Other studies at Coimbatore reveal that NAA @ 10-20 ppm at 60 and 70 DAP produced higher lint yield and quality. Delinted seeds soaked with 0.2% of succinic acid for 6 hrs is best for getting higher plant growth and yield. Even seed soaked with KCl @ 2% for 16 hrs with seed to solution ratio 1:5 (1kg of seed in 5 litres of water) is also recommended for higher germination and better plant stand. Seed hardening with cycocel @100ppm for 6 hrs is also beneficial.

Thus, physiological possibilities for enhancing quality fibre production may be reduction in seed index, higher no. of seeds/locule, enhancing fertilization and seed set, production of higher no. of bolls at initial nodal points, topping /nipping as required to arrest indeterminate terminal growth & resultant sink diversion, higher /optimum plant population & consequently higher yield per unit area and application of suitable hormone & nutrient mix. Besides this, there should be a concept of premium price/ market demand for high quality out put.

Conclusion

Since fibre properties are primarily governed by the genetic make up of the cultivar, yet strong genotype and environment i.e. soil and climate including management interaction exists which modify the ultimate expression of fibre properties. Fibre property modulations due to the application of agronomic practices are not confirmatory and even contradictory to the complex interactive effects of genotypes, climate and soils. Thus, knowing about the chemistry of cotton fibre, physiology of fibre development and the response of cotton bolls to the environmental variables is essential for realizing yields with acceptability quality parameters.

Towards future

Some of the thrust areas for future are included here for further research in areas untapped or under-explored in cotton so far long and extra long staple is concerned.

1. Agro-techniques for cotton based cropping systems for improvement of fibre quality and integrated nutrient/weed/water/tillage management should be evolved on a system basis.
2. Popularization of soil/water conservation measures especially in rainfed/dry land areas especially drip irrigation (a good example of synchronous supply of water, nutrient &/or herbicides) in areas where there is water-scarce or quality of water is poor.
3. Balance application of NPK and supplementation of secondary and micro- nutrients viz., S, Mg, Zn, Fe & B as foliar sprays or soil application once in 2-3 years where deficiencies are coming in for limiting both quality and productivity of fibre.

References:

Annonymous, 2003-04. Annual Report, TMC MM2, ARS, Sriganganagar, Rajsthan.

Bhatt, J.G.1996. Cotton Physilogy.*Ind. Soc. Cot. Imp., Mumbai, 259 p.*

Constable, G.A. and Hearn, A.B. 1981.Irrigation for crops in a sub-humid environmentVi. Effect of irrigation and nitrogen fertilizer on growth, yield and quality of cotton. *Irrigation Science, 3, 17-28.*

Govil, B.P. and Kaore, S.V. 1997. On-farm experiences of IPNS development by IFFCO. In *Proceedings of the FAO-IFFCO international Seminar on IPNS for Sustainable Development,* November 25-27,1997. New Delhi: Indian Farmers Fertilizers Cooperative Limited.

Johnson, R.M., Drowner, .G.Bradow, J.M.,Bauer, P.J. and Sadler,E.J. 2002.variability in cotton fibre yield, fibre quality and and soil properties in SE coastal PlainAgron J., 94:1305-1316.

Nalayini ,P. T.P. Rajendran, R.Anandham, K.Sankaranarayanan and Anderson, A. Kumar. 2005. Polyethylene mulching-A new technique for better water management and efficient weed control in cotton.Pp.75-77.

Nehra,P.L. 2005. Integrated nutrient management for high quality fibre and yield. In: *Proceedings of the National Level Training on Advancement in cotton Research*, conducted from 5-6 Sept., 2005 by CICR, RS, Sirsa,.65-82.

Patil, K.C. Halemani, H.L., Hallikeri, S.S., Nooli, S.S. and Bandiwadar, T.T., 2004. Response of hybrid cotton to drip irrigation and fertigation. *Proc. of the International Symposium on Strategies for Sustainable Cotton Production-A Global Vision,* Crop Production (Vol-2), 23-25 Nov.m,2004, UAS, Dharwad.Pp.145,202& 207.

Porter, P.M. Sullivan, M.J. and Harvey, L.H. 1996. Cotton cultivar response to planting dates on the south eastern coastal plains.J. Production Agriculture, 9:223-27.

PraharajC.S,K. Sankaranarayanan and T.P. Rajendran2005. Studies on fibre yield and qquality as influenced by cropping systems and integrated nutrient scheduling to cotton. . *Proc. of the International Symposium on Strategies for Sustainable Cotton Production-A Global Vision,* Crop Production (Vol-2), 23-25 Nov.m,2004, UAS, Dharwad.Pp.69-74.

Praharaj C.S, , T.P. Rajendran and K. Sankaranarayanan 2005. Studies on the incorotraion of various organics sources to soil n the perfotmance of hirsutum coytton.*Proc. of the International Symposium on Strategies for Sustainable Cotton Production-A Global Vision,* Crop Production (Vol-2), 23-25 Nov.m,2004, UAS, Dharwad.Pp.130-133.

Rattan, R.K. Neelam, S. and Datta, S.P. 1999. Micronutrient depletion in Indian soil: extent, cause and remedies. *Fertilizer News,* **44** (2):35-50

Reddy, K.R. oti, S.Davidonis, G.H. Reddy, V.R. 2004. Inteercative effects of CO2 and N on cotton growth, development, yield and fibre quality. Agron. J. 96:1148-57.

Shanmugham, K. and Bhat J.G.J. 1991. *Ind.Soc. Cot. Imp.* **16** (1):31-35.

Sucking Pest Management In The Long And Extra Long Staple Cotton Varieties / Hybrids

K. Natarajan

Principal Scientist (Entomology)
Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

A. Cotton thrips: ***Thrips tabaci, T. palmi, Scirtothrips dorsalis***
(Thripidae: Thysanoptera)

Thrips are generally one of the main early season cotton pests. They initially damage the cotyledons and then several other plant parts and the types of damage vary according to the parts of the plant attacked. Most damage occurs during early vegetative stage of the crop, when the nutritional qualities of tissues are ideal for these insects.

Damage

Both adults and nymphs usually remain on the under surface of leaves, lacerate the tissues and suck the cell sap. Cotyledons are damaged immediately after emergence. The appearance of glistening white silvery patches on the under surface of the leaves is the characteristic initial symptom. The leaves become thickened, blistered and bronzed due to continuous feeding. The browning and bronzed symptom appears on the upper surface also. Cotyledonary lèaves fall prematurely affecting the plant growth. When the apical meristem is damaged, the proper furling of leaves is hampered, growth is affected and the plants become stunted. Affected young leaves get thickened, curl at the edge and get distorted. Heavy infestation causes leaves to turn coppery brown or reddish and the affected leaves curl and fall prematurely. On the under surface of the affected leaves, tiny black specks – which are the faeces of the thrips can be seen particularly near the veins.

Feeding on developing bolls, makes them turn brown due to development of necrotic patches. Thickening of boll rind can also be noticed when bolls are attacked, boll opening is affected.

Description

Adult thrips are small, 1-2.0 mm long and elongate and they possess a pair of fringed wings (could be seen clearly under microscope). Nymphs are similar to adults in appearance except that they are wingless. Both nymphs and adults can be seen in large numbers on the under surface of leaves. They are yellow, straw yellow to dark brown in colour.

Management- Use of systemic insecticides like Methyl-demeton or Imidacloprid or Thiamethoxam or Acetamiprid gives better contol of this pest.

Cotton jassid- *Amrasca devastans* (Cicadellidae: Homoptera)

Jassids (leafhoppers) are the important sap feeding insects in all the cotton growing regions of India. Among the 10 different species recorded on cotton, the most important and widely distributed species is *Amrasca devastans* (*A.biguttela biguttela*).

Host range

It is a polyphagous pest. In addition to cotton, the important alternate host is okra. The other host plants are castor, brinjal, sunflower, cucurbits and many malvaceous weeds.

Damage

Nymphs and adults remain usually on the under surface of the leaves, particularly at the base of the vein and suck the sap of the mesophyll layers. While feeding, they introduce a toxin that impairs the photosynthesis in proportion to the number of nymphs present. The initial symptoms are the paling of the green colour to yellow at the edges of the leaf, followed by downward curling of the leaf edges and bronzing. Due to continuous feeding, the leaves become brick red with the development of necrotic patches between the veins causing drying up of leaves. In severely infested fields with susceptible cultivars, the crops get blighted and appear as though it is burnt with fire, with dried leaves which drop off. This type of symptom is known as 'hopper burn'. When the damage occurs in early stage of the crop, the plants succumb to the injury. Plants at preflowering stage are most susceptible. In grown up plants, the growth is retarded the plant become stunted and fruiting bodies such as square, flower and boll may shed. Attack during bolling stage reduces the boll size and boll opening and the quality of the fibre. Even presence of 3-4 nymphs / leaf can cause severe 'hopper burn' leading to heavy yield loss.

Description

Nymphs

Nymphs are frog-shaped, flat and pale yellowish green measuring about 0.5 mm in the first instar. There are five nymphal instars. The fourth and the final instar are about 2.0 –2.5 mm long. Nymphs feed near the bases of the leaf vein. Nymphal period is about 15-20 days.

Adult

The adult is 2.5-3.0 mm long, elongated, wedge shaped, light green to dark green in colour with semitransparent shimmering wings. They have characteristic sideways movement, quick to hop and fly when disturbed. Adults can live for 20-30 days.

Adult show the typical sideways movement and are confined to the under surface of the leaves particularly in the upper part of the canopy. As many as 11 generations in a year have been recorded. The population generally declines during the dry season. A cool and wet period favours the pest build up. In Tamil Nadu, high population of the pest occurs during November-December.

Natural enemies

Though, the egg parasitoid *Anagrus* spp. (Mimaridae: Hymenoptera) has been recorded, it does not play any significant role in reducing the population

Resistant varieties

Cotton varieties having glabrous leaves are highly susceptible to jassid as compared to hairy (hirsute) varieties. The susceptibility is correlated with both density and length of hairs on the under surface of leaf particularly on veins, where the jassid feeds and lays eggs. High hair density without length is ineffective. Semi –glabrous varieties can tolerate jassid population to certain extent. As jassid can attack cotton leaves at all stages of development, they cause the most significant damage even to resistant varieties during the first 2-3 weeks after germination.

Chemical control

Insecticides are commonly necessary when the jassid population reaches 2-3 nymphs / leaf although for glabrous varieties, the threshold may be lowered to one per leaf if the cotton crop is highly susceptible or jassid population build up. The choice of insecticide to be selected depends upon the age of the crop and the density of jassid population.

Application of any one of the systemic insecticides methyl-o-demeton, imidacloprid, Thiamethoxam or Acetamiprid gives good control of Jassids. The contact insecticides chlorpyriphos, quinalphos and endosulfan are not effective in cotton crop against this pest. Very often, the cotton fields treated with these insecticides have more jassid population.

Cotton aphid- ***Aphis gossypii*** **(Aphididae: Homoptera)**

Aphids (plant lice) are widely distributed in all the cotton growing regions of India. Earlier, it was considered as a minor pest, but now causes serious damage particularly in cotton fields after use of synthetic pyrethroids which induce resurgence of this pest. Aphids are found particularly underside of the leaves in large number.

Damage

Direct

The degree of damage depends on the period of attack and the size of the population, insecticide previously used and the weather conditions. A dry weather with prolonged drought favours the fast build up of this pest. Aphids remain in colonies on the under surface of leaves and terminal shoots and suck the plant sap and the general vigour and growth of the plant is arrested. Initially, the edges of the leaves curl downward and crinkle, the tender portions fade gradually and the whole plant becomes stunted. The attack is severe in younger plants. Heavy infestation in old plants particularly after the use of synthetic pyrethroids reduces the overall vigour and growth of the plant. Flowering and boll formation are also reduced. Shedding of fruiting bodies is noticed. Boll opening is hampered and the fibre quality is affected.

Indirect

The excess sugar in the plant sap (phloem sap) on which the aphids feed is excreted in the form of 'honeydew' which is deposited on the foliage forming a sticky glistening substance. This can be seen as fine drops on the underlying vegetation. Deposition of honeydew over the foliage interferes with respiration of the leaves and also provide substrate for the growth of a black sooty mould. The sooty mould interferes with the photosynthetic activity of the plant by hindering light absorption by chlorophyll. Further, if attack occurs or persists later in the season during boll opening period, the honeydew may drip on to the open bolls and is one of the causes of 'stickiness' of lint, sooty mould which develops over the honeydew also discolour the seed cotton and thus reduce the market value.

Description

Aphids are small, ovate (1-2 mm). soft bodied, sluggish moving gregarious insects with slender legs and antennae. They are characterized by a pair of tubular process called 'cornicle' projecting backward and upward from near the end of the abdomen.

In a colony, both winged (alate) with two pairs of long transparent wings and wingless (apterous) forms can be seen. Aphids are variable in colour and colonies are always made up of individuals of different colours, green to dark green, yellowish, brown orange yellow, lemon yellow and sometimes very blackish brown. Size also varies considerably (apterous 0.9 to 1.8 mm, alate 1.0 to 2.0 mm). Infested plants can be easily noticed by the presence of ants, moving around the plant to feed on the sweet 'honeydew' excreted by the aphids.

Usually, winged females are the first to arrive on a young plant. They reproduce by giving birth to young ones (nymph) without mating. This type of reproduction is called 'parthenogenetic viviparity'. Nymphs resemble adults in all respects except for size and immature abdominal segments. Wingless females are slightly large and more globular than the winged forms. Multiplication is carried out by the wingless females. Winged forms appear in the colony only when the dispersal of the colony is needed and are developed due to crowding and poor food quality. Sexual reproduction and egg stage are not usually observed in South India.

As overlapping continuous generations are observed, 50 generations have been recorded in a year. The average life span of an individual aphid is about 20-25 days and a female can give birth to 80-100 nymphs at the rate of 3-5 nymphs per day depending upon the nutritional status of the plant and insecticides applied on the crop. In synthetic pyrethroid treated fields, the reproductive capacity (fecundity) and the longevity of the individual is greatly high.

Host range

A. gossypii is present in all cotton growing area of the world. It is polyphagous and recorded on 300 host plants. The most important crop hosts are cucurbits, okra, hibiscus, legumes and numerous ornamental plants.

Favourable condition

The favourable condition for the pest multiplication is dry weather with prolonged drought and a moderate temperature of $25\text{-}30^0$ C. Heavy plant canopy, higher nitrogenous fertilizer and improper usage of insecticide also favour the pest build up. Heavy rain reduces population directly by washing them away. Further, high humidity enhances the appearance of entomopathogenic fungi, which in turn reduce the aphid population.

Natural enemies

Aphids are preyed upon by species of coccinellids (*Menochilus sexmaculatus*, *Coccinella repanda, Coccinella* sp. and *Scymnus* spp.) chrysopids and syrphids. The parasitoid *Aphelinus gossypii* also plays an important role in reducing the population during the cooler months of the year. A high degree of control is normally exerted by these natural enemies. Growing cowpea as an intercrop is encouraged to increase the natural enemy build up. Unless the attack is severe, it is better to leave control to natural enemies as the early application of insecticides may result in heavier attack by more serious pests later in the season.

Chemical control

Sowing the cotton seeds treated with the insecticide, imidacloprid or thiamethoxam (5-10 g /kg of seed) gives protection to the crop from the sucking pests particularly aphids, thrips and jassids for about 45 days.

When the pest infestation is observed in more than 15 per cent of the plants, the following insecticides can be used depending upon the age of the crop and severity of the pest. Application of methyl-o-demeton or imidacloprid or Thiamethoxam or Acetamiprid gives good control of this pest.

Cotton whitefly – *Bemisia tabaci* (Aleyrodidae: Homoptera)

The cotton whitefly, an occasional pest of cotton in India has emerged as a major pest in several states in recent years. Severe outbreak was first noticed in Guntur region of Andhra Pradesh during 1984-85 and now continues to be in all the cotton growing regions. It is believed that continuous drought, excessive application of nitrogenous fertilizers and the indiscriminate use of synthetic insecticides particularly synthetic pyrethroids have induced the resurgence of this pest.

Distribution

It is known to occur throughout tropical and subtropical countries and severe outbreaks in cotton in recent years have been reported from California in USA, Central America, Egypt, India, Israel, Pakistan, The Philippines, Sudan, Thailand, Turkey and Zimbabwe.

Host range

It is polyphagous with an extremely wide host range. It can breed and feed on over 400 host plants of cultivated and non cultivated species. Among the cultivated crops, cotton, brinjal, tobacco, sunflower, okra, tapioca, potato, sweet potato, tomato, pulses, cucumber etc. are the important hosts. Its weed hosts, to mention a few include

Abutilon indicum, Solanum nigrum, Sida cordifolia, Urena lobata, Lantana sp and *Tribulus terrestris.*

Damage

Direct

The nymphs and adults remain in colonies on the surface of leaves and suck the sap. Due to continuous feeding chlorotic spots develop on the leaves which later coalesce and the leaves become reddish, brittle and finally drop off prematurely. This results in reduced nutrition to the plant leading to stunting, shedding of fruiting bodies and reduction in the size of bolls. The bolls are also forced to burst prematurely leading to poor quality lint. The oil and protein contents of seeds are lowered.

Indirect

In addition to the direct damage, the 'honey dew' excreted by this insect drops on the upper surface of lower leaves and bolls which favour the development of black sooty mould fungus on thc leaves, which in turn interferes with the photosynthesis of leaves. Heavy fungal growth on honeydew covered leaves leads to premature leaf drop. Honey dew deposition on open bolls causes' stickiness black sooty mould also develops on honey dew. Sticky cotton interferes with picking, ginning and spinning and hence fetches low price.

Life cycle

The adult whitefly is a tiny soft bodied moth like insect measuring; about 1.0 mm in length having yellowish body with transparent waxy wings dusted with milky white powder. Adults can be seen in large number on the under surface of terminal leaves as they prefer younger leaves for feeding and breeding.

Eggs

The female whitefly deposits the eggs on the under surface of younger leaves. The eggs have short fine subterminal stalks which are inserted into the leaf tissues. These are inserted in such a way that they are almost perpendicular to the leaf surface. A female can lay 200-300 eggs either singly or in groups. Freshly laid eggs are light yellow in colour and they turn brown to dark brown before hatching. Maximum hatchability is seen at 30-35 C and the incubation period is 3-5 days, which may extend upto 30 days in winter. Extreme high temperature results in the mortality of eggs.

Nymphs

There are four nymphal stages including the fourth pupal instars. The first instar nymph is minute and pale yellow, flattened in appearance with bristles on margin. The first instar alone is the mobile stage in the nymphal period and other instars are sedentary. It is provided with relatively well developed long legs and antennae. Immediately upon hatching, it crawls about on the under surface of the leaf on which it has hatched, searching suitable feeding site. Once the crawler inserts its mouthparts for feeding, it loses its legs and antennae, secretes waxy filaments at the edge of the body and becomes sessile. The other two nymphal stages have 2-3 pairs of bristles. The nymphal period lasts for 9-14 days and extends upto 70 days in winter. The adult develops within the fourth instar, which is known as pupal stage. The pupa is flat when freshly formed. Later become slightly convex, subeliptical, light yellow to dark yellow in colour. During the advanced stage of development, reddish eye of the developing adult can be seen below the transparent pupal skin. The pupal stage lasts for 2-8 days. The fully developed adult emerges through an inverted 'T' shaped spilt in the dorsal surface of the pupal case. The adult starts to powder itself with white waxy powder secreted by the wax glands. Usually, life cycle is completed within 13 to 20 days and may be extended upto 107 days during winter depending upon the temperature.

Eggs are laid usually after mating but males are produced by means of parthenogenesis on certain occasions. Finding of the opposite sex is made easier because of the gregarious nature of the adults. Mating occurs within a day after emergence. Adults copulate several times. The preoviposition period is 2-3 days. Adult longevity is 10-20 days and males are short lived. There are 12-15 overlapping generations in a year. Adults can fly to short distances, but wind can disperse them to several kilometers.

Natural enemies

Several species of Aphelinid parasitoids play vital role in suppressing the population buildup. The important parasitoids, recorded recently are *Eretmocerus mundus* and *Encarsia* sp. and the natural parasitism was upto 85 per cent. The parasitoid whitefly nymphs can be identified by observing the parasitic grub developing inside the transparent nymph and the dark brown to black parasitised pupae. The pupal cases of whiteflies from which the parasites have emerged can be recognized by an irregular circular hole which is chewed by the emerging adult parasites. The eggs and first instar nymphs are also preyed by the phytoseid mite *Amblyseius* sp. The green lace wing (*Chrysoperla* sp) and the coccinellids, *Brumus* sp and *Scymnus* sp feed on nymphs and adult whiteflies.

Varietal reaction to whitefly

In general, the whitefly population is observed to be high on hairy type of cotton varieties, which are otherwise resistant to jassid. Most of the glabrous cotton varieties are found to have less population of whitefly than hairy types. The cultivars LK 861, Kanchana and Supriya are tolerant to whiteflies.

Management of whitefly

As the pest is assuming great importance, the following integrated approach is suggested for its management.

- Cotton should be grown only once in a year in the proper season
- Late sowing should be avoided. If late sowing is unavoidable, whitefly tolerant varieties (LK 861 and Supriya) may be grown.
- Cotton should be rotated with non-host crops like cereals (Cholam, Maize) so as to avoid continuous food supply to the pest. Immediately after last picking, cotton stalks should be removed to avoid carry over of the pest during off-season.
- Alternate weed hosts should be removed from the field and neighboring areas.
- Adopt recommended spacing for the cultivar and closer spacing always conducive for this pest.
- Judicious use of nitrogen and irrigation should be practiced to check excessive vegetative growth and consequent pest buildup in the system. Balanced application of fertilizers with P and K is needed.
- The appearances, activity and the population buildup of whitefly should be monitored by setting yellow sticky traps.
- The use of synthetic pyrethroids at frequent intervals and at very early vegetative phase of the crop should be avoided. It should be used only during peak flowering and boll formation stages depending upon the bollworm density. It should not be repeated unless warranted.
- Repeated use of acephate and monocrotophos also cause resurgence of this pest.
- Extending of crop growth beyond its duration with additional fertilizers and irrigation is to be avoided to prevent the cycle of the pest.

- Application of **fish oil resin soap (2%)** and **neem oil (0.5 %)** is found effective in suppressing the population. While using neem oil alone, teepol or soap solution at the rate of 1 ml per litre of water has to be added for emulsification of the oil and for better contact of the spray fluid with the foliage.
- Application of methyl-o-demeton (1 litre/ ha) in the early phases of crop growth and spraying **triazophos (2.5 litre / ha)** in the late stages of crop growth will be useful to manage this pest. Five hundred liters of water per ha in the early stages and 750-1000 litres per ha in the late stages may be used for spraying with knapsack sprayer. For power sprayers, 200 – 250 litres of water may be needed.
- Use either high volume or low volume sprayers and ensure thorough coverage of the under surface of the foliage where the insects remain in colonies. Avoid use of Heli or Garden sprayer (Akela) and spraying highly concentrated insecticides.
- Avoid scheduled application of insecticides and sub lethal dosage of insecticides as it hastens the development of resistant strain of insect population.

Sustainable IPM / IRM Strategy For Cotton

T. Suruli Velu

Principal Scientist (Entomology)

Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

Integrated pest management for cotton

In India about 48,000 metric tons of technical grade chemical pesticides are used annually to protect crops from pests which cause losses of about 18 % of the crop yields worth more than Rs. 60000 crores annually. Insecticides constitute almost 60 % of the total pesticides used, followed by fungicides and herbicides. Among the crops, cotton, rice and horticultural crops account for more than 80% of total pesticides used. Excessive and indiscriminative use of chemical pesticides in a few crops particularly cotton has created several adverse problems such as development of pest resistance, pest resurgence, outbreak of secondary pests, destruction of beneficials & non-target organisms, environmental pollution and crop failures leading to socio-economic problems including suicides by cultivators. In the National Agricultural Policy, Government of India has laid special emphasis on Integrated Pest Management (IPM) to overcome these problems and also to minimize the dependence on chemical pesticides by encouraging use of non-chemical methods of pest management. IPM is a holistic system approach combining a wide array of crop production and protection practices to reduce the economic losses caused by the pests. It emphasizes on careful monitoring of pests, conservation of beneficials and need based critical intervention with appropriate tactics of pest management.

Most of the IPM activities emphasize heavily on the preventive measures especially before the crop is sown. Agronomic practices such as summer ploughing, cleaning of crop residue, crop rotation, water management, weed management, intercropping, trap and border cropping, nutrition management and use of pest resistant / tolerant varieties etc., are some of the major tools for significant reduction of pest incidence.

Pest scouting, assessment of ETL and regular pest monitoring programme pay rich dividends in reducing the pest control costs. Analytical interpretation of population dynamics of pests, defenders, abiotic factors and farmers' past experiences are also major tools for decision making and timing of IPM interventions to obtain maximum efficiency from pest control tactics. Various IPM interventions such as mechanical, biological, cultural, botanical and less hazardous chemical measures are applied individually or hormoniously blended to achieve maximum benefit in pest management and thereby to increase the crop yields.

Diversity of cotton cultivation has critical bearing on plant protection efforts. In India, cotton crop is grown under three distinct agro-climatical regions in North zone, Central zone and South zone varying with respect to irrigation, rainfall and soil type. All the four cultivated species of cotton are grown besides several inter and intra-specific hybrids, with no apparent systematic control over their development. The rainfed areas of Central zone and parts of South zone (about 5.7 m.ha) are repeatedly exposed to uncertainities of monsoon pattern and farmers have little control over executing sowing, intercultivation and crop protection operations in ideal time. The highly intensive and remunerative irrigated North zone has turned totally 'inorganic" and cotton is grown round the year in the South zone and the pest problem have thus aggravated.

First major village level effort in cotton IPM was made by CICR, Coimbatore in the late seventies and practical successful IPM implementation had been experienced in the early eighties in several villages of Coimbatore region. Later on multilocational trials on IPM started in all the three zones under AICCIP programme. Various modules had been tried in different regions, and location specific IPM Module has been identified for each of the various cotton growing regions of India.

Insecticide resistance management strategies for cotton

Cotton pest management has become a tough challenge in recent times. It is more acute on account of development of insect resistance to insecticide. In such a situation insecticide resistance management (IRM) assumes significant importance, if pest management programmes are to be successful.

In India, the first report of resistance to insecticide was in 1952 that of mosquitoes to DDT followed by resistance to number of household, veterinary and stored grain pests to mainly organochlorines till date 1960's. Field crop pests *Spodoptera litura* and *Plutella xylostella* were also identified as resistant to certain insecticides by early 1980. Insecticide resistance was however recognized as a major contributory factor to pest control difficulties (or) failures in 1987 in the coastal belt of Andhra Pradesh. The cotton bollworm, *Helicoverpa armigera* Hubner was found to survive and cause extensive damage to cotton crop despite repeated applications of insecticides of even upto 30 sprays. Subsequently Dhingra *et al* 1988 and Mc Caffery *et al* 1989 attributed high levels of resistance to synthetic pyrethroids to control failures. Cotton crop worth of Rs 500 crores was lost to this insect pest in Andhra Pradesh alone. (Kishor, 1992)

IRM Strategies for *Helicoverpa* Management in Cotton

The IRM strategies developed by CICR are fairly simple, the participatory IRM trials were designed to manage insecticide resistant bollworm of cotton *H.armigera* through minimum use of insecticides and incorporate strategies based on several years of intensified research on IRM at CICR. The technology designed for implementation is a relatively simple, knowledge intensive package. It includes farmers training in identification of insect pests, their natural enemies and the application of economic threshold levels in spray decisions (and use of recommended sprays based on susceptibility levels) and general agronomic management. Emphasis was placed on the management of resistant pest through the use of resistance monitoring generated over the past several years. This strategy has been successfully evaluated in several villages of Tamil Nadu through farmers' participatory programme.

Components of Sustainable Cotton Pest Management

Agronomic Practices

- Follow proper nutrition management, apply fertilizer based on soil testing. Avoid high doses of nitrogenous fertilizers to prevent excessive vegetative growth (luxuriant green growth) which otherwise attracts more pests.
- Avoid close spacing which leads to dense canopy which in turn encourages faster multiplication of pests particularly bollworms.
- Follow summer ploughing to destroy resting stages of insect population. Avoid Monocropping and ratooning of cotton. Destroy the crop residues to prevent the carry over of population.

Plant Tolerance

- Grow sucking pests tolerant "moderately hairy" genotypes which help to delay the first spray and thus conserves beneficials.
- Avoid growing tall and bushy hybrids which do not facilitate easy spraying and uniform coverage, thus not amenable for pest management.

Seed Dressing and Conservation of Beneficials

- Treat the seeds with imidacloprid (7g/kg of seed) or thiamethoxam (Cruiser 5g /kg seed) to protect the crop upto 40 to 50 days against sucking pests and also to avoid or reduce the early season insecticide application and thus to conserve the beneficials.
- Avoid dust formulation and broad spectrum insecticides that are detrimental to the beneficials.

Bund crop and Trap crop

- Grow Cowpea as "Bund crop" to sustain and enhance the built up of natural enemies.
- Plant "Trap crops" (Marigold or Pigeonpea) to divert Helicoverpa oviposition from main crop.

Cultural and Mechanical Measures

- Remove terminals of cotton crop ("Topping") at 80-90 days of growth to reduce Helicoverpa oviposition and also to encourage sympodial branching which bears more fruiting bodies.
- Erect bird perches to encourage predation by insectivorous birds.
- Adopt hand picking of grown up larvae to eliminate the possible development of resistance. It also helps to minimize heavy build up of future population.

"Bio-rationals" During Early Fruiting Period

- Use NSKE 5 % or other neem compounds 0.5 % or Pongamia oil emulsion 0.2 % as a strong oviposition deterrent when there is low egg load.
- Release egg parasite @ 1.5 l/ha or apply ovicidal chemicals (Profenofos 0.1 % or Thiodicarb 0.08 % or Triazophos 0.08 %) for heavy egg load.
- Spray HNPV @ 500 LE / ha with jaggery (adjuvant) during evening hours against early instar larvae for maximum effectiveness.

Pest Monitoring and Need Based Application

- Use pheromone traps @ 5/ha to monitor the brood emergence of moths so as to synchronize insecticide application against vulnerable stage of early instar larvae.
- Adopt need based application based on ETL: Aphid and Thrips - 15-20 % infested plants /10 per leaf; Jassid - 50 nymphs in 25 terminal leaves; Mite - 10 per square cm; Whitefly - 10 adults and / or nymphs per leaf; Spotted

bollworm - 10 % infested fruiting bodies; Cotton bollworm, H. armigera- Egg: 1 per plant, Larva : 1 per 2 plants, Fruiting bodies damage: 5 %; Pink bollworm - 10 % infested flowers and / or bolls with live larvae.

- Use correct dosage of right chemical and ensure uniform coverage with small spray particles of uniform size at the vulnerable stage of the pest.
- Alternate with various chemical groups (Cyclodiene, Organophosphates, Carbamates, Pyrethroids) based on resistance monitoring / susceptibility levels for maximum – effectiveness and also to reduce the chances of development of resistance in insects.

Sustainable cotton pest management has become an important issue in the past two decades in India. Researchers have established that certain modules of IPM were suitable for some locations in the country. Many international and Indian institutions conducted several successful IPM demonstrations all over the country. The efforts through that IPM methods were useful and enhanced yields. However there has been over all unanimity in the view that farmers do not adopt to IPM easily. Some of important reasons attributed have been inconsistency in performance, non availability of biological components and resistance to insecticides. If insecticides worked effectively it would be possible to minimize their use and the need for biological alternatives would be minimum. For insecticides to work the problem of insect resistance to insecticides needs to be tackled. This would then help making cotton IPM programmes sustainable even in years of pest outbreaks. The IPM / IRM strategies developed at CICR were implemented in several villages and have been widely accepted by farmers in all the regions wherever introduced. Ready acceptability by farmers is due to its simplicity and sustainability.

Bollworm Management And Cotton Production To Meet The Quality Cotton Requirements Of The Industry

S. Mohan

Professor (Entomology)
Tamil Nadu Agricultural University, , Coimbatore-641 003

Cotton is a crop that is depredated by a number of insects pests at various stages of growth and development among the insects pests those feeding on fruiting forms such as Spotted bollworm, Spring bollworm, American bollworm and Pink bollworm ravage the crop at different stages of growth and cause huge economic loss both in terms of quality (fibre) and quantity.

Bollworm management

- Remove the Cotton crop and dispose off the crop residues as soon as harvest is over.
- Avoid stacking of stalks in the field.
- Avoid ratoon and double Cotton Crop.
- Adopt proper crop rotation.
- Use optimum irrigation and fertilizers.
- Grow one variety throughout the village as far as possible.
- Treat the seeds with imidacloprid or use designer seed (Delinted seed + Polykote @ 3g/kg + carbendazim @ 2g/kg + imidacloprid @ 7g/kg + Pseudomonas fluorescens 10g / Kg + Azophos 40g/Kg). When the treated seeds are used, it protects against sucking pests upto 45 days after sowing and promotes early vigour of the crop.
- Synchronise the sowing time in the villages and complete the sowing within 10 to 15 days.
- Avoid other Malavaceous crops in the vicinity of cotton crop.
- Timely earthing up and other agronomic practices should be done.
- Hand pick and burn periodically egg masses, visible larvae, affected and dropped squares, flowers and fruits and squash pink bollworm in the rosettes.
- Use locally fabricated light traps (modified Robinson type) with 125-Watt mercury lamps to determine the prevalence and insect population fluctuations.
- The magnitude of the activity of the moths of the Cotton pink bollworm, the cutworm (Spodoptera litura) and the American bollworm can be assessed by

setting up the species-specific sex pheromone trap each at the rate of 12 per ha.

- Apply insecticides only where it is absolutely necessary when pest population or damage reaches ET level.
- Intercropping with pulses viz., Cowpea, green gram, black gram, soybean and maize reduces the bollworm incidence and population of sucking pests of cotton, viz., aphid and leafhopper with the highest activity of natural enemies viz., spiders and predatory lady bird beetles.

Economic Threshold level for important pests

Pests	ETL
Boll-worms	
Spotted	10% infested shoots/squares/bolls
Spiny	10% infested shoots/squares/bolls
Pink	10% infested shoots/squares/bolls
Helicoverpa	One egg or one larva/plant

Pest management strategies

American bollworm *Helicoverpa armigera*

Monitoring:

Pest monitoring through light traps, pheromone traps and in situ assessments by roving and fixed plot surveys has to be intensified at farm, village, block, regional and State levels. For management, an action threshold of one egg per plant or 1 larva/plant may be adopted.

Cultural Practices:

- Sychroniseds sowing of Cotton preferably with short duration varieties in each Cotton ecosystem.
- Avoid continuous cropping of Cotton both during winter and summer seasons in the same area as well as ratooning.
- Avoid monocropping. Growing of less preferred crops like green gram, black gram, soyabean, castor, sorghum etc., along with the cotton as intercrop or border crop or alternate crop to reduce the pest infestation.
- Removal and destruction of crop residues to avoid carry over of the pest to the next season, and avoiding extended period of crop growth by continuous irrigation.
- Optimizing the use of nitrogenous fertilizers, which will not favour the multiplication of the pest.
- Judicious water management for the crop to prevent excessive vegetative growth and larval harbourage.

Biological Control:

- Application of Nuclear Polyhedrosis virus (NPV) at 3 X 10^{12} POB/ha in evening hours at 7th and 12th week after sowing.
- Conservation and augmentation of natural predators and parasitoids for effective control of the pest.

- Inundative release of egg parasitod, Trichogramma spp., at 6.25 cc/ha at 15 days interval 3 times from 45 DAS
- Egg-larval parasitod, Chelonus blackburnii and
- Predator Chrysoperla carnea at 1,00,000/ha at 6th, 13th and 14th week after sowing.
- ULV spray of NPV at 3 X 10^{12} POB/ha with 10% cotton seed Kernel extract, 10% crude sugar, 0.1%each Tinopal and Teepol for effective control of Helicoverpa.

Note: Dicofol, endosulfan, methyl dementon, monocrotophos and phosalone are comparatively sdafer to Chrysoperla larva recording low egg mortality.

Chemical Control :

- Discourage the indiscriminate use of insecticides, particularly synthetic pyrethroids.
- Use of proper insecticides which are comparatively safer to natural enemies such as endosulfan, phosalone, etc. at the correct dosage and alternating different groups of insecticides for each round of spray.
- Avoid combination of insecticides as tank mix.
- Adopt proper delivery system using spraying equipments like hand compression sprayer, knapsack sprayer and mist blower to ensure proper coverage with required quantity of spray fluid and avoid ULV applications or Akela spray applications.
- Proper mixing and preparation of spray fluid for each filling of spray fluid tank.
- At early stages of square formation apply endosulfan 35 EC 2 l/ha.
- During the bolling and maturation stage, apply any one of the following insecticides (1000 l of spray fluid / ha) :

  Phosalone 35 EC 2.5 l/ha ; Quinalphos 25 EC 2.0 l/ha

  Carbaryl 50 WP 2.5 kg/ha; Pyraclofos 50 EC 1.5 l/ha

Pink bollworm *Pectinophora gossypiella*

- Use Pheromone trap to monitor the adult moth activity.
- Spray triazophos 40 EC 2.5 l/ha and endosulfan 35 EC 2.0 l/ha in alternation even after 100 DAS

Tobacco cutworm *Spodoptera litura*

- Use of light trap to monitor and kill the attracted adult moths. Set up the sex pheromone trap Pherodin S.L. at 12/ha to monitor the activity of the pest and to synchronise the pesticide application, if need be, at the maximum activity stage.
- Growing castor along border and irrigation bunds.

- Removal and destruction of early stage larvae found in clusters which can be located easily even from a distance.
- Collection and destruction of shed materials.
- Hand picking and destruction of grown up caterpillars.
- Spray any one of the following insecticides per ha using, a high volume sprayer covering the foliage and soil surface.

  Chlorpyriphos 20 EC 2.0 l ; Dichlorvos 76 WSC 1.0 1; Phenthoate 50 EC 2.0 1 ; Chlorpyriphos 20 EC 1.25 l; Fenitrothion 50 EC 625 ml
- Spraying nuclear polyhedrosis virus at 1.5 x 10 10^{12} POB per ha.
- Spraying of insecticides should be done either in the early morning or in the evening and virus in the evening.

Use of poison bait pellets prepared with rice bran 12.5 kg, jaggery 1.25 kg, carbaryl 50% WP 1.25 kg and water 7.5 litres. This bait can be spread in the fields in the evening hours so that the caterpillars coming out of the soil, feed and get killed.

Insecticide Resistance:

In case of control failures monitor the insecticide resistance with following discriminating dose screen.

Helicoverpa armigera (Topical assay with III instar larva weighing 30-40 mg)

1.	Cypermethrin	0.1μg / μl
2.	Cypermethrin	1.0 μg/μl
3.	Fenvalerate	0.2 μg/μl
4.	Endosulfan	10 μg /μl
5.	Quinalphos	0.75 μg/μl
6.	Chlorpyriphos	1.0 μg/μl

B. Tobacco caterpillar – Spodoptera litura

(early III instar 8 day old larva weighing 30-40 mg and measuring 12±0.5 mm length)

1. Endosulfan	topical	2.0 μg
2. Profenofos	topical	3.0 μg
3. Chlorpyriphos	topical	0.15μg
4. Fenvalerate	topical	0.2 μg /μl

C. Cotton leafhopper – Amrasca devastans (Distant)

1. Dimethoate	IRAC method VIII (leaf disc)	400 ppm
2. Methyl demeton	IRAC method viii (leaf disc)	800 PPM
3. Acephate	IRAC method VIII (leaf disc)	850 ppm

Resurgence

Repeated application of the following insecticides can cause resurgence of the insect pest of cotton

- ***Aphis gossypii*** : Carbaryl, Cypermethrin, Deltamethrin, Endosulfan, Fenpropathrin, Fenvalerate, Flucythrinate, Fluvalinate, Monocrotophos, Permethrin, Phorate
- ***Amrasca Devastans*** : Deltamethrin, Dimethoate, Disulfoton, Methylparathion, Phorate
- ***Bemisia tabaci*** : Cypermethrin, Deltamethrin, Dimethoate, Endosulfan, Fenvelerate, Monocrotophos, Phosalone
- ***Ferrisia virgata*** : Cyoermethrin, Deltamethrin, Fenvalerate, Permethrin
- ***Tetranychus cinnabarinus*** : Acephate, Carbaryl, Cypermethrin, Deltamethrin, Endosulfan, Fenvelerate, Fluvalinate, Phosphamidon

Integrated Disease Management To Reduce Yield Losses In Quality Indian Cotton

P. Chidambaram[1] and I. Johnson[2]

1. Principal Scientist (Plant Pathology), 2. Research Associate
Central Institute for Cotton Research, Regional Station, Coimbatore – 641 003

Cotton (*Gossypium* spp.) is a crop of warm climate and requires regular supply of water, either natural in the form of rainfall or assured through canals from the above surface and/or from underground sources. Although cotton is not a water loving plant, it requires a regular supply of water for maintaining growth and balance between vegetative and reproductive phase. About 55% of the world cotton area is under irrigation and the balance is rainfed. Contrary 70 per cent of the cotton cultivated area in India is under rainfed conditions. Water stressed seed or plant, will have poor growth leading to low yield as well as exposure to diseases.

In India, the cotton is being grown in three distinct zones *viz*., North (Punjab, Haryana, Rajasthan and few thousand acres in Utter Pradesh), Central (Gujarat, Maharashtra and Madya Pradedsh) and South (Orissa, Andra Pradesh, Karnataka and Tamil Nadu). In the North, Cotton is sown during April-May, in Central June-July and in South July-September. In Tamil Nadu, the summer cotton as well as rice fallow cotton are sown during January-February. In view of the differing agro-climatic conditions, the prevalence of diseases also varies. Various diseases affect all the four cultivated species of *Gossypium*. Only few diseases are common for all regions and the rest are specific to individual zones.

Since the quality cotton crop remains in the field for nearly six months or more, it is affected by various diseases caused by organisms such as fungi, bacteria and viruses that grow on and with in the plant tissues. These organisms often cause stunting of the plants, defoliation, reduced vigour and yield and sometimes death of the plants. Seeds and seedlings attacked by these pathogens often die, while older plants usually survive with poor productivity. Diseases can also be caused by environmental changes such as too much or too little of water or fertilizer, air pollutants and chemical injury such as those caused by herbicides and their residues. The diseases caused due to environmental changes become localized and do not spread where as diseases caused by organisms are contagious and can be spread by wind, water or vectors. We discuss here some of the important diseases which affect the quality cotton caused (Table 1) and their management through an integrated approach.

Seedling diseases

Causal Organisms:

Seedling diseases cause an estimated average annual yield loss of about five per cent. Several fungi are responsible for this disease *viz.*, *Rhizoctonia solani*, *Rhizoctonia bataticola (Macrophomina phaseolina) Pythium* spp., *Phoma exigua* (Ascochyta), and *Fusarium* spp. Seedling diseases do not usually kill the entire seedling population, but rather result in uneven, slow-growing stands with gappiness in the rows necessitating replanting. The most common fungi associated with seedling diseases are *Pythium* spp. and *R. solani*. Often both fungi can be found on the same seedling. The same fungus may cause seed decay, seedling root rot or both. However, *Pythium* spp. and *Fusarium* spp. usually attack the seed and below-ground parts of young seedlings, while *R. solani* usually causes sore shin. *Rhizoctonia solani* and *P. exigua* may attack seedlings from the time they emerge until they are about six inches tall. After this stage, the stem becomes woody and subsequent infection rarely occurs unless the stem is injured

Symptoms:

These disease-causing organisms can attack the seed before or at germination. They also can attack the young seedling before or after emergence. Symptoms include seed decay, decay of the seedling before emergence, partial or complete girdling of the emerged seedling stems, and seedling root rot. A soft and watery rot characterizes seed and seedling diseases. Damaged seedlings that emerge are pale, stunted, slower growing and sometimes die within a few days. Examination of infected seedlings may reveal dark lesions on the stem and root. Often the taproot is destroyed, and only shallow-growing lateral roots remain to support the plant. The "sore shin" phase of seedling disease is characterized by reddish brown, sunken lesions at or below ground level. These lesions enlarge, girdle the stem and cause it to shrivel.

Favourable factors for disease development:

Cultural and environmental factors that delay seed germination and seedling growth may predispose the seed and seedlings to diseases. Seedling diseases occur more frequently under cool, wet conditions and seem to be more prevalent on sandy soils with low-organic-matter and other factors such as planting too deep, poor seed bed conditions, compacted soil and nematode or insect infestations may increase the problem. The herbicides pendimethalin (Stomp) and prometryn (Gesagard, Prometrix) that are used on cotton may also cause significant increase in the incidence of *R. solani*-induced cotton seedling damping-off in the field.

Foliar diseases

Bacterial leaf blight

Causal Organism - ***Xanthomonas axonopodis*** **pv.** ***malvacearum***

Symptoms:

Dark green, watersoaked, angular lesions of 1 to 5 mm across the leaves and bracts, especially on the undersurface of leaves. Hence called angular leaf spot. Extensive dark green, watersoaked lesions along the veins known as vein blight. Symptoms are usually more prevalent on lower leaves than on upper leaves. Lesions dry and darken with age and leaves may shed prematurely resulting in extensive defoliation. Black lesions on the stem which girdle and spread along the stem or branch known as black arm. Dark green, watersoaked, greasy, circular lesions of 2 to 10mm across the bolls, especially at the base of the boll under the calyx crown. As the boll matures the lesions dry out and prevent normal boll opening. This phase of symptom is called as "Boll rot"

Favourable factors for disease development :

Pathogen inoculum may either be present in the field on infected crop residues from a previous season or it may be introduced at planting with infected seed. Lesions on cotyledons may be initiated by inoculum within the seed during germination. Inoculum from infected crop residues may be splashed onto the foliage and into the growing point of young seedlings where it can survive saprophytically on leaf surfaces. When environmental conditions are favourable the bacteria enter the plant via the stomata or wounds. Symptoms of bacterial blight develop when the temperature is over 25°C and relative humidity exceeds 85%. As lesions develop, bacteria exude out onto the leaf surface for further dispersal through wind driven rain. The pathogen is able to enter the seed when mature, open, blight-infected bolls are exposed to wet weather prior to harvest. This disease is prevalent in the entire cotton growing tracts of India.

Alternaria leaf spot

Causal Organisms: ***Alternaria macrospora, A. alternata***

Symptoms: *Alternaria macrospora* causes brown, grey brown or tan lesions 3–10mm in diameter, especially on lower leaves. Sometimes with dark or purple margins and with concentric zones. . Affected leaves develop an abscission layer, senesce and drop to the ground. Circular dry brown lesions up to 10mm across may also be seen on the petiole, stem and bolls. *A. alternata* causes usually purple specks or small lesions with purple margins on leaves and bolls. This disease is seen in all cotton growing areas, but more serious in Gujarat, Karnataka and Andhra Pradesh.

Favourable factors for disease development:

The environment is most favourable within the crop canopy and therefore Alternaria leaf spot should be most severe on lower leaves and least severe on the upper leaves (unless the upper leaves have been affected by premature senescence). When a susceptible crop is exposed to a favourable environment, defoliation occurs rapidly. Epidemic development is therefore favoured by either repeated heavy dews or extended periods of wet weather with the temperature of 20-30°C. Under ideal conditions, the pathogen kills the surrounding leaf tissue and produces more spores on the surface of the lesions within a few days. Numerous spores are produced on defoliated leaves on the ground under the crop. *A. macrospora* leaf spot becomes serious threat to the cotton crop under conditions less than optimal for growth of the host, especially wind damage, inadequate nutrition or ill-drained soils (poor soils).

Grey mildew (Areolate Mildew/ Dahiya)

Causal Organism: ***Ramularia areola***

Symptoms:

This disease initially appears on older leaves as the plants reach maturity, in the form of irregularly angular, pale translucent spots, 1-10mm (usually 3-4 mm) in diameter and with a definite and irregular margin formed by the veins of the leaf (called areolae). The lesions are light to yellowish green on the upper surface. As the spots grow older, the leaf tissues turn yellowish brown, while a whitish frosty growth appears on both under and upper surfaces. Lesions occur on the bracts subtending the bolls. As the leaf becomes chlorotic, the lesion turns reddish brown and defoliation takes place. Early and severe defoliation leads to premature boll opening and immature lint.

Favourable factors for disease development:

In the South zone states of Andhra Pradesh, Karnataka and Tamil Nadu, the winter cotton season is favourable for the disease development. The prevailing temperature of 20-30°C from October to January helps in the onset and the development of disease. In addition, the intermittent rains during the north-east monsoon season help to maintain the wet and humid conditions which are conducive for further spread and development. In Central zone states the disease appear during the second half of the crop season.

Leaf Curl virus disease

Causal Organism: CLCuV – Gemini virus

Symptoms:

The initial symptom is characteristic Small Vein Thickening (SVT) on young upper leaves of plants. Later, upward cupping and curling of leaves occurs due to the uneven growth of veinal tissues on the abaxial side of the leaves. Subsequently,formation of cup shaped or leaf laminar out growth called enations appear on the underside of the leaf. In severe cases and in plants affected at early age, reduction of inter-nodal length leading to stunting and reduced flowering/fruiting is observed.

Favourable factors for disease development:

This disease is transmitted by the insect vector *Bemisia tabaci* which acquire the viral particle and transmit throughout its life. The virus and vector are having wide range of host plants including cotton, brinjal, tomato, bhendi, tobacco and chilli and weed hosts like *Abutilon indicum*, *Tribulus terrestris*, *Achyranthus* sp., *Melilotus indica* , *Sida* sp. etc. Early multiplication of the vector which reaches high population levels when the cotton is still young and highly susceptible leads to the early appearance of the disease. At present this disease is also prevalent in the north zone states of Punjab, Haryana and Rajasthan.

Wilt Diseases

Cotton wilts are caused by pathogens such as *Fusarium oxysporum* f.sp. *vasinfectum, Verticillium dahliae*, non-pathogenic factors such as stem or ash weevil etc. The details on the various wilts are given in the Table 2.

Integrated Disease Management:

A plant disease occurs when there is an interaction between a plant host, a pathogen and the environment. Plants are said to be normally immune or completely resistant to almost all pathogens. However, some pathogens have developed the ability to overcome the natural resistance mechanisms of particular hosts. The host is then regarded as being susceptible to that pathogen and the pathogen is described as being virulent. When the environmental conditions are conducive, the virulent pathogen attacks the susceptible host and the disease appears. Therefore, any disease management strategy should focus on the host, the pathogen and/or the environment. Hence, an 'Integrated Disease Management' involves the selection and application of a harmonious range of control strategies that minimize losses and maximize returns.

The following are some of the steps/strategies that can be adopted for the management of the diseases.

1. **Proper Identification of pathogen causing the disease:** The identification of the disease and differentiate it from other (e.g. insect damage) is essential for evolving the strategy for the management of diseases.

2. **Exclusion of the pathogen from the area (quarantine)** prevents the pathogen from entering particular area where the disease is not prevalent . Seed is the basic input for any commercial venture of agriculture. It is needless to mention the importance of good quality seed. In cotton, for obtaining good quality of seed, acid delinting with commercial sulphuric acid (100 ml/kg of seed) followed by seed treatment with either bio-fungicides or any systemic chemicals is being adviced. This leads to near total elimination of pathogens in seed and seedlings.

3. **Use of resistant varieties/hybrids** is the basic tenet of any IPM/IDM programme. Accordingly lots of disease resistant materials have been developed and released for commercial cultivation. The following are the resistant variety/hybrid to the respective diseases.

Disease	Variety/hybrid
Verticillium wilt	MCU 5VT, Surabhi, Savita (Hybrid)
Bacterial leaf blight	MCU 10, L 604, L 389
Grey mildew	GMR 5, GMR 9 (resistant lines)
Alternaria leaf spot	CCH4 (resistant line)
CLCuV disease	RS 810, LHH 144, LH 1556, H 1117, F 1861, LRA 5166, Anjali, CP 15/2

4.Cultural practices

There are several ways to incorporate cultural practices in the integrated disease control system.

i). **Field sanitation** is another essential part of disease management. The main source for the development and spread of the foliar diseases is only through previous year's crop residues and also weed hosts near the fields. Hence, destruction of the crop residue as well as weed hosts around the field is essential. Crop residue management to eliminate the pathogens being carried over (e.g. The CLCuV infected plants should be uprooted immediately and burnt).

ii). **Use of good quality seeds:** As a general approach the farmers should take steps to sow only good quality seed materials. Seeds having above 80% germination will have vigorous growth and there by they do not suffer from infection due to soil borne organisms.

iii). **Time of sowing** is also important. If the farmers are able to take up sowing during warmer temperature (i.e. at 65°F temperature and above) there will be better germination and seedling growth.

iv). **Excessive application certain organic manures** like poultry manure will induce high vegetative growth which is conducive for foliar diseases like *Alternaria* leaf spot and grey mildew. Provision of balanced nutrition is important (e.g.) potassium deficiency results in increased susceptibility to *Alternaria* leaf spot and the application of potassium increases the natural resistance of the host.

v). **Irrigation management** is an important factor involved in disease control. Timing and duration of irrigations should satisfy crop water requirement without allowing for excess water. Over watering will favour soil borne pathogen.

vi). **Incorporation of composts** in to the soil is a fundamental increases the soil fertility and also help in disease management. The disease control is possibly effected through

(a). Successful competition for nutrients by beneficial microorganisms

(b). Antibiotic production by beneficial microorganisms

(c). Successful predation against pathogens by beneficial microorganisms and

(d). Activation of disease resistant genes in plants by composts.

vii). **Crop rotation** is another important strategy especially for the management of diseases like *Verticillium* wilt. Converting *Verticillium* infested fields to paddy crop will greatly reduce the microsclerotial population in the soil. It is also known that growing *Chrysanthemum* will be inhibitory to *Verticillium*.

viii). **Elimination of alternate hosts/weed hosts:** The pathogens of *Verticillium* and *Fusarium* wilts, *Alternaria* leaf spot, grey mildew, bacterial blight and leaf curl virus have many weed/alternate hosts (e.g. Alternate hosts like Bhendi for CLCuV and its vector should not be grown between March to June to avoid build up of virus and vector).

5. **Chemical control**

Carbendazim 50 WP is an effective fungicide for the management of grey mildew, *Cercospora* leaf spot and boll rot. The recently introduced triazole compounds *viz*., propiconazole, hexaconazole, cyproconazole and tebuconazole and prochloraz (imidazoles) Benzothiodiazole group chemical Bion (Benso (1, 2, 3) thiadiazole -7-carbothioic acid S-methyl ester) are effective broad spectrum fungicides which can be used in the management of grey mildew, *Alternaria* leaf spot and other diseases of cotton. Control of insect vectors transmitting diseases like cotton leaf curl virus disease can often be managed through the control of vector (White fly – *Bemisia tabaci*).

6. **Biological control**

Biological control agents (BCAs) have been found among the most abundant plant associated microbial genera such as Plant Growth Promoting Rhizobacteria (*Bacillus*, *Burkholderia*, *Pseudomonas*, *Streptomyces*) and the fungal genus *Trichoderma*. While synthetic toxins have their place in disease control, there is growing awareness that Biological Based Pest Management fitting in the existing IPM/IDM strategies provide more environmental friendly and economically viable alternatives for agriculture.

The advantages of biological agents as seed treatment are (i) the saprophytic nutritional status of biocontrol agents makes large-scale production feasibility, (ii) small amounts of inoculum requirement, (iii) simple methods of application, (iv) independent of energy sources for survival, (v) systemic spread along the surface of the developing root system (vi) antagonistic activity on the root surface during the economically important phase of early root infection by the pathogens, (vii) ecofriendly (viii) cheaper than synthetic toxins by 50 per cent.and (ix) no resistance development in the pathogen. Their versatile metabolism, fast growth, active movement and ability to readily colonize the root surface make the rhizobacteria suitable for seed bacterization. In addition some of the PGPR have the added advantage of plant growth promoting activities also. However, some of the disadvantages of the biopesticides are (i) narrow spectrum of activity, (ii) inconsistent performance in practical agriculture, (iii) environmental sensitivity and (iv) short shelf life.

When biocides are used as seed treatment and/or foliar sprays for control of *Alternaria* leaf spot, grey mildew etc. they antagonize, inhibit or compete with the pathogen. Moreover the application of biocontrol agents or systemic activators will turn on the host plants natural defense mechanisms against the pathogens.

Conclusion

Whenever the diseases occur, they can be managed through an integrated approach by adopting various techniques mentioned above and get proper reward.

Selected References

Chidambaram, P. and Johnson. I. 2002. Grey mildew. In: *Twenty five years achievements in cotton pathology at CICR (1976 - 2001).* Published by The Director, CICR, Nagpur. pp. 29 - 39.

Sheoraj, Monga, D. and Gupta, K.N. 2002. Leaf curl. In: *Twenty five years achievements in cotton pathology at CICR (1976 - 2001).* Published by The Director, CICR, Nagpur. pp. 16 – 25.

Srinivasan, K.V. 1994. *Cotton diseases.* Published by Indian Society for Cotton Improvement, Bombay. p.312.

Watkins, G.M. 1981. *Compendium of cotton diseases.* American Phytopathological Society.

Table 1. Major diseases of cotton and their distribution in India.

Disease	Organism	Distribution
1. Seed and Seedling diseases		
Seed infection	*Alternaria, Aspergillus, Colletotrichum, Fusarium, Rhizopus and Xanthomonas axonopodis* pv *malvacearum*	India
Shore-shin disease	*Rhizoctonia solani/R. bataticola*	Andra Pradesh, Maharashtra and Tamil Nadu
Damping off	*Pythium, Rhizoctonia solani, R. bataticola, Fusarium solani, F. moniliforme, F. o.* f.sp. *vasinfectum*	Bihar, Madhya Pradesh Tamil Nadu, Andra Pradesh and Central India
Seedling blight	*Xanthomonas axonopodis* pv *malvacearum*	North and Central India and not common in South India
Root rot	*Macrophomina phaseolina (R. bataticola)*	Punjab, Rajasthan, Utter Pradesh, Bihar, Gujarat, Andra Pradesh and Tamil Nadu
	Sclerotium rolfsii (Collar rot)	Maharashtra, Madhya Pradesh, Andhra Pradesh and Tamil Nadu
2. Foliar diseases		
Alternaria leaf spot	*Alternaria macrospora, Alternaria alternata*	Karnataka, Gujarat Andra Pradesh and Tamil Nadu
Grey mildew	*Ramularia areola*	Madhya Pradesh, Bihar, Maharashtra, Karnataka, Andra Pradesh and Tamil Nadu
Bacterial blight	*Xanthomonas axonopodis* pv *malvacearum*	Tamil Nadu, Karnataka, Maharashtra, Madhya Pradesh, Andra Pradesh, Punjab, Haryana and Rajasthan
3. Viral diseases		
a. Leaf crumple	Virus	Maharashtra
b. Leaf Curl	Virus	Rajasthan, Haryana and Punjab
c. Stenosis	Virus	Gujarat, Andhra Pradesh, and Karnataka
4. Vascular wilts		
Fusarium wilts	*Fusarium oxysporum* f.sp. *vasinfectum.*	Maharashtra, Gujarat, Madhya Pradesh, Haryana, Andhra Pradesh and Karnataka
Verticillium wilt	*Verticillium dahliae*	Karnataka and Salem and Madurai districts of Tamil Nadu

Table 2. Wilt diseases of cotton – a comparison

Fusarium wilt	Verticillium wilt	Sudden wilt
Caused by *Fusarium oxysporum* f.sp. *vasinfectum*	Caused by *Verticillium dahliae*	Unknown etiology
Plants may be affected at any time throughout the season	Most common late in the season or after wet and/or cool weather	Occurs after wet weather or water logging
Favoured by mean temperatures above 23 °C	Favoured by means temperatures below 23 °C	Favoured by cultivation prior to irrigation and warm weather
Plant death, wilting, yellowing, stunting, defoliation, some attempted re-growth	Leaf mottling, death of leaf tissue between the veins and around margins, defoliation sometimes	Sudden wilting followed by defoliation and some re-growth
Brown/chocolate discolouratiojn of vascular tissue throughout the entire main stem	Dark brown, tan to black discolouration of vascular tissue throughout the entire main stem	Some browning of vascular tissue in the lower stem-especially under the bark
Areas of reduced or patchy stand usually spreading in the direction of irrigation	Stand usually not affected. Diseased plants scattered throughout stand	Stand usually not affected-isolated plants or several plants together in a row-especially in low patches or near tail drain
Soil-inhabiting, spread with soil and plant debris-especially in irrigation water	Soil-inhabiting, spread with soil and plant debris-especially in irrigation water	Soil-inhabiting, spread with soil especially in irrigation water or flood water
Survives as singly celled, thick-walled chlamydospores (7-13 microns)	Survives as multi-cellular, thick-walled microsclerotia (30-60 microns)	Survives as a saprophyte living on plant debris in soil
Can be seed borne	Not seed borne	Not seed borne
Host range- *Sesbania*, Pea and dwarf *amaranths*	Egg plant, sunflower, soybean, potato, tomato etc., and weed hosts	--

Nutritional and Physiological Disorders of Cotton

S.E.S.A. Khader and A.H. Prakash
Senior Scientists (Plant Physiology)
Central Institute for Cotton Research, Regional station, Coimbatore – 641 003

Nutritional problems and deficiency symptom in cotton depend on areas of production, which is directly or indirectly influenced both by soil and climate. With the introduction of new high yielding varieties and hybrids, rapid depletion of nutrients from soil has become a limiting factor in cotton production. Hence, the cotton growers have increased the rate of application of the major plant nutrients in the form of concentrated fertilizers every year, which have led to non-availability of secondary, and micronutrients in the soil. The amount of filler or carrier materials have been drastically reduced or eliminated in the fertilizers, thereby reducing the secondary and micronutrients substantially. Application of farmyard manure which is a potent substitute for secondary and micronutrients besides enriching the soil health is disappearing in modern cultivation. Therefore, the secondary and micronutrient requirements of cotton have to be supplemented along with fertilizer dose applied in soil or introduced into the plants through foliar application.

I. Nutritional deficiency symptoms in cotton:

The capacity of cotton plants to develop an extensive tap root system may partially account for the lack of widespread deficiency of micronutrients such as zinc, manganese, copper, boron, iron and molybdenum. Further more, the appearance of deficiency symptoms in cotton does not always imply that the nutrient in question is in short supply in the soil. Their solubility and availability can be influenced by one of the several factors like drought, water logging, climate conditions, pH of the soil, soil and plant health, antagonistic effect of other elements, etc.

a. Nitrogen Deficiency:

Nitrogen is usually concentrated in the growing points of the plant which influences both rate and extent of growth. As a component of chlorophyll, it is vital to carbohydrate metabolism. The severity of nitrogen deficiency symptom is usually greater in cotton growth under coarse textured soils where organic matter is low.

A pale yellowish green colour, coupled with reduction in leaf size is the most striking symptom of nitrogen deficiency in cotton. Eventually, the cells become disorganised accompanied by development of red pigments called anthocyanins.

Nitrogen deficient plant is also characterized with little vegetative growth, lack of vigour coupled with stunted growth.

b. Phosphorus Deficiency:

Phosphorus is required in a lesser quantity than nitrogen. This nutrient simulates early and extensive development of the root system. The presence of this nutrient is essential for synthesis and break down of carbohydrates involved in energy transfer. It also promotes flowering and seed formation in cotton. Phosphorus when applied gets fixed in the soil particularly in low pH and becomes unavailable to the plant. Therefore, raising the soil pH of those soils to appropriate levels through application of lime is suggested to increase the efficiency of applied phosphorus.

Leaves of Phosphorus deficient plants remain dark green in colour with reduced leaf size. The deficiency symptom is first reflected in the lower or older leaves of cotton plant. The deepening of the green colour of the leaves progresses upward towards to the growing point to the extent phosphorus is deficient, suggesting that the nutrient moves to younger tissues as the supply diminishes. An extreme deficiency of phosphorus not only reduces the plant size, but also suffers from lack of secondary branches and reduction in boll number. It also leads to delay in blooming, fruiting and maturity of the bolls.

c. Potassium deficiency:

Potassium is the third major nutrient required for optimum production of cotton. Potassium is very much essential for movement of starch and sugars between different parts of the plant for normal cell division, growth and for nutralisation of organic acids. Also, a definite inter-relationship is maintained among potassium, calcium and sodium in tissues of cotton plant.

Lack of potassium results in a striking malnutrition symptom called 'cotton rust'. A yellowish white mottling of the foliage with characteristic change in leaf colour to light yellowish green spots appear between the veins. The tips of the leaf and margins break down and curl downwards. Finally, the whole leaf becomes reddish brown, dries and prematurely drops from the plant affecting the normal development of bolls, which remain small and immature. Many bolls fail to open altogether with poor quality fibre.

d. Calcium Deficiency:

Calcium is required within the plant cell to favourably influence the enzyme activity and also to cement the cell walls in the form of calcium pectate particularly in the growing points of roots and shoots where cell division and cell elongation take place. Cotton is known to be a calcium accumulator in order to synthesize organic acid compounds in the plant.

Calcium deficiency is generally manifested in early stage of the crop. The leaf petioles start bending and collapse later. These symptoms are seen in cotyledons as well as in true leaf stage of the crop.

e. Magnesium Deficiency:

Magnesium plays an important role in photosynthetic process and is a key element in the chlorophyll moiety and related enzymes. Deficiency symptoms appear in areas where fertilizers contain large amount of nitrate, sulphate or chloride ions. Where ammonium phosphate is used as the source of nitrogen, magnesium deficiency is at its minimum. This is due to the formation of magnesium ammonium phosphate, which prevents leaching of large quantities of magnesium from light textured soils.

The characteristics symptom of magnesium deficiency in cotton is the purplish red leaves with green veins. Deficiency symptoms first appear on the lower leaves and shed prematurely. Loss of leaves, with a corresponding reduction in photosynthetic activity results in poor yields.

f. Sulphur deficiency:

Comparatively, large amounts of sulphur are utilized by cotton plant. since, cotton seeds are rich source of protein and oil, sulphur becomes an important constituent. it is also associated in the formation of green pigment and sulphur containing amino acids. cotton soils generally gets replenished with sulphur through air, irrigation water and conventional fertilizer.

Cotton plants grown in sulphur deficient soil put forth yellowish leaves. New leaves deficient of sulphur become yellower as the growth progresses while the old leaves remain green because sulphur is not readily translocated to the growing points. In other aspects, symptoms of sulphur deficiency are similar to those which result from inadequate supply of nitrogen. Sulphur deficient plants are characteristically small, spindly with slender stalks.

g. Boron deficiency:

Although boron is required in trace amount, it plays a very important role in the reproductive process of the cotton plant. Boron influences conversion of nitrogen and carbohydrates into more complex substances such as proteins and help in transfer of sugars within the plant. Since boron occurs in mineral form as well as in the soil organic matter, deficiency can be expected in soils, which have low mineral level or low organic matter content.

Boron deficiency frequently appears first in the terminal growth of the cotton plant. The terminal bud often dies checking further vertical growth. Consequently, many lateral branches arise with shorter internodes giving a bushy appearance often referred to as 'rosette' condition. At low boron level, flower buds become chlorotic and the bracts flare open. Even surviving bolls are deformed presenting a flat-sided appearance. Excessive shedding of both squares and young bolls are a common feature.

h. Manganese deficiency:

Manganese is required in minute quantity for optimum production of cotton. It is associated with iron movement within the plant which inturn helps in the synthesis of chlorophyll. Manganese deficiency does not occur widely in field condition. However, where deficiency of manganese occurred particularly under high acid soil condition, the young leaves are affected initially.

They become yellowish or reddish grey in colour with green veins. Excess quantity of water soluble manganese in the soil will also lead to appearance of abnormal leaves. They become puckered, mottled, partially chlorotic and distorted in early stages with necrotic lesions subsequently appearing along the veins. As the plant approaches maturity, the affected leaves become slightly thickened and brittle.

i. Zinc deficiency:

Zinc deficiency has become a limiting factor in crop production now-a-days. Heavy use of lime on acid soils raise the pH with the formation of zinc hydroxide which has very low solubility. Also, excess application of phosphorous tend to form zinc phosphate which decreases the availability of zinc to the plants.

Cotton seed germination appears to be normal under zinc deficient condition. However, soon after the true leaf apperance, a general bronzing and interveinal chlorosis appear. The leaves become thick and brittle with their margins cupped upwards. Squares and flowers that are formed tend to shed. With renewal of further growth, additional squares that are formed may mature into bolls depending on other factors.

II. Nutrient uptake and translocation in cotton

Cotton plant is perennial in nature and has been domesticated as an annual plant to overcome production and plant protection problems. However, the plant has a vigorous growth pattern drawing considerable amount of major and minor nutrient from the soil. Generally, nitrogen (N) and potassium (K) are taken up three folds than the phosphorous (P) and the 3:1:3 ratio of N P K is maintained.

Studies have shown that maximum uptake of nutrient was in tune with maximum dry matter production. The concentration of n and p decreased in leaves as bolls matured, whereas in stem and root, the n and p remained at constant level. Potassium contents of roots, stem and leaves decreased with boll development. Thus n and p were transported from leaves only, while potassium was transported from all vegetative parts to the developing bolls. The calcium and sulphate content in the leaves remained unchanged indicating the continuous absorption process. The magnesium content of the leaves decreased slightly during initial boll formation stage. Most of the nutrients were depleted from the leaves except calcium during maturity stage.

Studies revealed that nutrient uptake depends on the plant type traditional variety like mcu-1 with 160 days duration continued to be more vegetative for the first 100 days after sowing with utilization of NPK for vegetative growth. During boll formation the vegetative parts showed a rapid decline in the nutrient concentration. On the contrary in a short-branched compact variety PRS 72, the distribution pattern of nutrient appeared to be in a balanced way because of its less vegetative habit and tendency to fruit early. Even at maturity the nutrient content in the leaves and stem of PRS 72 were reduced appreciably whereas more nutrients remained unutilized in mcu-1. The study concluded that for producing the same quantity of yield, PRS 72, required less amount of nutrient (table 1) suggesting that plant architecture and earliness influenced the nutrient uptake in cotton.

Table 1. Nutrients removed and yield of seed cotton (kg/ha)(Bhatt and Appukuttan, 1971)

Variety	N	P	K	Yield (kg/ha)
MCU-1	217	72	227	3017
PRS 72	130	44	136	3151

III. Physiological disorders in cotton

Cotton is commercially grown as a Kharif crop during the month of August-September. During the crop growth, cotton is exposed to unpredicted vagaries of nature and is prone to many physiological disorders like bud and boll shedding, leaf reddening and excessive vegetative growth etc. leading to poor yields.

a. Bud and Boll Shedding

Flowering in cotton commences from the month of October – November coinciding the North East monsoon. During this period, the crop suffers from insufficient light due to cloudy days with intermittent rainfall for several days. Consequently, the photosynthetic rate of the plant decreases and development of flowers and young bolls are retarded for want of proper nutrition. Besides, due to insufficient light, production of key hormones like auxin in the leaf is also limited inducing a hormonal imbalance in the plant. Under such circumstances, release of ethylene is triggered with formation of abscission layer in the fruiting zone leading to bud or boll shedding. Only one-third of the total flowers produced contributes to final yield. The remaining two-third are shed at various intervals either due to insect-pest or due to environmental reasons like continuous drought or water logging, high humidity in the atmosphere, continuous rainfall affecting the pollination process etc. Studies have shown that application of NAA and DAP to irrigated crop of MCU-5 **(Table-2)** reduced the buds and bolls shed and increased yield significantly. Similar effect was observed on rainfed cotton **(Table 3).**

Table 2 : Effect of NAA and DAP on yield in irrigated cotton MCU-5 (Bhatt, 1975)

Treatment	**Buds and bolls shed per plant**	**Yield (Kg/ha)**
Control	24	1507
NAA 20 ppm	20	1743
DAP 1%	18	1820
NAA alternated with DAP	16	1970

Table 3 : Effect of NAA and DAP on yield of rainfed cotton var. 1412 (Bhatt and Nathan, 1986)

Treatment	**Buds and bolls shed**	**Bolls retained**	**Boll weight (g)**	**Yield (kg/ha)**
Control	6.1	4.0	2.5	183
NAA 20 ppm	3.4	7.4	2.8	345
DAP 1%	3.2	7.1	2.9	422
NAA alternated with DAP	2.5	8.5	3.0	556

Sometimes, shedding may be due to other factors like reduced availability of nitrogen or phosphorous. Under such conditions, foliar application of 1% urea or 2%

diammonium phosphate (dap) during flowering at 10-15 days interval was found beneficial.

b. Leaf Reddening :

It is generally observed 90 days after sowing particularly where cotton is grown in red or laterite soils. The leaf initially starts yellowing and finally the entire leaf turns red leaving the midrib and other vascular regions green. Deficiency of nutrient, high temperature during the day coupled with low temperature at night, water stress or water logging are some of the important factors attributed to leaf reddening. Generally, by 100th day the cotton crop is heavily laden with developing bolls. During this phase, the demand for assimilate by the developing bolls is high and the plant is not in a position to meet the demands of the sink. Subsequently, the nitrogen concentration in the leaf is depleted below the critical level in the leaf and uptake of magnesium from the soil is antagonized leading to nitrogen induced magnesium deficiency in the plant **(Table 4).**

Table 4. Nitrogen and magnesium content of leaves in hybrid cotton (Dastur and Singh, 1947)

Cultivar	Type of leaves	Nitrogen (%)	Mahgnesium (Mg O)%
H4	Green healthy leaves	2.667	1.249
H4	Advanced leaf reddening	1.083	1.243
Varalaxmi	Green healthy leaves	2.833	0.820
Varalaxmi	Early leaf reddening	1.450	0.480
Varalaxmi	Advanced leaf reddening	1.165	0.554

Gradually, the chlorophyll moiety of the cell is broken down and cells become disorganized with the formation of anthocyanin pigments giving a red appearance to the leaf. Foliar spray of 2% DAP once in 10 days was found to be economical and effective to correct the disorder. In places where the disorder is severe 0.5% magnesium sulphate should also be added along with the spray schedule.

c. Excessive Vegetative Growth:

In cotton, it is established that only the lower two-third portion of the plant contributes to 90% of the yield and the upper one-third either remains immature or with poor quality fibre. Hence detopping or trimming the top 10cm of the plant at 100-120 days after sowing will arrest the excessive vegetative growth and allow more penetration of light to the lower side of the plant. This also reduces lodging and facilitates easy control of pests and diseases, besides increasing boll retention and boll size.

d. Control Measures :

Thus an integrated approach to reduce the physiological disorders in cotton is through foliar application of naphthalene acetic (20ppm) + 1% of diammonium phosphate and 1% of murate of potash which are commercially available in the market. The sprays should be given from the flowering phase of the crop at 10-15 days interval until harvest followed by detopping the upper 10cm of the plant at 100-120 days after sowing. The following precautions should be taken.

- The sprays should be only in the evening hours
- Diammonium phosphate should be prepared and left overnight to extract maximum nutrient and the extract should be filtered before spray.
- 0.1 percent teepol can be added as surfactant
- Insecticides can also be mixed with DAP extract if necessary to reduce the cost of labour
- Timely spray will help better performance of the crop

Fibre Quality Parameters of Extra Long Staple Cotton in India and the Future Outlook and Post Harvest Management

G.F.S. Hussain

Principal Scientist
Central Institute for Research on Cotton Technology, Mumbai

Introduction:

With the establishment of the WTO regime, India becomes a part of the global textile market bereft of quotas. Import and export of textiles would be driven by quality and price competitiveness. Indian garments, fabrics and yarns will have to be of high quality matching with those produced in competing SE Asian countries if our market share in international trade is to be sustained and enhanced. Even to retain the hold on domestic market in an open market system, quality improvement is a must.

High standards of quality based on Uster Statistics are demanded by overseas buyers for yarns. Concepts of zero defect fabrics, and of long length fabrics without dye shade variation are catching up. Trash and contaminant-free cottons with excellent fibre quality attributes such as high strength, high maturity, low variations in properties, low short fibre content, negligible incidence of motes and seed coats etc. are prerequisites for production of textiles fit for the export market.

What the mills look for in cottons is Staple length, Micronaire and strength, the primary characteristics on which yarn quality depends. Yarn strength, extensibility, count uniformity, U%, neps, thick places, thin places, hairiness and performance in dyeing are very important yarn characteristics that determine the export worthiness of yarns. Long fibre length, low micronaire and high strength contribute to high yarn strength. Count uniformity and low U% are ensured not only by the quality of processing, but also by low short fibre percentage. To keep hairiness under check, short fibre content should be maintained at low levels. The use of an extensible fibre and selection of appropriate twist are essential for producing yarn with high breaking extension.

It is important to note that many export oriented units are resorting to underspinning cotton to realise high yarn uniformity and CSP. Since high standards are demanded in the overseas market, qualities such as low short fibre content, low incidence of seed coats and motes, high fibre maturity etc. must be maintained in all varieties of cotton.

On the basis of the count mix in yarn production practised by Indian mills in recent years and considering the tendency of mills to underspin cotton to realise higher CSP and uniformity characteristics demanded by overseas buyers, an estimate of cotton requirements in the coming years has been worked out at CIRCOT [Table 1]. Very recently the ICMF, the premier body in the country representing the cotton mill industry has projected the requirement of cotton by 2010 as about 350 lakh bales. The count wise requirement both for 2006-07 as well as for 2020 is shown in Table 1 below. It would appear that consumption of medium staple cottons will continue to remain high in the coming years. Also long staple cottons in the length range of 28-30 mm will be required in large quantities. The current trend of cotton imports from several countries also clearly indicate preference for long staple cotton.

Table 1 : Cotton Requirements in Different Staple Classes

Staple Length Class	Present Consumption (Lakh Bales) 2003-04	Requirement in 2006-2007 (Lakh Bales)	Requirement in 2009-2010 (Lakh Bales)
Short (less than 20 mm)	18 (10.2%)	21	34
Medium (between 20.5 mm to 24.5 mm)	61 (34.5%)	77	121
Medium Long (between 25.0 mm to 27.0 mm)	30 (17.0%)	42	65
Long (between 27.5 mm and 32.0 mm)	61 (34.3%)	70	110
Extra Long (above 32.5 mm)	7 (4.0%)	13	20
Total	**177**	**223**	**350**

Cotton Imports: The last few years have witnessed a strange phenomenon of massive cotton imports despite adequate domestic production. On account of considerable decline in international cotton prices during the past few years, many prominent mills in India have found imported cotton to be cheaper than Indian cotton. Cottons from Australia, China, Uzbekistan, Sudan, Turkey, Greece, Egypt and several western and central African countries have found their way into Indian mills.

Three reasons are cited by mills for their preferences for foreign cottons :

- Lower price
- Credit facility
- Superior quality

Quality of Indian Cottons: In the industry circle, the common refrain is that Indian cottons are of poor quality. More often than not, poor quality is identified with high levels of trash and contamination. Of course, fibre attributes and lot-to-lot variability of the fibre attributes are also factors that decide the quality of cotton. Not infrequently, bad ginning practices too contribute to quality diminution characterized by fibre breakage, occurrence of cut seeds and excessive nep formation.

Table 2: Cotton Quality Determinants

Colour	:	Genetic, exposure to sunlight, dust
Trash	:	Agronomic, harvesting style, use of precleaner
Contaminants	:	Inadequate care in harvesting, storage and handling at farm yard, market mandi and ginnery
Motes, cut seeds and neps	:	Genetic, agronomic, ginning style
Variability of fibre quality	:	Genetic, agronomic, mixing of varieties, mixing of cotton from different pickings
Intrinsic fibre quality	:	Genetic, agronomic

It is said that many Indian varieties have deteriorated in quality over the years. Staple length has diminished. The Micronaire of fine varieties has come down due to immaturity. Coarse varieties have become coarser, thus reducing the yarn CSP. Fibre strength has declined in some varieties. It is also mentioned that variability in fibre quality characteristics has increased. Fibre properties like length, strength and fineness show considerable variation between lots of the same variety making the spinner's task of maintaining consistency of yarn quality very difficult.

Most Indian cottons are characterized by high variability in all fibre quality characteristics. Table 3 gives ranges of three major fibre properties, namely, fibre length, Micronaire and strength, displayed by some Indian varieties [3(a)] vis-à-vis those of varieties from USA[3(b)]. It is apparent from a comparison of data on Indian and American cottons that the spread in fibre length in the former is very high, often in the range of 5-10 mm. Micronaire shows wide variations even in American cottons, but Indian varieties show markedly higher variations. The range of fibre strength found among lots is also much higher in Indian cottons than in American varieties. As discussed earlier, here again it will be hazardous to interpret the results unless we separate the effect of mixing.

Table 3(a) : Quality Ranges of Indian Cottons

Sl No	Variety	Range of Values		
		Fibre Length (mm)	Mic (μg/in)	Tenacity (g/t)
1	J.34	3	1.5	5
2	NHH.44	6	1.6	6
3	LRA.5166	7	1.9	7
4	H.4	5	1.3	9
5	MECH.1	5	1.3	3
6	MECH.11	5	1.6	5
7	JKHY.1	6	1.8	7
8	S.6	5	1.4	6
9	MCU.5	10	2.2	5
10	DCH.32	6	0.9	6
11	Suvin	3	0.3	5

Table 3(b) : Quality Ranges of American Cottons

Sl. No	Variety	Range of Values		
		Fibre Length (mm)	Mic (μg/in)	Tenacity (g/t)
1	All-tex	5	1.6	5
2	Deltapine	4	1.5	4
3	Hyperformer	2	1.0	4
4	Paymaster	4	1.0	4
5	Ranger	2	1.5	4
6	Stoneville	2	1.0	4
7	Suregrow	4	1.0	4
8	Tamcot	3	1.8	4
9	Pima	2	1.2	3
10	Brownfield	2	1.5	4
11	Germains	2	1.2	4

Norms for Quality in Breeding: The textile industry as well as textile research organisations in the country have been asking for better fibre quality in Indian cottons. Industry's suggestions with regard to each of the fibre quality parameters like staple length, uniformity, Micronaire, extensibility and tenacity, required for spinning yarns of different counts have been incorporated in Table 4. These norms will serve as guidelines for breeders while making selections in cotton improvement programmes.

Table 4 :Fibre Quality Norms for Cotton Breeding – Industry's recommendation

Yarn Count	2.5% span length (mm)	UR%	Mic	Tenacity g/t (Minimum)	Elongation (%)	Maturity Pm(%)	FQI	CSP
6s-20s	22-25	50	4.0-5.0	20-22	6.0	80	200-270	2400
21s-30s	26-27	50	3.8-4.8	22-23	6.0	80	270-320	2500
31s-40s	28-30	50	3.8-4.5	24-25	6.0	80	320-380	2600
41s-50s	30-31	50	3.5-3.8	25-27	6.0	80	380-450	2800
51s-60s	31-33	48	3.3-3.5	27-28	7.0	75	450-510	2900
61s-80s	33-35	48	3.2-3.4	28-30	7.0	75	510-590	3000
81s-100s	36-38	48	3.2-3.4	30-32	7.0	75	590-680	3200
101s-120s	36-38	48	3.2-3.4	30-32	7.0	75	590-680	3400

Quality Gaps in Indian Cottons : The quality spectrum presented by Indian cottons is very wide. We have the coarsest and the finest cottons in the world, the longest and shortest, as well as the strongest and the weakest. The right combination of these three characteristics is, however, not found in many varieties. This is particularly so in cottons in the staple length range of 28-30 mm for which there is growing demand. In fact, most of imported bales belong to the length range of 28-30 mm combined with a Micronaire of 3.8 to 4.2 and a strength of 22-25 g/t. Indian cottons in the above staple length range are found to be either too fine (and immature), or too weak. There is urgent need to evolve varieties to fill this gap in the quality spectrum. Breeding programmes should endeavour to bring the Micronaire level of 28 mm cottons to about 4.0 and raise their strength to 25 g/t.

Table 5 depicts the fibre attributes of extra long staple varieties released during last six decades. It is evident from the data that most of the varieties belong to interspecific G.hirsutum x G.barbadense , a few to barbadense and hirsutum varieties . Expect for a few varieties which were spinnable to 50s count, most of varieties were spun to counts above 60s.

Table-5 : Extra Long Staple Cottons Released

Sr. No.	Variety/Hybrid	2.5% SL (mm)	Mic	S 3.2mm	Count	Year	Species
1	Sea Island Andrews	33.0	3.5	28.0	70s	1956	B
2	Gujarat-67	31.0	3.4	28.0	60s	1963	H
3	MCU-4	30.0	3.8	24.0	60s	1967	H
4	MCU-5	33.0	3.2	26.0	60s	1968	H
5	Sujata	33.0	3.2	32.0	100s	1969	B
6	NHB-1	33.0	3.5	26.0	80s	1972	HB
7	Varalaxmi	34.0	3.2	28.0	80s	1972	HB
8	CBS 156	35.0	3.2	30.0	100s	1974	HB
9	Suvin	36.0	3.2	38.0	120s	1974	B
10	MCU-9	30.0	3.4	24.0	60s	1978	H
11	Hybrid-6	30.0	3.8	25.0	70s	1979	HH
12	RHR 253	32.0	3.6	25.0	80s	1979	HB
13	KCH I	32.0	3.2	28.0	60s	1980	HB
14	JKHY- 11	32.0	3.2	28.0	60s	1981	HB
15	TNB I	34.0	3.4	28.0	100s	1981	B
16	DCH 32	38.0	3.0	30.0	80s	1981	HB
17	MCU-5 VT	32.0	3.3	25.0	60s	1982	H
18	NHB 80	36.0	3.2	24.0	80s	1982	HB
19	MECH I	30.0	3.5	26.0	60s	1983	HH
20	Savita	33.0	3.8	26.0	60s	1987	HH
21	BCS 2 3-18-7	33.0	3.7	32.0	80s	1988	B
22	G. Cot DH 9	31.0	4.7	23.0	50s	1989	HA
23	NHB 12	34.0	3.0	28.0	80s	1989	HB
24	HB 224	35.0	2.9	30.0	80s	1989	HB
25	TCHB 213	35.0	3.6	25.0	80s	1989	HB
26	ACP 71	30.0	3.8	23.0	50s	1990	H
27	RCH 2	30.0	3.4	24.0	50s	1992	HH
28	LK 861	30.0	3.8	24.0	50s	1993	H
29	TM 1312	32.0	3.4	26.0	50s	1994	HH
30	DHB 105	32.0	3.2	25.0	60s	1994	HB
31	NBHB 11	35.0	3.7	25.0	60s	1996	HB
32	VRS 7	32.0	3.2	24.0	60s	1996	H
33	CDHB I	35.0	3.5	28.0	80s	1996	HB
34	Kashinath	34.0	3.0	25.0	80s	1997	HB

Table 6 provides the summarized date on the fibre attributes of Extra long Indian cottons and corresponding foreign cottons.

Table 6: Fibre Attributes of cottons in the staple group 31 to 36 mm

Origin	2.5% S.L.(mm)	U.R. %	Mic. Value	Tenacity (g/t)
		Foreign		
Male	33.8-35.6	47-49	3.8 – 4.0	31.1 – 35.2
Gala	34.2 – 35.5	48 – 51	3.8 – 4.1	31.5 – 35.4
Plori	34.5 – 35.0	49 – 50	4.0 – 4.1	33.0 – 31.9
Tajakistan	34.3	48	4.1	29.4
Turkmenistan	33.1	47	4.0	30.3
		Indian		
Bunny	27.2 – 35.7	43 – 54	3.0 – 4.7	20.2 – 28.1
DCH-32	30.1 – 37.9	42 – 53	2.6 – 3.9	23.4 – 29.6
Hybrid 102	38.8	52	3.2	29.9
Surabhi	31.3 – 34.2	45 – 51	3.3 – 4.6	21. 5- 27.1
Navbharat Kranti	36.2	51	4.1	27.2
Suvin	38.8 – 39.4	46 – 50	3.5 – 3.6	32.7 – 35.4

It is evident from the Table that Indian cottons in the staple group 31- 36 mm have been found to have lower micronaire value not exceeding 3.5 units in majority of the cases as compared to an average value of 4.0 in import growing. The lower micronaire value has been found to be not due to intrinsic finer nature of the cotton but has more to do with immaturity arising from lack of adequate cell wall development . The tenacity values in Indian cottons in this category have been noted to be on the lower side by about 4 – 10 g/tex.

Table 7 sums up fibre traits of Extra long cottons which were prevailing in the market during the years 2001 to 2005.

Table-7: Quality of Extra Long Cottons Prevailing in the Market

Year	Variety	2.5% SL (mm)	Mic	S 3.2 mm
2001	DCH 32	31.6-36.1	2.6-3.1 (2.9)	25.0-30.4 (27.7)
	DHB 105	29.8-30.8 (30.3)	2.3-2.3 (2.3)	23.9-24.8 (24.4)
	L 389	30.1-30.9 (30.5)	3.7-3.8 (3.8)	21.4-22.1 (21.8)
	MCU-5	28.2-34.6 (30.9)	2.3-4.4 (3.7)	21.4-27.3 (24.5)
	Surabhi	30.2-31.7 (31.1)	3.1-3.7 (3.3)	22.9-25.8 (24.5)
	Varalaxmi	35.9-37.0 (36.5)	3.1-3.4 (3.2)	29.2-30.8 (30.2)

Year	Variety	2.5% SL (mm)	Mic	S 3.2 mm
2002	Bunny	27.6-33.7 (31.3)	3.0-4.2 (3.7)	20.0-27.5 (24.4)
	DCH 32	32.2-37.8 (34.8)	2.5-3.5 (2.9)	23.2-30.8 (27.1)
	MCU-5	28.3-34.4 (30.9)	2.5-4.2 (3.5)	22.0-27.5 (24.7)
	RCH	28.2-33.4 (30.2)	2.6-4.6 (4.0)	20.0-23.4 (21.3)
	Surabhi	33.8-34.8 (34.4)	3.8-4.1 (4.0)	26.2-27.9 (26.9)
	Suvin	37.5-37.5 (37.5)	3.5-3.5 (3.5)	30.1-30.1 (30.1)
2003	Bunny	27.4-33.2 (30.6)	2.7-4.2 (3.6)	20.8-26.9 (23.8)
	DCH 32	29.4-37.5 (33.9)	2.2-3.5 (3.0)	22.1-32.7 (27.8)
	MCU 5	28.9-34.0 (32.1)	2.7-4.2 (3.7)	20.8-29.0 (24.7)
	MECH 11	30.8-30.8 (30.8)	3.7-4.1 (3.9)	23.1-25.4 (23.9)
	Surabhi	31.9-32.6 (31.8)	3.1-3.7 (3.5)	22.7-26.3 (25.0)
	Suvin Gold	38.1-38.1 (38.1)	3.3-3.3 (3.3)	31.9-31.9 (31.9)
	Varalaxmi	34.8-34.8 (34.8)	2.4-2.4 (2.4)	28.3-28.3 (28.3)
2004	Ankur Akka	30.5-31.7 (31.1)	3.7-4.2 (4.0)	23.3-23.9 (23.6)
	Bharathi	30.7-32.9 (31.8)	4.1-4.5 (4.3)	23.0-24.0 (23.5)
	Brahma	28.1-34.0 (30.7)	3.1-4.7 (3.9)	21.0-25.2 (23.4)
	Bunny	27.2-35.7 (31.2)	3.0-4.7 (3.7)	20.2-28.1 (23.8)
	DCH 32	30.1-37.9 (34.3)	2.6-3.9 (3.0)	23.4-29.6 (27.0)
	HB 102	38.1-38.1 (38.1)	3.5-3.5 (3.5)	30.6-30.6 (30.6)
	Hybrid 102	38.8-38.8 (38.8)	3.2-3.2 (3.2)	29.9-29.9 (29.9)
	Krishna	29.6-32.2 (30.9)	4.1-4.1 (4.1)	23.2-24.2 (23.7)
	MCU-5	27.6-33.1 (31.3)	3.0-4.1 (3.5)	20.2-26.4 (24.2)
	Navbharat Kranti	36.2-36.2 (36.2)	4.1-4.1 (4.1)	27.2-27.2 (27.2)

Year	Variety	2.5% SL (mm)	Mic	S 3.2 mm
	Supriya	30.4-30.4 (30.4)	3.9-3.9 (3.9)	25.2-25.2 (25.2)
	Surabhi	31.3-34.2 (32.5)	3.3-4.6 (4.0)	21.5-27.1 (23.5)
	Suvin	38.8-39.4 (39.1)	3.5-3.6 (3.6)	32.7-35.4 (34.1)
2005	Anjali	31.0-31.0 (31.0)	4.2-4.2 (4.2)	25.3-25.3 (25.3)
	BB (Brahma)	28.6-33.8 (31.6)	2.8-4.5 (3.7)	22.0-26.7 (24.6)
	Bunny	27.0-33.2 (30.4)	3.0-4.3 (3.7)	20.4-25.8 (23.1)
	DCH 32	30.9-36.5 (33.7)	1.9-3.4 (2.9)	24.9-30.9 (28.0)
	H 4	28.5-32.4 (30.4)	2.9-4.0 (3.4)	21.3-26.3 (23.9)
	H 6	30.8-31.3 (31.0)	3.4-3.8 (3.6)	22.6-23.4 (23.0)
	H 8	31.3-31.3 (31.3)	3.1-3.1 (3.1)	22.0-22.0 (22.0)
	JKHy- 1	31.0-33.0 (32.1)	3.2-3.5 (3.4)	24.0-25.9 (25.1)
	Laxmi	29.3-36.9 (32.8)	1.9-3.1 (2.5)	27.8-28.8 (28.3)
	MCU-5	30.4-34.3 (32.8)	3.2-4.5 (3.8)	23.8-25.9 (24.8)
	MECH 12	30.0-30.1 (30.1)	4.2-4.4 (4.3)	24.5-25.4 (25.0)
	Nathbaba	29.3-32.6 (30.9)	3.9-4.6 (4.3)	23.8-25.5 (24.8)
	NCEH-2R	29.0-32.2 (30.8)	3.9-4.8 (4.3)	23.9-25.5 (24.8)
	Surabhi	32.8-32.8 (32.8)	3.1-3.1 (3.1)	26.2-26.2 (26.2)

Extra Long Staple Cottons in Pipe-line (AICCIP)

Table 8 shows the extra long varieties, which are in the pipeline through AICCIP.

Table-8: Extra Long Staple Cottons in Pipe-Line

Variety	2.5% SL (mm)	Mic	S 3.2 mm
JKCHB 213	35.6	3.3	27.5
HAGHB 1042	36.0	3.1	27.7
CCHB 630	33.6	2.6	27.5
VBCH 2231	32.7	3.5	27.2
NRCH 1779	31.6	3.5	27.8
GSGHH 52	30.8	4.3	27.8
G. Cot Hy 102	36.7	3.4	27.9
Teja	34.9	4.6	27.3
SUCH 619	31.0	2.7	27.5
ARBHB 924	37.0	3.2	27.8
RAHB 163	32.0	2.9	27.4
GSHB 811	35.1	3.4	28.1
ZCHB 5762	35.6	4.0	28.0
CCHB 727	34.0	3.0	28.6
SSB 7	34.3	2.9	28.1
KDCHB 407	33.8	2.9	29.7
RAHB 47	33.2	3.5	29.9
GSHB 811	34.7	3.6	28.3
NCHB 225	34.0	3.5	32.4
Nimbkar 129	34.5	3.2	32.2
Harita 225	35.3	3.2	28.0
RHB 2003	34.9	2.9	27.9
Sandocot HB 5	35.4	3.5	27.8
RAHB 25	35.6	3.0	29.8
BCHB 6188	31.2	3.2	27.6
DHB 904	33.5	3.1	33.6
RHB 0488	35.0	3.1	32.7
GSHB 737	34.3	3.3	33.8

Post Harvest Management:

Main reasons attributed for import of cottons are the shortage of good quality cotton, high percentage of trash and contaminants found in Indian Cottons. At various stages from picking down to ginning and pressing trash level goes on increasing. To reduce trash and contaminants the following measures need to be adopted strictly at various stages.

At Farms

Do's:

- Only after morning dew drops have evaporated picking should be started.
- Pick kapas from only well opened bolls.
- Use of cotton bags for picked cotton.

- Cotton should be covered with cotton cloth or tarpaulin to avoid soiling of cotton.
- Labourers should cover their heads with cloth to prevent contamination of hairs.
- Remove insect-infected, stained and hard locks from the clean kapas.
- Clean the bullock cart, tractor trolley before loading the kapas.

Don'ts:

- While harvesting cotton, do not pick leaves; stem bits, twigs, bracts.
- Do not add water to kapas
- Avoid mixing of different varieties or different picking of kapas.
- Do not allow fodder, papers and polyethylene bags to be mixed with kapas.
- Don't store fire crackers near kapas stock to prevent fire.

II) At market yards

Do's:

- Keep the market yards clean.
- Cotton should be unloaded only on cemented surface or on cotton cloth.
- Cover kapas heap with tarpaulin.
- Ensure those paved platforms are away from the heap.

Don'ts:

- Never unload cotton on the ground or otherwise cotton will get contaminated with soil.
- Does not mix seed cotton lots of different varieties.
- Do not expose to kapas to element of nature such as sun, rain or wind.
- Do not throw empty packets of tobacco, betel nuts etc on kapas heap.

III) At Ginning and pressing factories

Do's

- Impose use of cotton-cloth covers while transporting kapas to ginneries.
- Keep factory premises clean.
- Keep kapas on clean, paved platform or in well ventilated covered go-downs.
- Remove contaminants and foreign matters before forming kapas heaps.
- Keep moisture content in kapas within 7-9% limit.
- Use Benson's fan or nozzle spray system to maintain moisture level.
- Install Kapas pre-cleaners or use jalicots to remove immature bolls and foreign matters.

- Install either pneumatic or belt conveyers with stone-catcher to transfer kapas to gin.
- Maintain proper overlap settings and insure periodic grooving of leather rollers to avoid seed cut and good quality lint.
- Use proper seed grids for processing and drain out seeds of different varieties.
- Adopt pneumatic conveying or belt conveyor with online super-cleaner to transport lint from gin house to baling press.
- Adopt auto tramping and modern press for baling.
- Use cotton cloth for wrapping the pressed bales and cover it fully.
- Use cotton threads for stitching the bale and new iron strips of 18-19 gauge and 12.5mm width for fastening.
- Bale specification should be printed on the cloth cover and store cotton bales in covered godown.

Don'ts

Never stock cotton on bare ground to prevent it from soiling and other impurities.

- Do not roll boras on the ground while transporting to the gin house or press house.
- Do not spray water directly either on kapas or lint before ginning or baling.
- Do not use jute bags and jute treads either for transporting or tying bags and bales of cotton.
- Do not keep inflammatory material inside the factory premises.
- Do not allow children playing; people eating, smoking and vehicles near the kapas heaps.

Utilisation of Cotton Plant Stalks for Value – added Products

A. J. Shaikh & R. M. Gurjar

Central Institute for Research on Cotton Techology, Matunga, Mumbai – 400 019.

Cotton is mainly cultivated for its lint, which is the most sought after textile fibre till date due to its inherent ecofriendly and comfort characteristics. It is also one of the important cash crops of many of the Afro-Asian countries like India, Iran, Egypt, Sudan, Uzbekistan, Tanzania, etc. and plays a major role in their economic development. However, of late, cotton cultivation in general and especially in these countries is becoming non-remunerative on account of higher cost of inputs by way of plant protection measures, rainfed cultivation practices, etc. As a result, the cultivators are not able to get adequate returns commensurate with their inputs. **Hence, there is an urgent need to explore alternative means of increasing the returns from cotton farming**. At this juncture a judicious approach to promote the use of by-products from cotton cultivation offers an attractive proposition to generate additional income to the farming community. At the same time, cotton stalks being a renewable and naturally available lignocellulosic material, its promotion as a substitute for forest timber is likely to have significant impact in arresting the environmental degradation caused by the fast depletion of forest resources.

A brief summary of cotton cultivation scenario in India and the economic potential of one of the by-products of cotton crop viz., cotton plant stalks is given below :

In Indian alone, as much as 25-26 million tonnes of cotton stalks are available. Numbers of technologies have been developed in India and elsewhere. However, two technologies namely, preparation of particle boards and binderless boards appears to be economically viable. These two technologies have been addressed in this paper with a view to generate more employment to rural youth and additional income to farmers.

Utilisation of Cotton Plant Stalks

Cotton is one of the most important cash crops of India, popularly known as "White Gold". In India, all the four cultivated cotton species viz, *G. arboreum, G. herbaceum, G. hirsutum* and *G. barbadense* are grown on a commercial scale apart from hybrids. The current total area under cotton cultivation is about 8.5 million hectares and the production is around 15.5 million bales of 170 kg each.

There are three agroclimatic zones in India where cotton is grown. In Northern Zone cotton is grown entirely under irrigation in sandy loam soils, In Central zone it is grown predominantly under rain fed conditions on black soils and loamy soils and in Southern zone under rain fed conditions in black and red soils. Sixty five percent of the crop is rain fed. Species wise distribution of area under cotton in India is as given below:

	Species	Area (Million hectares)
1.	G. *hirsutum*	2.20 (26 %)
2.	G. *herbaceum* and G. *arboreum*	2.20 (26 %)
3.	G. *barbadense*	Marginal
4.	Hybrids	4.10 (48 %)

Cotton is cultivated during the period June to December and the crop is harvested from January to March. Cotton is cultivated almost throughout the country. Following table gives information about the Area, Production of Cotton and availability of stalks in various states of the country.

Table : Area Under cultivation, Production of Indian Cotton & Availability of Cotton Stalks (State-wise) 1999-2000

	States	Area (M. ha)	Cotton-Production (M. bales)	Availability of stalks (M. tonnes)
Northern Zone 3,7 & 8	1. Andhra Pradesh	1.039	2.250	3.117
	2. Gujarat	1.539	2.750	4.617
	3. Haryana	0.546	1.065	2.780
Central Zone 2, 5 & 6	4. Karnataka	0.540	0.700	1.620
	5. Madhya Pradesh	0..525	1.550	1.575
	6. Maharashtra	3.254	3.800	9.762
Southern Zone 4 & 9	7. Punjab	0.475	0.785	2.375
	8. Rajesthan	0.583	1.300	1.749
	9. Tamil Nadu	0.185	0.550	0.555
	10. Others	0.045	0.150	0.135
	Total	**8.731**	**14.900**	**26.193**

Total area under cotton cultivation in India is around 8.5 million hectares. The average yield of seed cotton is around one tonne per hectare. As per an estimate about 3-5 tonnes of cotton stalks are produced for every tonne of seed cotton. The yield of biomass varies from species to species, it is highest in the case of hybrids and lowest in the case of G. *arboreum* species. However, on an average about 3 tonnes of cotton plant stalks are available in one hectare of land. Depending upon the variety and the crop condition the sticks are 1 to 1.75 meter long and their diameter just above the ground may vary from 1 to 2.5 cm. The specific weight of short chopped stick is about 160 kg/m^3.

Most of the stalk produced is treated as waste, though a small part of it is used as domestic fuel. The bulk of the stalk is burnt off in the fields after the harvest of cotton crop. The following table gives the chemical composition of cotton plant stalks from different species of cotton.

Constituents of Cotton Plant Stalk of Different Species

Species	Hot water soluble %	1% alkali soluble %	Ash %	Alcohol Benzene soluble %	Holo-Cellulose %	Lignin %
1. ***G. arboreum***	13.12	25.14	7.02	4.50	77.3	25.8
2. ***G. herbaceum***	13.77	26.80	8.28	5.65	79.1	28.1
3. ***G. hirsutum***	14.83	30.63	6.68	5.90	82.9	27.1
4. ***G. barbadense***	12.92	24.54	8.10	3.63	79.2	29.2
5. ***Desi*** hybrids	13.30	22.97	6.84	5.03	77.3	27.6
6. ***Hirsutum*** hybrid	12.30	31.40	5.87	4.96	78.6	24.3
Mean Value	13.37	26.91	7.13	4.94	79.1	27.0
Range of values	12.30 to 14.83	22.97 to 31.40	5.87 to 8.28	3.63 to 5.90	77.30 to 82.90	24.30 to 29.20

On an average cotton plant stalk contains about 79% holocellulose, 27% lignin and 7% ash. It is interesting to note that in contrast to other agricultural crop residues, cotton stalk possesses fibre properties comparable to most commonly available species of hardwood.

Fibre Dimensions of Cotton Plant Stalks

Parameters	Maximum	Minimum	Average
Fibre length (mm)	2.10	0.40	0.82
Fibre diameter(micron)	30	6	19

It could therefore be used profitability or the manufacture of particle boards and binder less boards.

Particle Boards from Cotton Stalks

Particle board is a panel produced by compressing small particles of wood while simultaneously bonding them with an adhesive. The various types of particle boards differ greatly in regard to the size and geometry of the particle, the amount of resin (adhesive) used, and the density to which the panel is pressed. The properties and potential uses of board differ with these variables.

The technology for making particle board was developed during the second world war, primarily to meet the acute shortage of timber. In an age of dwindling forest resources, the use of reconstituted wood gains a lot of importance. It is reported that in Western Europe, particle board has replaced wood in a variety of applications. The world production of particle board is estimated to be around 40 million cubic metres and the share of India in this works out to a meager 0.06 percent.

The major types of particles used for preparation of board are : -

- A piece of wood (wood particle or chips) chopped from a block by a large knife or hammer by a pulpwood chipper
- Chips from cotton stalk and other similar agricultural fibrous material
- Sugarcane bagasse
- Bamboo
- Rice husk etc.

Presently, boards are mainly made from wood particles. The increase in demand for wood and panel materials in the country cannot be met from the existing forest resources. The regeneration of forest takes considerable time and therefore it is unlikely that timber alone can serve as the raw material required by the wood product industries.

Particle board is manufactured out of dry wood particles (chips) or fibres, which are coated with a synthetic resin binder and wax and formed into flat sheets under pressure. Heat is applied with the pressure, to cure the resin binder. The resin binders used are, urea formaldehyde (UF) for interior applications and phenol formaldehyde for exterior applications. Bitumen is also used for certain specific applications. Particle board may have a uniform structure throughout its thickness or, it could be a sandwitched matrix, with coarser grains at the centre and finer ones on both sides. It is manufactured in different thicknesses and forms, such as plain, single or both sides veneered, single or both sides laminated, single and both sides covered with plywood lamination.

In all developing countries, particle board has succeeded to a greater extent in meeting the shortage of sawn timber and plywood. The world trend in wood based panel industries is to produce more of particle boards in order to efficiently use the scarce wood resources. Indian Plywood Industries Research Institute (IPIRI) has reported that particle board industry can very well succeed in India by producing boards suitable to the prevailing tropical environment are produced.

CIRCOT has standardised the process of preparation of particle boards from cotton plant stalks which involves chipping of stalk to 1.5 – 2.0 cm size, rechipping to particles of 1/20" to 1/8" size. Mixing of chips with synthetic binders such as urea formaldehyde and phenol formaldehyde followed by preparation of a three layered mat comprising coarser particles at core layer and finer at top and bottom layers respectively is the next step in the process. Finally, between heated platens of a hydraulic press for specific time and pressure the mat is pressed to get board. The boards are cooled to attain dimensional stability and then cut to the desired size. By using different chemicals and additives, these boards can be made water proof, fire proof, termite resistant, etc. These boards have been found to meet BIS specifications and can be used for interior decoration, false ceiling, partitioning, paneling etc.

Flow Chart of Particle Board Preparation

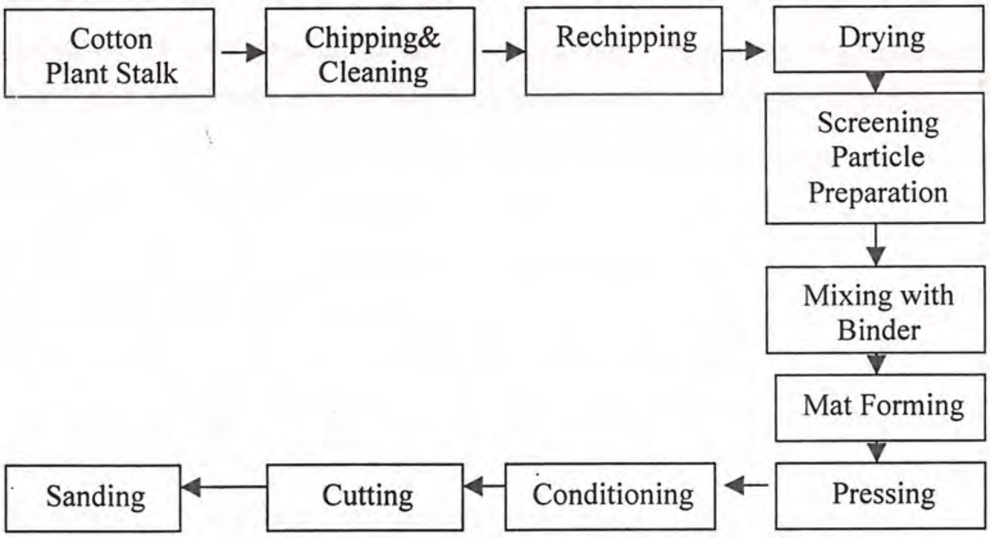

Table 1. Properties of Three Layered Particle Boards from Cotton Plant Stalks

Sr.No.	Properties	Unit	Flat pressed Three layer / multi-layer particle board BIS 3087-1985		CIRCOT Board
			Type I	Type II	
1.	Density	Kg/m3	500-900	500-900	750
2.	Average Moisture Content	%	5-15	5-15	11
3	Water Absorption a) 2 h. soaking ii) 24 h. soaking	%	 10 20	 40 80	 20 40
4	Swelling Thickness	%	8	12	9
5	Swelling due to surface absorption	%	6	9	6
6	Modulus of Rupture i) Up to 20 mm ii) Above 20 mm	N/mm^2	 15.0 12.5	 11.0 11.0	 17.6 -
7	Internal bond strength i) Upto 20 mm thickness ii) Above 20 mm	N/mm^2	 0.45 0.40	 0.3 0.3	 0.51 -
8	Screw withdrawal strength Face Edge	N	 1250 850	 1250 700	 1400 860
9	Nail withdrawal strength	N	1250	---	1300

BIS – Bureau of Indian Standard

* Three layered plain particle board (Type II)

As can be seen from Table 1 the particle boards from cotton plant stalks possess all the desirable properties to be used for internal as well as external applications such as false ceiling, partitioning, paneling, etc. However, it may be mentioned that boards made from cotton plant stalks using urea formaldehyde as binder lack in water resistance properties as compared to boards made from other raw materials, which is mainly, due to higher percentage of bark having more fibres resulting in increased absorption of water. This problem is not observed in phenol-bonded boards. However, by use of different chemical additives, the water resistance property can be improved with minimal increase in the cost. These boards can also be made fire resistant, termite resistant, etc. by use of chemical additives.

The applications of particle boards are many. The areas identified include door panel inserts, partitions, wall panels, pelmets, furniture items, floor and ceiling tiles, etc. for residential houses, commercial buildings, schools, hotels, theatres, etc. In recent years, particle board is being used increasingly in place of commercial plywood, in the preparation of printer blocks.

In all the above applications, substitute materials for particle boards are, timber, commercial plywood, marine plywood and block board in general and for false ceilings the plaster of Paris. The advantages of particle board are many.

i) It is free from natural defects of wood, like warping.
ii) It is easier to fix. For instance , the factory made panel doors with particle board are available in ready-to-fix form. Similarly, for wall paneling, false ceilings, table tops, etc., pre-laminated or pre-veneered particle boards can be used with advantage.
iii) It is cheaper than substitute materials.
iv) With proper protective surface coating and edge covering, particle board can be made termite proof and fire resistant. It can take a variety of surface finishes, like laminations, veneers, paint, varnish polish, etc. Attractive wall paper can also be used as surface finish.

Marketing Prospects Of India's Long Staple Cotton In The Post Era Of Multi Fibre Agreement (MFA) In World Trade

Isabella Agrawal,

Senior Scientist (Agricultural Economics)
Central Institute for Cotton Research, Regional Station, Coimbatore-641 003

With 86 million hectares, largest acreage in the world under cultivation of cotton, India is the third largest producer of cotton in the world after China and USA. However, yield is one of the lowest in the world – less than 300 kg/ha (world average 608 kg/ha, Australia 1545 kg/ha, China 1000 kg/ha, USA 760 kg/ha leaving aside Israel 1700 kg/ha). Only one-third of cotton area is irrigated while two-thirds is rain fed. India produces all types of cottons – short staple, medium staple, long staple and also extra long staple cotton. Our varieties are many but 20-25 of them will account for about 97% of cotton produced while 80-100 other varieties make up the remaining 3%. Despite adequate domestic production, cotton import is flourishing due to lower price, better cotton quality and credit facility. India, the world's third-largest producer of cotton and second-largest producer of cotton yarns and textiles, is poised to play an increasingly important role in global cotton and textile markets as a result of domestic and multilateral policy reform.

The world production of cotton is over 22 million tons which is dominated by 3 producers USA, China and India .The exportable surplus is above 7.0 million tons with USA, Africa and Central Asia accounting for over 65% of the world's exports. The major importing markets are in Asia such as China, Indonesia, Thailand, and Bangladesh etc. India is one of the world's premier producers of raw cotton with the world's largest acreage under cotton cultivation (9 million hectares!) and with a wide range of cotton staple length. (Everything from short staple to extra long staple). This enables us to produce almost every kind of yarn and has made us the world's largest exporters of cotton yarn.

The Indian Cotton Industry straddles 1543 spinning units, over 281 composite mills & 1.72 million registered looms. The installed capacity includes 36.37 million spindles and about 434,000 rotors. The abundant supply of local cotton, coupled with the liberalised import of raw cotton enables us to produce yarn to match any specification and count. It is a well-documented fact that India is the world's largest exporter of cotton yarn with 25 per cent of the world's yarn trade. What's less well known is that we have an even higher market share in the finer counts between 40s and 160s.

Cotton is one of the major crops cultivated in India. It accounts for more than 75 per cent of the total fibre consumption in the spinning mills and more than 58 per cent of the total fibre consumption in the textile sector. The twin objectives of assuring off-take of the farmers' produce at remunerative prices and making available adequate quantity of cotton at a reasonable prices to the domestic textile industry are sought to be achieved through timely announcement of remunerative Minimum Support Price (MSP) to the farmer and through appropriate export-import intervention as and when necessary.

Staple quality of Indian cotton

The largest share in the total production of cotton is of medium staple variety followed by long staple. The share of short staple is about 7%. The share of medium long staple is presently 39 per cent and that of share of long and extra long staple variety is cent and that of share of long and extra long staple variety is 54 per cent.

Improvement in Staple Quality of Indian Cotton (In lakh bales*)

Year	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Short	18.64	16.25	10.00	11.50	9.50	9.50	9.50	9.00	7.95	10.44
Medium	77.00	87.54	72.50	77.00	81.50	74.00	87.00	72.00	85.85	112.52
Long	70.69	68.45	71.00	71.50	60.00	52.00	58.00	51.00	83.20	109.04
Extra Long	3.87	5.66	4.50	5.00	5.00	4.50	3.50	4.00		
Total	**170.2**	**177.9**	**158**	**165.00**	**156.00**	**140.00**	**158.00**	**136.00**	**177.00**	**232.00**

By Indian standards, about one-half of Indian cotton is medium staple length, but, by international standards, only about one-quarter of Indian cotton is considered medium staple (fig. 27). The North zone tends to produce mostly short and medium staple varieties, the South zone mostly long and extra-long staples, and the Central zone a range of medium and long staple varieties. India has the capacity to produce the full range of staple lengths of cotton needed to meet the needs of its textile industry. .Imports accounted for about one-third of world use of all cotton (upland and extra-long staple) in 2004-05. This share is expected to remain relatively stable over the next 10 years, and world cotton trade in 2014-15 is forecast at 38.3 million bales, almost 20 percent higher than in 2004-05. For hundreds of years, importing countries have accounted for much of the world's cotton spinning and, as late as 1979, the imported share of the world's cotton spinning reached 46 percent. Later, spinning shifted to countries that grow rather than import cotton, and only 28 percent of global cotton spinning used imported cotton in 1998. More recently, major cotton growers, like China, have also become significant importers, raising the imported share of consumption once again. Economic growth primarily determines demand for cotton products. Changes in taste are also a factor, and both consumer preferences and government policy can shift consumers' preference for various fibers.

Characteristics of cotton produced

India is unique among major cotton-producing countries because a broad range of agro-climatic and soil conditions permit cultivation of all varieties and staple lengths of cotton. Indian and international standards use different staple length definitions for classifying cotton. And India's hand-picked cotton is considered superior to mechanically harvested cotton in terms of sheen of finished fabric, amenability to spinning, tensile strength, etc. India, however, has significant problems in meeting other quality needs. In particular, Indian cotton is generally contaminated with other fibers and foreign matter and often consists of admixtures of multiple varieties with different fiber characteristics. These problems reduce efficiency (yarn realization) in the spinning process and result in higher levels of yarn impurities and imperfections. A 2001 survey by the International Textile Manufacturer's Federation indicated that 5 of the world's 10 most contaminated traded cotton types came from India. Problems with contamination and other quality attributes of Indian cotton have been a key factor behind the upward trend in cotton imports by India's export-oriented textile mills since the late 1990s. The risk associated with the unreliable quality of domestic cotton leads some textile producers to prefer imported cotton to meet export orders that demand consistent quality. The significant problems with admixture of varieties and contamination stem from practices on farms and in market yards that are not amenable to quick solution.

INDIAN cottons are considered deficient in maturity/micronaire and fibre strength. Low micronaire, reflecting poor maturity, is a characteristic of many Indian cottons, partly because of genetic factors and also because of nutrient deficiencies or climatic factors. This deficiency is particularly noticeable in long and extra-long staple cottons. Long staple Indian cottons (28 - 32 mm) quite often record micronaire values below 3.8 while the equivalent foreign cottons (Australian, African, and so on) will show values in the 4.0 - 4.5 range, which is ideal for spinning yarns of 40s - 60s count.

Demand for cotton and manmade fibers in India will likely rise as a result of strong growth in incomes in India, as well as increased Indian exports of textiles and apparel associated with the end of MFA quotas. Imports of raw cotton have increased in concert with rising demand in recent years, but future growth will depend on the extent to which India can boost chronically low cotton yields and improve cotton quality. Low per capita use and the significant shares of income devoted to textile consumption indicate that fiber demand will continue to respond to the now rapid growth in rural and urban incomes. Fiber demand will, however, also be responsive to changing prices, so further reductions in the relatively high excise taxes on manmade fibers, coupled with strong rural demand for durable manmade fiber products, will likely continue to slow relative growth in domestic consumer demand for cotton fiber. The end of MFA quotas is likely to result in significantly faster growth in India's exports of cotton-based textiles and apparel. Market shares for the Indian cotton market appear to be sensitive to both price and quality. U.S. cotton, with a reputation for consistent quality, can maintain its market share provided it remains price competitive.

Multi fibre agreement (MFA)

The MFA system is a departure from two of the most fundamental principles of the multilateral trading system. These are: (i) the ban on quantitative restrictions, and (ii) the prohibition of discrimination between suppliers of textiles and apparels. In the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), the Agreement on Textiles and Clothing (ATC) negotiated the phase-out of the MFA over a ten-year period beginning in 1995. The ATC stipulated liberalization to occur in four stages and in two forms: (i.) integration, and (ii.) an acceleration of quota growth. At the end of fourth and the final stage, i.e., by January 1, 2005, all bilateral quotas between developing exporters and developed importers ceased to exist. Many studies project that India will be a major beneficiary of MFA textile quota eliminations, with textile exports expanding by as much as 25 percent. In addition, domestic textile consumption is also expected to increase rapidly in the future in so far as the International Monetary Fund (IMF) and the World Bank project the Indian economy to grow at 6-8 percent annually in the medium-term. The projected strong growth in textile exports and domestic consumption would lead to the expansion of mill demand for cotton, necessitating an increase in cotton production at a much faster pace than the historical rate of less than one percent annually. Since cotton acreage is unlikely to expand in the future, production growth will have to come through yield improvements. Unlike most of the past studies, mill demand for cotton and other fibers are modeled as an input for the finished product rather than a final consumer product. The year-end expiry of the multifibre agreement has generated new hopes for India's textile and apparel industry, particularly in terms of exports to the West. The multifibre agreement, established in 1975, allocates quotas on the amount of clothing and textiles that developing nations with cheap labor can export to rich countries, expires January 1, 2005. For once, India is ready for the opening up of these key markets, particularly in Europe and the US, and has already made careful, strategic plans such as the integration of agriculture (long staple cotton), yarn and textile production to avoid cotton price fluctuation which would affect textile production costs. With most of the European and US apparel and garment brand producers already set up in India, the industry hopes to multiply its exports exponentially. If things go as planned, the country hopes to increase its textile and apparel trade from the current US$12 billion to $20 billion, and eventually touch $30 billion by 2012.

Opportunities and threats for Indian cotton

Although India has been waiting for this opportunity for years, it may not be easy sailing as it has to compete with China and Pakistan, and invest nearly $1.2 billion to modernize surviving textile mills - many have perished due to poor management, a lack of modern inputs and growing restrictions on exporting. A recent study by the Indian Council for Applied Economic Research shows that the $30 billion export target is feasible as Indian textile and garments exports will be worth $15 billion by 2007. Within two years of the removal of quota restrictions and with a 40-42 percent annual growth, India is likely to become the leading textile exporting country in the world. The study projects that part of this growth is likely to be helped by the relocation of some major textile companies from the Europe and the US to India for its cost advantages. This is particularly true for cotton because the mill's preference for a specific type of cotton depends on its end use. For example, ELS cotton is preferred for apparel manufacturing, whereas medium/short staple cotton is preferred for denim manufacturing. Thus, a textile mill that manufactures apparel will still demand ELS cotton even if the ELS price increases relative to the other types of cotton. But in a longer time period, demand might shift because of changes in consumption patterns or because technological development might enable millers to blend cheaper cotton to obtain the preferred characteristics. Study clearly suggests that the U.S. market share of cotton in the Indian market is likely to increase with the elimination of MFA quota.

The higher quality and consistency of cotton imported from the U.S. make it more desirable by the Indian textile mills. However, there are reasons to believe that the U.S. exporters need to develop strategies to counter the freight advantages and shorter delivery periods enjoyed by Egypt, Australia, Uzbekistan, and West Africa due to their geographical proximity to India. From Indian perspective, the results provide important insight into course of action that could potentially prevent India from becoming a net importer of cotton. In India, production of cotton needs to grow at a much faster pace than the historical rate to be able to meet domestic demand in the future. Since production increase through area expansion is limited, policies should be directed to improving productivity and quality. In order to achieve this, management practices encouraging widespread adoption of high yielding varieties of cotton and new technologies must be promoted. In addition, improvement in fiber quality is also essential to meet the demand of high quality cotton by export-oriented textile mills.

It is evident from this analysis that even under the existing bilateral quota restrictions, India is now in a position to become an increasingly important player in the international cotton market. Both the cotton and man-made fiber consumption and production are expected to increase significantly during the next ten years. Most of the cotton production growth in India is expected to result from yield improvements rather than area expansion. Total cotton acreage is expected to remain almost constant in the next decade (2004-05 to 2014-15), though shift in the cotton acreage among the three regions is likely based on relative profitability among crops. Increase in cotton acreage in the northern region is projected to be offset by decline in acreage in the central and southern regions. However, the cotton supply response being price-inelastic in India and given that yield is expected to increase only marginally during the next decade, increase in cotton production is not expected to be sufficient to meet the rising demand. Thus, it is likely that India would continue to rely heavily on cotton imported from other countries.

Need of the hour

It is clear that the textile world of manufacturing is undergoing restructuring and new buying strategies are evolving. Textile clusters are getting stronger around a limited number of countries. India is gaining because of its strong textile background on both technical and raw material base - it is the second best alternative to China especially for cotton textiles - yarn/fabric/garments. India is one of the lowest cost manufacturers of cotton based raw materials in the world and the Indian garment industry would be largely dependent on the domestic industry for its needs. This would lead to a major expansion of domestic demand for cotton yarn/fabric in India.

The expiration of the Multi-Fiber Arrangement will boost cotton use growth in the Indian Subcontinent (India, Pakistan, and Bangladesh) above the world average in MY 2005/06. However, the Subcontinent, the world's largest consumer of cotton outside China, will remain well over 90 percent self-sufficient, a strong contrast from China, which is forecast to be only 60 percent self-sufficient in MY 2005/06. World cotton use for MY 2005/06 is forecast at a record 111.5 million 480-lb bales, up 3.2 percent from the current season. Meanwhile, the Subcontinent's cotton use is expected to grow to a record 28.4 million bales, up 4.7 percent. Domestic use will surpass previous records in all three Subcontinent countries: India (15.8 million bales), Pakistan (10.8 million bales), and Bangladesh (1.8 million bales). Each country's record domestic use is attributed both to larger local consumer demand and exports of textile and apparel products. In addition to having some of the lowest labor costs in the world, receiving zero-duty preferential treatment from the European Union and the removal of the Multi-Fiber Arrangement have made the Subcontinent's textile and apparel industry very competitive.

India has an abundant supply of locally grown long staple cotton, which is used for fine count sheeting and bed sheets. This provides India with a competitive edge for manufacture of wider width fabrics, as other countries, like China and Pakistan, have relatively lower supply of locally grown long staple cotton. The country's cotton textile industry is looking up to research institutes and cottonseed manufacturers for new varieties of extra long staple cotton (ELSC) to improve availability of finer quality cotton. Domestic production of this cotton variety is just one tenth of the current demand and there are fears that once the US Government withdraws subsidy to its cotton cultivators, ELSC prices would shoot up in the international market. The US is one of the largest producers of this fine-quality cotton.

The production of long staple cotton should start from the farm level with stronger integration between mills and farmers most probably through contract farming. Growing long staple cotton with good quality would fetch more price and in turn higher returns to the farmer rather than going for short or medium staple cotton. It would suffice the mills' demand also in getting their raw product as desired. Forward and backward linkages between the farming community and mills with the back up of technologies for long staple cotton from research institutes would bear fruits for the Indian cotton textile industry.

Role of Private R & D in The Long And Extra Long Staple Cotton Production in the Country

K.Venugopal,

Consultant, Nuziveedu Seeds Limited, Secunderabad-500 003.

Introduction:

The asiatic species of cotton (*G.arboreum* and *G.herbaceum*) provided livelihood and security to millions of farming families living in rainfed, unirrigated areas in India. Until the middle of 18^{th} century, only these cotton varieties were grown in India. Due to the human skills and dexterity of the local artisans, very fine yarns were produced even from the short staple coarse cottons grown in India. With the spread of Indian hirsutum varieties (Indianised American Hirsutum Cottons - the Dharwad American, Punjab American, Madras Combodia Uganda cotton varieties) during 1950s, the qualititative composition of Indian cotton changed from 100% short staple to nearly 80% short staple and 20% long staple category. Of the four cultivated species of cotton, *G.hirsutum* is known for its high yield potential with medium to long staple fibre while *G.barbadense*, popularly known as Egyptian Cottons, are known for their long, extra long and strong fibres. The American Pima cotton, the Egyptian Giza cotton and a wide range of Interspecific Hirsutum x Barbadense hybrids contribute essentially to extra long staple category of cotton.

Development of Long and Extra long staple cotton in India.

The development of MCU.5 in 1976, a hirsutum cotton (but a derivative of multi species introgression including *G.barbadense*) was the milestone achievement in developing an extra long staple cotton. Secondly, the release of Suvin in the year 1975 as an extra long staple barbadense cotton was widely acclaimed, but the poor adaptability of this variety to the majority of agroclimatic conditions in India zeroed its success. However, interspecific (Hirsutum x Barbadense) hybrids were very successful as long and extra long staple cottons. Varalakshmi hybrid from Dharwad during 1982 and DCH-32 also from Dharwad during 1983 spread well and still rule as extra long staple cottons.

Emerging Seed Corporates in cotton seed production and marketting.

The 1970s witnessed organized growth of Indian Seed Sector, initially producing popular public bred varieties and hybrids and slowly augmenting their capacities for R & D to develop their own hybrids. "Mahyco" was the single largest company in India responsible for popularizing pubic-bred hybrids, besides their own hybrids Viz., MECH group of long staple interspecific hybrids. The medium to long staple cotton variety LRA-5166 from CICR, R.S. Coimbatore spread very fast since its release in the year 1983 in central and south some states and covered almost 20% of the national cotton area in a span of five years. Among the multitude of Private Seed Companies (big, medium and small numbering over 100) the MAHYCO was singularly responsible for pumping LRA 5166 seeds supply to majority of cotton farmers. Their turnover was nearly 50,000 quintals of LRA-5166 seeds per annum and thus private seed sector emerged as most efficient corporate in cotton seed supply besides popularizing the long staple varieties and hybrids like H-4, H-6, PKV-2 and JK-hy-1.

Private Seed Sector in developing long staple cotton in India

From 1985 onwards, there was a sudden spurt in the growth of seed companies who have turned their attention from hybrid cotton seed production and marketing to strengthening of their R & D for developing their own 'brand' Research hybrids. There are nearly 46 private seed companies and among them the following 12 seed companies have developed high profile R & D to develop cotton hybrids and also became partners in developing the next popular Transgenic Bt cottons.

Private seed companies with high profile R & D

1. Maharashtra hybrid seed company (MAHYCO), Jalna
2. Ankur Seeds limited, Nagpur
3. Nuziveedu Seeds Limited, Hyderabad
4. Nath Seeds limited, Aurangabad
5. Nav Bharat Seeds, Ahmedabad
6. RASI Seeds (P) Limited, Attur
7. Pro Agro seeds, Aurangabad
8. JK Agri Genetics, Secunderabad
9. Krishi Dhan seeds, Jalna
10. Ajeet Seeds, Aurangabad
11. Bio Seeds Research Limited, Hyderabad
12. Hindustan Lever Limited, Hyderabad

Till 1990s, the Mahyco, Nath seeds and Nav Bharat were the major private seed companies who supplied their own long and extra long staple interspecific (HxB) hybrids, besides catering to the needs of all popular public bred hybrids. The MECH and NATH group of interspecific hybrids (HxB) made significant dent in long staple cotton scenario.

Long staple intrahirsutum cotton hybrids from private seed sector.

(i) Development of RCH.2 Hybrid

From the pioneering work of the eminent cotton breeder and Advisor to Rasi Seeds (P) Limited, Sri. R. Krishnamurthy and enterprising Entrepreneur Mr. M. Ramasamy, RCH.2 (HxH) hybrid was released during 1992. This long staple hybrid (29-30 mm) with a good strength (24 g/tex) had created a revolution in hybrid cotton yields in parts of Andhra Pradesh and Gujarat. Progressive farmers recorded yield as high as 40 to 50 quintals kapas/hectare. RCH-2 hybrid spread very fast since then and attained its zenith by 1997, with the market potential for 20 lakh pockets (450 g each) and above. This was the beginning and a major breakthrough in supply of long staple cotton to the country.

During the same period, Hindustan Lever Limited, Hyderabad came up with hybrid "Brahmma" which had attractive big bolls bad long staple. This hybrid had a good spread in AP, Gujarat and Karnataka. The long staple interspecific hybrids from "Mahyco" and "Nath" waned with time due to spread of RCH-2, Brahmma, H-8 and NHH-44 hybrids during 1990s.

"Bunny" – A major breakthrough in Long staple cotton production.

During 1999, the Nuziveedu Seeds Limited with its noble breeder Dr.Anjaneyalu and the most enterprising and ever dynamic MD, Dr.M.Prabakar Rao, an extra long staple (31-33 mm) cotton "Bunny" was released. The yield potential of this hybrid had surpassed all previous achievements by any hybrid. Progressive farmers in parts of AP and Gujarat have recorded as high as 50 to 60 quintals kapas/hectare. During 2001, the same company came with one more extra long (32-33 mm) superfine HxH hybrid, "Mallika". Both these hybrids attract premium price in cotton market..

Estimated sale of Long staple group of cotton hybrid seeds from Private seed sector during 2004-05 season

Name of the Seed company	Hybrid	Lakh seed packets (450 gram each)
1.Nuziveedu Seeds Limited	Bunny(Non Bt) Mallika (Non Bt)	40.5 1.5
2.Mahyco Seeds Limited	MECH.184 Bt MECH 12 Bt	6.0
3. Hindustan Lever Limited	Bhramma	3.0
4. Viba Agro tech	Zigma, Dianana	2.0
5. Nath Seeds and other seed companies dealing HxB hybrids	Lakshmi, Kasinath, Basaveswara and others	3.0
	Total	**56.0**

The total seed supply of all cotton hybrids (both public bred and Private hybrids) accounted for nearly 140 lakh seed pockets. Nearly 40% of the hybrid seeds account for long and Extra long staple cotton. The spread of public bred long staple hybrids like Savita and varieties as MCU-5, LK-861, Surabhi, G.Cot.Hy.10 and others are declining to insignificance.

We hope that the above long staple Bt cotton hybrids during 2005-06 and the years ahead will account for record production in higher productivity and quality. It is worthwhile to mention that the Bt cottons had very low percentage (less than 3 %) of bad, stained kapas as compared to 8 to 15% bad kapas in Non Bt cotton. The staple length and strength were not affected due to Bt gene, while Bt confers more uniformity, fineness and maturity values on cotton. Thus, Bt cottons attract premium price in the market and Indian farmers adopt Bt cotton hybrids very dearly and quickly.

Genetically modified cotton for long staple and other good fibre qualities

Multinational seed companies as Monsanto, Syngenta, Bayer and others pursue serious efforts in developing G. M. cotton for pest control, weed control and drought tolerance. If the market demand crystallize for long staple cotton, they will definitely make efforts and succeed in G.M. cottons with long and extra long staple fibre sourcing from wild species.

Future R & D in long staple cotton in India

Market demand is the deriving force for development and spread of Extra long staple cotton. As Gururajan and Manickam (2005) have pointed out, the major and exclusive source of E.L.S cotton is *G .barbadense*. But surprisingly the genetic studies in respect of *G.barbadense* in India are very few. The Pima cottons from USA will be of help for useful introgressive breeding initiatives. A few eminent Plant breeders in India have worked for decades to evolve long staple hirsutum lines, sourcing from *G.barbadense* and a few wild cotton germplasm. A revival in this line will be worthwhile for Private Seed Industry as well. Mehetre *et. al*. (2004) in their review article pointed out ways and means for introgressive breeding with wild germplasm for better fibre qualities and also, listed useful germplasm for fibre length, strength and fineness. Serious attempts in their lines are needed mainly for the Public sector and "Public-Private" joint research will pay rich dividends.

Table-1 Qualitative Changes in production of different staple lengths in India

Period (Area, m. ha)	Production in million bales (170 kg each)			
	Long >24.5	Medium 19.5-24.0	Short <19.0	Total
1947-48 (4.31)	-	1.53	0.76	2.29 (81)
1961-66 (8.00)	0.92	3.70	0.82	5.44 (103)
1966-67 (7.84)	1.22	3.26	0.79	5.27(102)
1976-77 (6.89)	1.70	3.40	0.74	5.84(128)
1986-87 (6.95)	4.84	4.00	0.45	9.29 (227)
1996-97 (9.12)	11.43	4.93	1.43	17.79 (332)
1998-99 (9.11)	11.13	4.04	0.98	16.15(301)
2003-04 (7.61)	9.80	6.10	1.80	17.7 (374)
2004-05 (9.06) P	12.90	7.40	2.90	23.2 (440)

Table-2 Production and consumption pattern in cotton under various staple groups (2003-04)

Category	**Staple length**	**Production (Lac bales)**	**Consumption (Lac bales)**
Short	< 20 mm	18	6
Medium	20.5-24.5	61	40
Medium Long	25.0-27.0	30	33
Long	27.5-32.0	61	75
Extra long	>32.5 mm	.7	9
Total	-	**177**	**163**
Around 19 lakh bales is shortfall in long and extra long staple group.			

SELECTED REFERENCES

AICCIP Annual Report, 2004-05. CICR Regional Station, Coimbatore,Tamil Nadu-641 003

Gururajan, K.N. and Manickam, S. 2005.Fibre quality improvement in Egyptian Cotton (G.barbadense.L.). Lead Paper in National Seminar on improvement of Fibre quality traits in cotton:46-56(February, 15,2005)

Hand book of cotton in India, 1999. Indian Society for Cotton Improvement, Mumbai.

Mehetre, S.S., Patil,S.D., and Aher, A.R.2004. Improvement of fibre properties through Interspecific hybridization- A review. J.Indian Society of Cotton Improvement., August, 2004.

Integrated Cotton Cultivation

G. Xavier
Super Spinning Mills Ltd, Coimbatore.

Introduction

Cotton is the principal commercial crop of India grown in 84 million hectares. Per hectare yield in India is at lowest level compared with other countries like Israel, Australia, Syria, china and USA and the quality does not measure up to world standard.

In India though we have the required climatic condition for cotton production and other basic infrastructure, the production of cotton has not increased to the expected level. Further the agricultural produce does not fetch good price due to various reasons. In these circumstances, we are in a situation to choose the right crop for cultivation which is profitable to the farmers. It is evident that COTTON is the best choice, which can be grown with a very less investment.

Super spinning Mills started its spinning operations with 12000 spindles. With a steady progress and growth now it has 3 spinning units with 1,33,008 spindles capacity. Super Spinning Mills require 3 lacs bales per annum for its consumption. Super Spinning Mill sources quality cotton from other parts of the country and abroad for its requirement.

Indian cotton scenario

In India, there is an urgent need to increase productivity due to (1) availability of cheaper and better lint through import (2) Cost escalation in agro inputs and farm labour and (3) Higher volume requirements of cotton for spinning industry. Also, the cotton industry is facing problems on the quality front *viz*., admixture of different cotton fibres at farmer level and in ginning industries, high trash content, high foreign fibre contamination (like Jute, Polypropylene and hair) , improper ginning & false packing and inadequate fibre qualities to make suitable end products.

Integrated cotton Cultivation Programme:

In order to meet out all these requirements, Super Spinning Mills has started growing cotton through its Integrated cotton Cultivation Programme with the following objectives:

1. To improve productivity (yield/acre) by adopting innovative farming techniques.

2. To minimize input cost by soil specific fertilizer application and Integrated Pest Management techniques.
3. To educate and train farmers in post-harvest techniques to produce contamination free high quality cotton and
4. To create Win-Win position for both Farmers and Spinning Mills

Implementation procedures of integrated cotton cultivation programme :

a. Selection of programme area:

Different clusters of villages are selected for growing different variety of cotton based on the soil fertility, irrigation and agro climatic conditions.

b. Discussions with farmers and village group formation:

Agro-technocrats discuss with farmers on the advantage of the programme. Progressive farmers who are willing to join our programme are selected.

c. Identification of group leaders:

Group leaders are selected to co-ordinate between the farmers and the contract farming committee. These group leaders are vital links who act as animators.

d. Seed distributions:

Certified and freshly packed seeds are given which are sourced directly from the manufacturers. To protect against sucking pest attack, seeds were treated with effective pesticides.

e. Sowing operations:

Depending on the vegetative growth and duration of hybrid / varieties, spackling is altered (row to row and plant to plant). For gap filling, extra seeds are sown in poly bags and kept as reserves. This ensures sufficient plant population for higher yield.

f. Crop loan:

Super Spinning Mill enters into a tie-up arrangement with one of the nationalized / private banks for providing cotton crop loan to the contract farming farmers to enhance productivity.

Farmers who are willing to avail crop loan have to provide required documents to the bankers. A maximum loan amount of Rs. 8,000/- per acre is recommended.

Loan amount is disbursed as cash in two installments during (a) Weeding and (b) Harvesting. Kind portion is given in the form of fertilizers, micronutrients, plant growth regulators and pesticides to the farmers.

Mill stand as a surety to the banker for the crop loans provided to the contract farming farmers.

g. Crop insurance:

Mill arrange for crop insurance. Since the farmers are not able to pay the full extent of premium, the mill subsidizes a portion.

h. Field support:

Mill field personnel are specially trained in cotton crop cultivation

Each supervisor monitors a block of 150-200 acres of cotton field

Each supervisor will visit the farmer fields once in a week

i. Additional guidance by experts:

Technical experts from Tamil Nadu Agricultural University and Government Agricultural Departments are taken to the farmer fields for 1) Educating the farmers, 2) Accurate diagnosis of pest and diseases and 3) Remedial measures.

j. Agro input distribution:

Fertilizers and Pesticides are sourced from the manufacturers directly and delivered to farmers at cost price. Our field supervisors ensure correct and timely application of agro in-puts by farmers.

k. Integrated pest management:

IPM Technology is implemented to reduce the usage of plant protection chemicals and also to improve the fibre quality.

i. Plant protection sprayers:

A group of farmers are provided with imported sprayers at free of cost for spraying micronutrients and pest management.

m. Cotton cloth bags:

Cotton cloth bags are provided to the farmers to free of cost for packing of seed cotton. Jute and polypropylene bags are strictly banned.

Pre-harvest training:

Farmer groups are trained to harvest the seed cotton (Kapas) from fully matured and open bolls only. Method demonstration to harvest clean seed cotton (Kapas) in the morning time to avoid dust and dried leaves.

Seed cotton procurement procedure:

a. Pricing of seed cotton:

Prevailing market price at the time of procurement is taken as base price. Premium will be paid at the end of the season after consulting with the group leaders.

b. Seed cotton procurement:

Procurement starts as soon as the farmers are ready to handover the stock. Farmer has to bring the seed cotton only in the COTTON CLOTH BAGS provided to them.

c. Payment procedure:

Payment is settled within three days of procurement. Sale proceeds directly remitted to the bank for those who availed loan. After closing crop loan, farmers can withdraw the balance amount from the bank.

d. Shipment of seed cotton for ginning :

Seed cotton packed in cloth bags are segregated variety / hybrid wise and sent for ginning. Identification tags are attached.

Feed back meeting:

At the end of the season feed back meeting is organized. Officials from Government Agricultural departments and Tamil Nadu Agricultural Universities are called for the meeting.

Recognition:

Prizes are distributed to the highest yield achievers.

Benefits enjoyed by the ICCP farmers:

Particulars	Other farmers	ICCP farmers
Yield Per Acre	Average	15-25 % Incremental Yield
Input Cost Minimization	Nil	Rs. 1000 to Rs. 1500 per acre
Crop Loan Interest	12%	8.5%
Premium Price	Nil	Rs.200 + Rs. 300 per Qtl
Payment For Seed Cotton	30-60 Days	Within 3 Days Of Procurement
Crop Insurance Coverage	Not Available	Available
Proper Technical Guidance	In Adequate	Continuously Available

Benefits to the mill

Particulars	Market cotton	ICCP cotton
Trash Content	3-4%	2%
Contamination	10-18 gm Per Bale	0-1 gm Per Bale
Yarn Realization By Weight (Combed Counts)	68%	
Expenditure For Cleaning And Segregation	Rs. 1 Per Kg	Rs. 0.25 Per Kg

Area covered under "integrated cotton cultivation programme"

Year	Season	Districts in Tamil Nadu	Area in acres	No of farmers
2002	Kharif	Coimbatore	250	65
2003	Summer	Salem	1120	735
2003	Kharif	Coimbatore	1283	492
2003	Kharif	Vellore	150	83
2004	Summer	Nammakal	1272	435
2004	Summer	Madurai	445	120
2004	Kharif	Coimbatore	1145	462
2004	Kharif	Theni	750*	227
2004	Kharif	Salem	450	115
		Total	6865	2734

Additional area covered after rains in October/November 2004

		Karnataka		
2004	Summer	Mysore District	613	210