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NATURALLY COLOURED COTTON

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INTRODUCTION

Cotton with naturally coloured lint, other than white, is commonly referred as coloured cotton. In nature, coloured and white linted cottons are found from time immemorial. Coloured cotton is being grown and used by mankind since 2500 B.C. The Old World Asiatic diploid cottons are presumed to originate earlier than New World allotetraploid cottons. Coloured varieties were known in diploid cottons and were under cultivation in Asia, particularly Indian subcontinent, China and Central Asian Republics of former Soviet Union since long.

In India, brown linted varieties of tree cotton (G.arboreum L.) namely Cocanada 1, Cocanada 2 and Red Northerns were under commercial cultivation mainly on black soils under rainfed condition in parts of Andhra Pradesh. Red linted types were predominant and high in demand for their better dyeing qualities and colour fastness. However, the situation has changed with the advancement and standardization of dyeing techniques. Cultivation of coloured cotton was discouraged and almost abandoned in the latter half of this century. Coloured linted varieties could not remain popular with growers, mainly because of low productivity per unit area, poor fibre characteristics and non-uniformity of colours. Need of the hour was to increase cotton production in order to meet the basic requirements of ever increasing population for clothing. With the advancement of spinning and processing technologies, ease in imparting varied treatments of shades and colours during processing specially with the advent of synthetic dyes, greater emphasis was given in production of high yielding cotton with superior fibre quality, which resulted in the replacement of coloured cotton by white linted types. Yet, cultivation of coloured cottons continued in isolated pockets as novelty niche cotton and for aesthetic purpose.

In recent years coloured cottons are receiving increasing importance in view of their eco-friendly character. The awareness about the toxicity and pollution caused by synthetic dyes have revived the interest in cultivation of organic cotton. The urge for eco-friendly cotton can only be fulfilled preferably by organically grown coloured cotton, dispensing harmful chemicals in dying and processing.

TYPES OF LINT COLOUR

The lint colour of cotton under commercial cultivation is often white. In the cultivated species, brown and green colours are most common. Some of the genotypes in germplasm collection of USA and Russian Republics are reported to have coloured lint with shades of pink, red, blue, green and also black. Ms.Sally Fox of Vresers Ltd. claimed to have developed multicoloured lint, i.e. development of more than one colour on the same lint strand. However, genotypes with multi coloured lint have not yet been made available to the researches nor produced on large scale. The two commonly occurring lint colours, i.e. brown and green are briefly discussed below:

- **Brown colour**

Among the coloured cottons, brown is the most common colour. The brown colour is found in different shades which ranges from light brown to intense mahogany red. Depending on the intensity of colour, it is named as light brown, khaki / camel colour, brown, dark brown / chocolate colour, dirty grey, tan and red. Brown colour is found in all the four cultivated as well as many of the wild species. Brown colour is more stable than green clour. On continuous exposure to sunlight, brown colour also fades but gradually at a very slow rate. In India, brown linted varieties

of G.arboreum, namely, Cocanada-1, Cocanada-2 and red Northerns were under commercial cultivation during first half of the 20th century.

- **Green Colour**

Green is the second important commonly occurring lint colour in cotton. Green colour is less common than brown and occurs mainly in two shades i.e. light green and green. Green colour is more prone to fading, fades faster than the brown colour. Prolonged exposure to sunlight during boll opening leads to rapid fading of green colour and the colour turns to white, off-white or brownish. Portion of lint which is not directly exposed to sunlight retains its original lint colour. Green colour is mostly observed in G.hirsutum and probably varieties possessing green lint have not yet been released for commercial cultivation.

SOURCES OF LINT COLOUR

There are two important sources of coloured lint in cotton. These are- (i) germplasm collections, and (ii) wild species. These are briefly discussed below:

- **Germplasm collection**

Genetic resources are most vital for improvement of any crop. In India, about 40 coloured genotypes of upland cotton (G.hirsutum), mostly of various shades of brown and green colour are available in the National Gene Bank of Cotton maintained at the Central Institute for Cotton Research, Nagpur. These genetic stocks are indigenous collections as well as exotic accessions from USA, erstwhile USSR, Israel, Peru, Mexico, Egypt etc. In Asiatic diploid cottons (G.arboreum and G.herbaceum) about 10 germplasm lines possessing mostly light brown lint colour are also available. Most of the coloured linted germplasm lines have been evaluated for their economic attributes as well as fibre characteristics. Some important characteristics of the coloured linted lines are presented in Tables 1 and 2.

Table-1: Major economic and fibre characteristics of coloured linted upland cotton (G.hirsutum)

Lint colour and accessions	Seed cotton yield (g/pt.)	Duration (days)	G.O.T. (%)	2..5% span length (mm)	Maturity coefficient	Micronaire value	Strength '0' gauge (g/tex)	Uniformity ratio (%)
Dark Brown								
LC-1-1	50.2	165	33.2	23.4	0.89	3.1	38.0	54
Red 5-7	46.5	170	19.5	21.3	0.81	3.6	40.7	46
Cotonark (DB)	45.6	160	31.1	24.1	0.62	2.7	40.7	46
Medium Brown								
Extreme Okra Leaf	54.3	160	28.3	15.1	0.83	3.9	38.0	49
Parbhani American	68.7	165	35.1	14.8	0.83	4.5	35.0	53
Hirsutum Tashkent	39.2	160	32.3	20.0	0.78	3.6	36.5	51
Light Brown								
Kampala Coloured	24.9	160	30.9	22.9	0.64	2.8	37.4	44

Nankin Brown	63.7	160	31.5	20.0	0.76	3.4	34.6	51
LL 55-68-2	34.6	170	29.8	19.8	0.66	2.8	36.0	48
Khaki colour								
Khaki Coloured	37.4	165	30.5	20.0	0.65	3.0	35.0	46
Light Green								
Arkansas Green	46.5	160	19.5	18.5	0.59	2.6	32.0	50
Green								
Intense Red Green	31.5	160	20.7	21.7	0.56	2.8	32.2	47
Commercial White								
LRA 5166 (Check)	126.0	165	35.0	25.5	0.71	3.6	44.5	51

Table-2: Economic and fibre characteristics of brown linted germplasm lines of desi cotton

Sl. No.	Accessions	Seed cotton yield/plant (g)	Duration (days)	GOT (%)	2.5% span length	Fibre strength (g/tex)	Micronaire value	Uniformity ratio
	G.arboreum							
1.	Light brown	32.0	176	36.2	20.6	17.5	3.2	48
2.	SP 3936 (A)	30.5	182	38.0	21.1	18.1	5.4	50
3.	Malvensis	49.0	195	30.7	23.0	16.4	4.8	47
4.	7869 Brown	28.0	186	37.5	24.0	19.0	4.9	50
5.	Khaki colour 8631	32.1	195	38.0	20.0	17.1	5.3	50

Studies conducted at the Central Institute for Cotton Research Nagpur revealed that coloured cotton genotypes are poor in yield and possess weak fibre properties as compared to elite white linted cultivars.

- **Wild Species**

Wild species are important sources of coloured lint. Many of the wild species of genus Gossypium, including putative donors of present day tetraploid cotton i.e. G.herbaceum race africanum and G.raimondii have coloured lint. The brown colour in different shades is most common. Lint colours found in Gossypium species are given in Table-3.

Table-3: Lint colours found in Gossypium species

Continent	Species	Genome	Lint colour
America	G.aridum	D_4	Brown
	G.armourianum	$D_{2\text{-}1}$	Brownish
	G.darwinii	AD	Brownish
	G.mustelinum	AD	Brownish
	G.gossypioides	D_6	Greyish
	G.harknessii	$D_{2\text{-}2}$	Greyish
	G.laxum	D_9	Tan
	G.lobatum	D_7	Tan, white

	G.trilobum	D_8	Tan
	G.lanceolatum	AD	White
	G.tomentosum	$(AD)_3$	Red brown
	G.hirsutum	$(AD)_1$	Brown,tan,white,green
	G.barbadense	$(AD)_2$	Creamish, white
Africa	G.anomalum	B_1	Brownish
	G.capitis-virdis	B_4	Brownish
	G.somalense	E_2	Brownish
	G.herbaceum	A_1	Greyish,white
	G.longicalyx	F_1	Greyish
	G.triphyllum	B_2	Tan creamy
Afro-Asia	G.arboreum	A_2	Brown,tan,white
	G.stocksii	E_1	Brownish
Arabia	G.areysianum	E_3	Brownish grey
	G.incanum	E_4	Tan
Australia	G.australe	C_3	Brownish
	G.sturtianum	C_1	Brownish
	G.robinsonii	C_2	Greyish
	G.sturtianum var.nandewarense	C_{1-n}	Greyish

In addition to lint colour, some of the germplasm lines and wild species possess resistance for insect pests diseases, drought, salinity and also intrinsic fineness and strength of fibre.

DEVELOPMENT OF LINT COLOUR

Lint colour is a genetically controlled character. Accumulation of pigments in the lumen of lint starts before boll bursting. In upland cotton (G.hirsutum), pigmentation starts appearing in the developing lint 32 days after fertilization and it takes nearly six days to develop colour. In Asiatic cotton (G.arboreum) colour pigments observed 46-47 days after fertilization which take 5-6 days for colour development. However, complete expression of lint colour takes place only when the boll bursts open and the lint is exposed to sunlight. It takes about a week for the lint to develop a complete natural colour. The intensity and the time taken for complete development of colour varies with the genetic background of the genotypes. It is interesting to note that while sunlight is essential for the development of colour, continuous exposure leads to colour fading.

GENETICS OF LINT COLOUR

Inheritance of lint colour has extensively been investigated in Asiatic and New World species of cotton. In Asiatic species (G.arboreum and G.herbaceum), the inheritance of lint colour resembles to a single main gene, if segregants with varying colour intensity is considered as one group. Presence of modifiers, however, obscure the segregation making it difficult to ascertain exact number of genes for lint colour. Subsequent studies established the involvement of three loci alongwith variable complex of minor genes for lint colour. Following the rationalized system of gene nomenclature in cotton, these loci were symbolized as Lc_1, Lc_2 and Lc_3. Subsequently, Lc_4 and Lc_5 have been reported. Characteristics of individual loci and lint colour pattern governed by respective genes are presented below:

Table 4.Genes controlling lint colour inheritance in cotton

Loci	Genes	Characteristics
(a) Diploid Cotton		
Lc_1	Lc_1^K	Gene for khaki Lc_1^K is completely dominant, least affected by modifiers and shows little fading.
Lc_2	Lc_2^K	Determines khaki colour which is very slightly lighter than Lc_1^K and regarded as duplicate of Lc_1^K.
	Lc_2^M	Determines medium brown lint colour.
	Lc_2^B	Gene for light brown lint, Lc_2^B, shows low dominance and highly susceptible to modifier effect and fading.
	LC_2	Recessive allele, white lint.
Lc_3	Lc_3^B	Expression is similar to Lc_2^B and regarded as duplicate of Lc_2
Lc_4	Lc_4^K	Khaki colour lint
Lc_5	Lc_5^B	Light brown lint colour, may be duplicate of Lc_2^B.
(b) Tetraploid cotton		
Lc_1	Lc_1^K	Governs khaki lint colour in Guatemala upland cotton.
Lc_2	Lc_2^K	Governs brown lint colour in Egyptian enan's brown.Lc_2^K is independent but regarded as duplicate of Lc_1^K.
Lc3		Dark brown lint colour
Lc5		Determines light brown lint.
Lc6		Determines brown lint
DW		Dirty white lint colour.
Lg		Green lint colour.

In New World cultivated tetraploid species G.hirsutum and G.barbadense, inheritance of lint colour had been extensively investigated than that of Asiatic species. In various studies, it is observed that each of the lint colours-rust, dingy brown, yellow brown and green, is governed by a single incompletely dominant gene. The lint colour loci are allelomorphic showing blending inheritance indicating the involvement of plus modifiers. Several genes for lint colour have been identified. These are givenin Table.4 alongwith their characteristics.

EFFECT OF SUNLIGHT AND WASHING ON LINT COLOUR

The lint colour is influenced by sunlight and the fabric colour is affected by washing. These two factors in relation to lint / fabric colour are discussed below:

- **Effect of sunlight**

As stated above, the lint colour is greatly influenced by sunlight. The natural colours are not stable and long lasting. Exposure of coloured lint to sunlight leads to fading of colour. Prolonged exposure of green lint to sunlight during boll opening causes rapid fading of lint colour. The green colour is turned into white or off white. However, portions of the boll which are not exposed directly to sunlight retain original colour of the lint. Green colour fades more quickly than brown colour. Brown colour also fades but at a very slow rate.

- **Effect of washing**

The reaction to washing of natural colours is quite different from that of synthetic colours. Dyed fabrics more or less fade with each washing. On the contrary, fabrics from naturally coloured cotton improves its fastness and colour intensity with each washing. Experiments have shown that washing fabrics from coloured cotton intensifies its colour. The idea that the natural colour intensifies with the exposure to sunlight may be true for specific colours but is certainly not applicable to all colours of cotton.

ADVANTAGES OF COLOURED COTTON

There are several advantages of naturally coloured over the white cotton varieties. These are briefly discussed below:

- **Effect on Human Health**

Cotton fabrics with artificial dyes have been reported to have adverse effects on the skin and human health. Artificial dyes cause allergy and itching on the skin and sometimes may cause skin cancer. In cotton mills, several labourers come in contact with artificial dyes. Artificial dyes have adverse effect on their health. There is risk of skin cancer among the persons who regularly come in contact with artificial dyes. It is a known fact that most of dyes used in textile industries are carcinogenic. The fabric prepared from naturally coloured cotton lint is free from such adverse effects. There is no need of using artificial dyes, when the fabric is manufactured from naturally coloured cotton. Such fabric can be safely used even by those having sensitive skin. Thus, fabric manufactured from coloured cotton has been found to be the best for human health.

- **Effect on Environment**

Various artificial dyes are being used for dyeing of cloth manufactured from the white lint. After dyeing, the chemical residues in the form of dyeing or finishing affluents are thrown in nearby river contaminating water and soil. This form a major source of environmental pollution. When the fabric is manufactured from naturally coloured lint, there is no need of artificial dyes. Hence the residues of artificial dyes will not accumulate in the drains. Thus use of naturally coloured cotton helps in reducing environmental pollution caused by artificial dyes.

- **Effect on cost of fabric production**

The dyeing process adds to the cost of production of fabric. The dyeing process is omitted when naturally coloured lint is used for manufacturing of the fabric. Thus the cost of production of fabric can be reduced to some extent through the use of naturally coloured cotton. If the coloured cotton is paid higher price than white cotton, then the reduction in the cost of production of fabric caused by omitting dyeing process is compensated by high price of coloured cotton fabric.

LIMITATIONS OF COLOURED COTTON

Naturally coloured cottons have some inherent drawbacks. These are: low yield potential, poor fibre properties, limited colours, instability of colours, contamination of white cotton, low market demand, and lack of marketing facilities.

- **Low Yield Potential**

The yield potential of currently available coloured cotton genotypes is very low. The yield potential is almost half of the white linted varieties. Because of low yield potential, naturally coloured cotton could not become popular for commercial cultivation. In other words, low yield potential of naturally coloured cotton has acted as a barrier in the expansion of its cultivation. Its cultivation has been limited to small pockets in tribal areas only.

- **Poor Fibre properties**

The fibre of naturally coloured cotton genotypes, compared with white cotton, is of very low quality. Naturally coloured cottons are usually shorter in staple length, weaker in fibre strength and have low micronaire value. They also have low fibre maturity compred to white cottons. There is need to improve fibre properties of coloured cotton, particularly fibre strength to make it suitable for high speed spinning.

- **Limited Colours**

Naturally coloured cotton genotypes currently available in the germplasm have limited lint colours. There are only two colours i.e. brown in various shades and green. With only two colours, naturally coloured cotton can not compete with white cotton as varied treatments of colours and shades can be easily imparted to white cotton.

- **Instability of colours**

The colour of naturally coloured cotton is not stable and long lasting. All colours do fade in the sunlight. In sunlight, the green colour fades more quickly than brown colour. Brown colour also fades but at a very slow rate. The green lint which is exposed to sunlight becomes almost white and the portion which is covered with the bur (at the bottom of the locule) remains dark green.

- **Contamination**

Natural lint colour is governed by dominant / incomplete dominant genes. The green colour is controlled by one gene and brown colour with two or more genes. Cotton is an often cross-pollinated crop. In natural conditions, cross pollination occurs to the extend of 5-20 percent. Growing of coloured and white cotton in the vicinity will enhance the chance of contamination of white linted genotypes with coloured genotypes and vice-versa. Contamination may occur in three ways, viz. (1) through natural outcrossing with white cotton, (2) during ginning, and (3) during delinting. Growing of white cotton in the field in which coloured cotton was grown in the previous year may also lead to contamination through volunteers. Hence, cultivation of coloured cotton should be restricted to small areas only. Moreover, research work on coloured cotton should be restricted to only few research centres to avoid contamination of white cotton.

- **Low Market Demand**

There is very limited demand of naturally coloured cottons in India. In the last few years, the demand of naturally coloured cotton has increased in some European countries, which is about 5-6 lakh bales per annum. Looking to low demand, it would be desirable to restrict cultivation of coloured cottons to limited areas and to registered growers only. This will help to

avert the possible loss to the growers possibly due to its over production and very less or no market demand.

- **Lack of Marketing Facilities**

There is lack of proper marketing for the sale of naturally coloured cotton. It is necessary to develop marketing facilities before starting cultivation of coloured cotton on commercial scale. There should be written agreement between the purchaser and the producer for production of naturally coloured cotton.

AGRONOMIC PRACTICES AND PLANT PROTECTION MEASURES

Agronomic practices and plant protection measures for naturally coloured cottons are the same as those for white linted cotton.

PRACTICAL ACHIEVEMENTS

In India, coloured cotton varieties were released in Asiatic Cotton (G.arboreum L.) in the first half of 20th century. Three varieties, viz.Cocanada 1, Cocanada 2 and Red Northerns were released for commercial cultivation in parts of Andhra Pradesh. Thereafter, the work on coloured cotton was discontinued due to their low yield and poor fibre properties.

Recently, the work on coloured cotton has got momentum. Central Institute for Cotton Research, Nagpur and several State Agricultural Universities have taken up breeding programmes for improvement of coloured cotton. Major thrust of improvement activities is to improve fibre length, fibre strength, maturity of fibres and improvement of yield levels. Research on varietal development and identification of promising hybrids is in full swing. As a result of concerted efforts on varietal development, since 1990, an upland cotton variety KC 94-2 has been released for commercial cultivation from Jawaharlal Nehru Krishi Vishwa Vidyalaya, Khandwa Campus in 1996. Efforts are underway at several other Cotton Research Centres for identification of coloured cotton varieties and hybrids with high yield and improved fibre properties. Performance of some brown linted hybrids of G.hirsutum for economic and fibre characteristics is presented in Table-5.

Table-5: Major economic and fibre characteristics of some selected coloured linted cotton hybrids.

Hybrid	Seed Cotton yield (g/pt.)	Boll Wt.(g)	G.O.T (%)	2.5 % span length (mm)	Uniformity Ratio (%)	Micronaire Value	Maturity Coefficient	Strength 'o' gauge (g/tex)
Vikram x LC1-1	207.8	4.2	33.0	20.7	46	3.1	0.76	37.1
MCU5 x LC1-1	195.3	3.7	34.7	23.3	45	2.7	0.62	36.3
CNH 36 x LC1-1	174.7	4.0	36.2	22.8	45	3.4	0.78	40.7
Vikram x Parbhani American	170.3	3.6	38.0	21.4	42	3.1	0.73	37.7
CNH 36 x Parbhani	169.5	2.8	37.0	19.3	44	3.1	0.76	37.6

American								
Vikram x Arkansas Green	159.5	3.6	32.2	22.6	47	2.7	0.60	46.6
Vikram x Extreme Okra Leaf	140.0	4.0	36.2	22.2	47	3.2	0.73	39.2
CNH 36 x Extreme Okra Leaf	135.3	3.2	35.6	22.2	42	3.6	0.76	41.4
MCU 5 x Arkansas Green Lint	133.1	2.8	37.5	28.4	48	3.2	0.74	39.6
LRK 516 x LC1-1	130.3	3.5	37.0	24.4	40	2.5	0.57	37.2
MCU 5 x Parbhani American	130.0	3.8	35.0	22.2	46	2.8	0.62	37.6
LRA 5166 (Check)	173.3	3.2	34.2	25.7	46	3.4	0.77	45.3

FUTURE THRUST

The limitations which impede commercial cultivation of coloured cotton, itself signalize future thrust area of research. These are as follows:

- Development of wide range of colours with different shades, uniformity and stability.
- Improvement of fibre properties such as length, strength and maturity.
- Development of high yielding, early maturing varieties and hybrids.
- Development of coloured cotton varieties and hybrids amenable to mechanical picking.
- Development of male sterility based hybrids in desi and upland coloured cottons.
- Development of coloured transgenic cottons.

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