

Agronomy – Kharif Crops

Cotton

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COTTON

Botanical name: *Gossypium* spp.

Family: Malvaceae

Chromosome number: $2n=13$ (Desi)0

$2n=26$ (American)

Cotton (*Gossypium* spp.) is one of the most important commercial fibre crops of the world contributing 40% of raw material to textile industry, besides serving as raw material to over 25 industries. Hence it is called 'white gold'.

Cotton is chiefly grown for its seed fibre, which is used in the manufacture of cloth for the mankind. It is also used for several other purposes like making threads, for mixing in other fibres and extracting of oil from the cotton seed. The oil and protein content in the cotton seed is about 17% and 24% respectively. American varieties contain more percentage of oil. Deoiled cotton seed and cake are good organic manure with 6-3-2% of N-P₂O₅-K₂O. Cotton seed, and cotton meal forms concentrated feed for cattle.





Origin and Taxonomy

The genus *Gossypium* comprises 49 species, of which 4 are commercially grown for lint and seed purposes. Among them, two each are diploids and allo tetraploids species. The 2 diploid species ($2n = 26$) are known as old world or Asiatic cottons (in India, they are called *deshi* cottons). *Gossypium arboreum* L. also called tree cotton is cultivated in India and *G. herbaceum* L. called Arabian/Syrian cotton is cultivated in central Asia. The other 2 species called new world cottons are *G. hirsutum* L. (American or upland cottons) and *G. barbadense* L. (Egyptian or sea island cottons)

G. arboreum has originated in the Indo-Gangetic alluvium of north India. The cultivated *G. herbaceum* derived from *G. herbaceum* var. *africanum* (distributed in South Africa). *G. hirsutum* is native to Mexico and Central America, while *G. barbadense* has originated from South America (probably Peru).

Cotton has been used as a fabric in India since time immemorial. It has been cultivated in the Indus valley more than 5000 years. The excavation of Mohenjodaro indicates high degree of art in spinning and weaving with cotton at that time. India is considered as a center of an important cotton industry as early as 1500 BC. The cultivation of cotton spread from India to Egypt and then to Spain and Italy.

Geographic Distribution

Cotton is the most important fibre crop of the world cultivated over an area of 35.2 million ha with a total production of 69.9 million tonnes of seed cotton. The important cotton growing countries are India, China, USA, Pakistan, and Brazil (Table 1).

Table 1. Area, production and productivity of cotton in different countries (2004)

Country	Area (m ha)	Seed cotton		Lint (2003-04)
		Production (m tonnes)	Productivity (t/ha)	Production (000 bales)*
USA	5.285	7.437	1.41	18,255
China	5.690	12.640	2.22	22,300
Uzbekistan	1.456	1.968	1.35	4,200
India	8.988	5.130	0.57	13,100
Pakistan	3.192	4.852	1.52	7,750
Argenteina	0.253	0.190	0.75	-
Turkey	0.637	1.390	2.18	4,100
Brazil	1.149	2.466	2.15	5,650
Turkmenistan	0.525	0.445	0.85	-
Greece	0.377	0.590	1.56	-
Australia	0.321	0.912	2.84	-
Egypt	0.301	0.449	1.48	-
World	35.234	69.936	1.98	93,465

* Bale= 480 lb (240 kg)

Source: FAO Production Year Book, 2004

India ranks first in the world in respect of acreage and third in seed cotton production. Of the total acreage, 3.5 m ha are under Bt cottons during 2006. In India, cotton is grown on a large scale in Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Punjab, Rajasthan, Haryana, Tamil Nadu and Uttar Pradesh. Gujarat is the largest producer of cotton in India followed by Maharashtra and Punjab (Table 2).

Table 2. Area, production and productivity of cotton lint in important states of India (2004-05)

State	Area (000 ha)	Production('000 bales) *	Productivity (kg/ha)
Andhra Pradesh	1178.0	2190.0	316
Assam	1.0	1.0	170
Chattisgarh	0.5	0.8	272
Gujarat	1906.3	4724.8	421
Haryana	621.0	2075.0	568
Karnataka	521.0	688.0	224
Kerala	2.7	4.4	277
Madhya Pradesh	576.1	626.1	185
Maharashtra	2840.0	2939.0	176
Orissa	45.9	111.2	412
Punjab	509.0	2087.0	697
Rajasthan	437.8	764.6	297
Tamil Nadu	129.4	194.8	256
Uttar Pradesh	4.9	5.1	177
West Bengal	2.0	3.0	255
India	8786.6	16428.6	318

*Bale : 170 kg

Source: Fertilizer association of India, 2006

Classification

Genus *Gossypium* includes 49 species of cotton including wild as well as cultivated species. The cultivated species have spinable lint, while wild species have only short seed fuzz or

smooth seeds. Out of the total species, only 4 are cultivated, of which 2 are diploids (*deshi*) and two tetraploids (American cottons).

Gossypium arboreum ($n = 13$) – *Deshi*/ Asiatic cottons: It is most widely grown deis cotton. The lint is short (staple length <25 mm) and coarse with micronaire value >60 .

Gossypium herbaceum ($n = 13$) - *Deshi* / Asiatic cottons: It is less widely grown.

These two species accounts for $\sim 2\%$ of world cotton production. In India, they account for 28% of the cotton acreage.



Gossypium herbaceum

Gossypium hirsutum (n = 26) – American or African upland cotton: These are medium staple (staple length 25-30 mm) cottons with micronaire value ranging from 3.8-5.0. it accounts for over 90% of global cotton production.





:Gossypium hirsutum

Gossypium barbadense (n = 26) – Egyptian cottons: The fibre length is long (staple length .32 mm) and fine with micronaire value of < 4.0. it accounts for about 8% of global cotton production.



Gossypium barbadense



Gossypium barbadense

India is divided into 3 cotton zones based on species grown as below.

1. Northern *hirsutum*, *arboreum* and hybrid zone: In this zone short (<20 mm) and medium staple (>20.5 -25.5 mm) cotton is cultivated under irrigation.
2. Central *hirsutum*, *herbaceum*, *arboreum* and hybrid zone: In this zone medium (26.0-27.5 mm) and long staple (28.0-33.5 mm) cotton is cultivated under rain fed situation.
3. Southern *arboreum*, *hirsutum*, *herbaceum*, *barbadense* and hybrid zone: In this zone long (28-33.5 mm) and extra long staple (>35 mm) cotton is cultivated under irrigated or rain fed situations.

Botanical Description

In the wild state, cotton is a perennial plant, attaining height of 5-6 m. However, most of the cultivated cottons are annuals. Cultivated cotton is a herbaceous plant, which attains a height of 75-200 cm.

Root system: Cotton plant has a tap root with secondary roots that branch laterally from primary root.

Stem: The main stem is erect and profusely branched. The branches develop from buds located at the nodes of the main stem. There are 2 buds at the base of each leaf petiole. The true axillary buds develop into a vegetative branch, which only bear leaves and no flowers. The accessory bud generally develops into sympodial or fruiting branch. Vegetative branch may arise either from axillary or an accessory bud. There is tendency for the lower branches to be vegetative, while the upper ones as fruiting branches.

Leaves: The leaves are spirally arranged on the main stem and vegetative branches, except on fruiting branches, where they form 2 alternate rows. The leaves are petiolate. The outline of leaf is more or less cordate with 3-9 lobes depending on variety. The leaves are green, but in some species such as *arboreum*, leaves contain some purplish colour.

Flowers: The flowers develop at the node of opposite to a leaf in fruiting branches only. The flowers are typical of the mMalvaceae family. The flower buds appearing as small, and pyramidal shaped green structure are called 'square'. The flowers open about 18-24 days after the squares are formed. Flowers consist of pistil, the stamens arranged in a tube-like staminal column the revolves the style of the pistil, 5 petals and 5 green sepals, joined together to form a cup like calyx.

Fruit: The fruit is the enlarged ovary that develops into 3-5 loculed capsule or boll. The bolls vary in size and shape, but are usually more or less egg shaped. When the boll is ripe, the capsule cracks or splits along the lines or sutures where carpels meet, and the cotton within expands greatly in a white fluffy mass. The number of seed in the boll varies from 24 to 50. The cotton fibre is simply an elongation or outgrowth of an epidermal cell of the seed coat. The long outgrowth forms the 'staple' or 'lint', while shorter outgrowth forms 'fuzz'.

Climatic Requirements

Cotton, a warm season (semi-xerophyte) woody indeterminate shrub, is grown under a wide range of climate. The minimum temperature for germination is 15.5°C, while the optimum being 18-38°C. For vegetative growth, 21-27°C is suitable. For reproductive growth, a night and day temperature of 20 and 30°C respectively is the optimum. It has the ability to withstand the various degrees of drought. The mean relative humidity in the growing season should be >50%. However, it can tolerate temperatures as high as 43°C. During fruiting phase, cool nights are required. Abundant sunshine during the period of boll maturity and harvesting is essential to obtain a good quality produce.

A frostless season of 180-240 days is required in north India for successful cotton growing. High temperature of about 45°C during sowing and seedling stage and extremely low temperature with frequent frost during winter coinciding with picking, and moderate rainfall of 30-70 cm usually occur in the northern zone. In central and southern zones, the climate is more uniform. The maximum temperature during the season varies from 32 to 40°C, while minimum temperature ranges between 10 and 20°C. In Tamil Nadu and Andhra Pradesh, a part of the rainfall is received during September to December through the north-east monsoon.

Varieties

Since first five year plan, several promising cotton varieties have been released and recommended for different regions of the country. Regionwise recommended Bt cotton hybrids, hybrids and varieties are given below.

Bt. Cotton hybrids suitable for cultivation in different agro-climatic zones of India

Agro-climatic zone	BG-I (BollGaurd I)	BG-II (Boll Guard II)
Northern Zone (Punjab, Haryana, Rajasthan)	MRC 6304, MRC 6301, MRC 6025, MRC 6029, Ankur-651, Ankur 2534, RCH 134, RCH 317, RCH 308, RCH 314, NCS 913, NCS 138	
Central Zone (Gujarat, Maharshttra, Madhya Pradesh)	Mech 12, Mech 162, Mech 184, MRC 6301, RCH 2, RCH 118, RCH 138, RCH 144, RCH 377, Ankur 09, Ankur 651, NCS 145 Bunny Bt., NCS 207 Mallika Bt, GK 205, Tulasi 4, Brahma Bt, VCH-111, ACH 33-1, ACH 155-1, VICH 5, VICH 9, PRCH 02	ACH-11-2 KDCHH-444, MRC 7301 MRC 7326 MRC 7347
South Zone (Tamil Nadu, Karnataka, Andhra Pradesh)	Mech 162, Mech 184, MRC 6322, MRC 6918, RCH 2, RCH 20, RCH 368, RCH 111, RCH 371, RCHB 708, NCS 145-Bunny Bt, NCS 207, Mallika Bt, GK 209, Brahma Bt, NCS 913, PRCH-02, PRCH-02, PRCH-103, GK 207, ACH 33-1, PCH 2270, KDCHH-9632, VICH 5	MRC 7351 MRC 7201

Cotton hybrids recommended for different zones

Zone	Desi hybrids <i>herbaceum</i> x <i>arboreum</i> (diploid hybrids)	Intra- <i>hirsutum</i> hybrids	<i>hirsutum</i> x <i>barabadense</i> hybrids
North Zone	LDH-11*	Fateh, LHH 144, Dhanalaxmi, Maruvikas, Omshankar	
Central Zone	GDH 7, GDH 9, Pha 46	CICRHH-1, Hybrid 4, Hybrid 6, Hybrid 8, Hybrid 10, PKV Hy2, PKVHy3**, PKV Hy 4**, NHH 144, JKHY-1, JKHY-2, Godavari, NHH-302	NHB-12, NHB 302, JKHy-11
South	DDH-2	DHH-11, Suguna**, Surya, Savita	Varalaxmi, DCH 32, DHB 105, CBS 156, TCHB 213, HB 224, Sruthi, KCH-1, Savitri

*Intra *arboretum* hybrid; ** Male sterility based hybrids

Cotton varieties recommended for different zones

Zone	<i>arboreum</i>	<i>herbaceum</i>	<i>hirsutum</i>	<i>barbadense</i>
North Zone	G 27, Lohit, Shyamali, RG 1, LD 133, LD 230, LD 327, DS 1, HD 11, RG 8	Digvijay	Ganganagar Ageti, SH 131, Vikas, F 414, H 777, Pramukh, H 14, LH 900, F 505, F 848, H 794, PST 9, F 1054, HS 45, Pusa 31, Pusa 8-3, F 286, LH 372, BC 761, F 1861, RS 310, H 1117, RS 20113	
Central Zone	Sanjay, Maljari, AK 235, G 22, AKH 4, AKA 1, AKA 5, Sujay, Eknath	F 46, V 797, Digvijay, G.Cot. 11, G.Cot. 13, G.Cot. 18, G.Cot. 19, G.Cot. 23, CNH 36	Laxmi, Khandwa 1, Khandwa 2, Khandwa 3, Vikram, LRA 5166, PKV 081, L 174, Devitej, Gujarat 67, DHy 286, Purnima (NH 239), Badnawar 1, Nimbakar 1, Buri 1007, Narbada, AKA 8401, Deviraj, Arogya, Rajat	Suvin
South Zone	Nardium, Srisailam, Mahanandi, Pandaripur, Coconada red, K 7, K 9, K 10, Gorani 6	Jayadhar, Westerns 1, Raichur 51, Ajanta (DB 3-12)	Laxmi, Hy 14, Bhagya, Sharada, MCU 6, MCU 7, MCU 8, MCU 9, MCU 10, MCU 12, LRA 5166, Kanchana, LK 861, L 389, L 603, L 604, Mysore Vijay, Hampi, Krishna, Mahalaxmi, Suman, Sowbhagya, Sumangala, Supriya, Pratima	Suvin, Sujata, TNB 1

Recently released varieties and Hybrids:

RHy 253, LAHH 4, LAHH 5, Lam Hybrid 1, Vagad Kalyan (RB 423), HHH 223, Arvinda (NDL 2708), ICMF 20, Shana, RAMPBS 155, Parbhani 316, GBhv 179, GSGDH 2, ADCH 1, HD 123, CDHB 1, NFHB 109, WHH 9, AAH 1

Jawahar Kapas 4 (Madhya Pradesh); RHH 492, RHB 388 (Maharashtra); Narasimha, Veena (Andhra Pradesh)

Soils

Cotton is grown on extremely diverse soil types. However, a deep (>60 cm), friable, well drained and fertile soil is most suitable. Silty clay to clay soils are the best. Soils with a pH >9.0 and <6.5 and CaCO₃ content > 10% in root zone are not suitable for cotton cultivation. It is raised mainly as a rainfed crop in the black cotton and medium soils and as an irrigated crop in the alluvial soils.

The predominant types of soil on which the crop is raised are:

Alluvial soils (*preponderant in the northern states of Punjab, Haryana, Rajasthan and Uttar Pradesh*), Red sandy loams to loams (*preponderant in Gujarat, Maharashtra, Madhya*

Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu) and Laterite soils (found in parts of Assam, Tamil Nadu and Kerala).

Land Preparation

Cotton requires thorough land preparation for germination and growth of the crop. In cotton-wheat cropping system of north, cotton is sown immediately after harvest of wheat leaving little scope for proper land preparation. The field is irrigated immediately after *rabi* crop followed by ploughing with MB plough and planking.

Under rainfed conditions, land preparation starts with the onset of monsoon. However, a deep summer ploughing is desirable once in 3 years to ward off perennial weeds and also to kill pests and disease propagules hibernating in the soil. After the start of monsoon, the field is harrowed 3-4 times followed by planking in vertisols of central and southern India. However, in red soils of southern India, 2-3 light ploughings are given before planking. Land preparation costs can be minimized by adopting minimum or zero tillage coupled with use of suitable herbicides.

Cropping systems

Cotton is grown mixed with maize, sorghum, sesame, pulses or vegetables in many parts of central India. Intercropping with ragi or other millets or groundnut is also quite common in parts of Tamil Nadu, Karnataka and Andhra Pradesh. Intercropping and mixed cropping under rainfed conditions serve both as an insurance against crop failures and as a preventive measure against soil erosion.

The most important cotton based rotation in irrigated areas of Punjab, Haryana, northern Rajasthan and Uttar Pradesh is cotton-wheat. The growing of berseem and clusterbean (*guar*) has been found to have beneficial effect on the succeeding cotton crop. In central and western India, cotton-sorghum, cotton-pearl millet, cotton-wheat, cotton-gram and cotton-sesame are the useful rotations followed.

Seed and Sowing

Seed rate and spacing

The seed rate varies with species, growing zone and availability of irrigation. A highly branching monopodial variety/hybrid requires more spacing than non-branching sympodial types. With the evolution of compact varieties, the concept of wider row planting has been changed to closer planting systems which can accommodate more plant population.

Species	Growing condition	Cotton zone	Seed rate (kg/ha)	Spacing (cm)
<i>G.hirsutum</i>	Irrigated	North	20-25	75 x 15
	Irrigated	South	10-15	75 x 30/45
	Rainfed	North/Central/Southern	18-20	60 x 30
	Rainfed	Southern	10-12	90 x 30
G.arboreum/ herbaceum	Irrigated/Rainfed	North	10-12	60 x 30

Species	Growing condition	Cotton zone	Seed rate (kg/ha)	Spacing (cm)
	Rainfed	Central/Southern	12-15	45 x 25/ 60 x 30
<i>G.barbadence</i>	Irrigated	Southern	8-10/12-15	90 x 30/ 75 x 30
Hybrids	Irrigated	Southern	2-3	90 x 30/ 45/60
	Rainfed	Central	3-4	150 x 60
	Rainfed	Southern	2-3	120 x 60

Method of sowing

In case of *desi* cottons, line sowing behind the seed drill is common. However, in case of hybrids and Bt cottons dibbling the seeds is preferred owing to higher seed costs. Square planting are beneficial than rectangular planting methods. The optimum depth of sowing is 4-5 cm.

Gap filling and thinning

As the crop is grown at wider spacing, the gaps arising due to failure of seed germination or seedling mortality or incidence of pests / disease must be filled by sowing water soaked seeds. To ensure full stand, 2-3 seeds/hill are dibbled. After germination, the weak/diseased/damaged seedlings are removed by keeping a healthy seedling/hill.

Seed treatment

The seed is covered by short fibre called ‘fuzz’ in most of the American cottons that makes sowing difficult owing to clinging of seeds. Its separation is essential for ease of sowing and is achieved by the following ways.

- *Non-chemical method:* The seeds are soaked in water overnight, and then rubbed with cowdung and wood ash or saw dust to separate fuzz from seeds. The seeds are dried in shade before sowing. The rubbing also helps in crushing the pink boll worm affected seeds.
- *Chemical method:* Seeds placed in an earthen pot are soaked for 2-3 minutes in concentrated sulphuric acid. The seeds are immediately washed in water 3-4 times to remove acid residues left on the seed and dried in shade before sowing.

For chemical seed treatment, wood or metal container should not be used. The operator should wear the plastic gloves. The water containing acid and alkali residue should be properly disposed off in the waste land. Inadequate washing or delayed washing of the seed after seed treatment and residual acid on the seed if not neutralized may impair the germination of seed.

Add 10 g of ceresan wet and 0.5 g of streptomycin or 15 g of agrimycin 100 in 10 litres of water and soak the seed in it for 6-8 hours to prevent primary infection of seed-borne pathogens. In case of acid delinted seeds, soaking for 2-4 hours is sufficient. If ceresan wet is not available, use of 10 g agallol or 5 g of tafasan / aretan may serve the purpose. One g of succinic acid in 10 litres of water may also help to promote good establishment of plant stand, and better early growth.

Time of sowing

The optimum time of sowing is 1st week of May in north. However, this may be extended up to 3rd week of May to the first week of June with selection of new compact varieties. Under rainfed conditions of central and south zone, the sowing starts with onset of monsoon in June and may be extended up to first week of July. Under irrigated conditions, the optimum time of sowing varies from first fortnight of March (western Maharashtra) to 2nd to 3rd week of May (Vidarbha region of Maharashtra and Khandesh tracts of Madhya Pradesh). In Tamil Nadu cotton is planted during September-October under both irrigated and rainfed conditions. The time of sowing in rice fallows depends on the harvest of rice crop from October-November. For spring cotton, February is the optimum time of sowing.

Nutrient management

Cotton is a heavy feeder of nutrients. It requires adequate supply of nutrients through manures or fertilizers. Cotton soils are universally deficient in N, but are moderate to adequate in respect to phosphorus and potassium. This shows the importance of N nutrition.

For moisture conservation and better response to applied nutrients, FYM application @ 5-10 and 10-20 t/ha under rainfed and irrigated conditions is recommended. It is applied at the last ploughing for proper incorporation into the soil.

The N dose varies from 40-60 kg/ha (rainfed) to 100-150 kg/ha (irrigated conditions). Similarly *desi* cotton requires less N than hybrids. The N demand of crop is spread over from sowing to boll development. Therefore, split application is desirable. The number of splits may vary from 2-3. In case of 3 splits, 50%, 25% and 25% of total N is applied at sowing, square formation and flowering. In hybrids, spot application of top-dressed N is more efficient than broadcast. Inoculation of cotton seed with *Azotobacter* and *Azospirillum* has been found effective in meeting N requirement of cotton to the extent of 30 kg/ha.

Application of phosphatic and potash fertilizers should be based on soil test values. The P₂O₅ dose varies from 30-40 and 40-60 kg/ha under rainfed and irrigated conditions respectively. It should be applied as basal at sowing and placed at 7-10 cm below soil for efficient utilization. The response to K fertilization is rare in India. However, hybrids under irrigated conditions with high N and P fertilization usually respond to K fertilizer. It is applied similar to P fertilization.

Use of phosphate solubilizing microbes (*Bacillus*, *Pseudomonas*, *Aspergillus*) along with rock phosphates are more effective than rock phosphates alone. Responses to S and Zn fertilizers have also been reported. Zn deficiency is accentuated with alkalinity of soils.

Water Management

Cotton, a predominantly rainfed crop, has only 34.3% of the total area under irrigation (2003-04). Hence, both moisture conservation and water management are equally important.

Rainfed crops have low yields owing to erratic and uneven rainfall. Moisture stress during reproductive phase is most harmful to the crop performance. Tied ridging at 6 m interval, broad-bed and furrows and ridge planting are effective in rain water conservation. Use of farm yard manure and effective weed management are conducive for moisture conservation.

In cotton, four critical stages of irrigation have been identified viz. commencement of sympodial branching (60-70 DAS), flowering (90-100 DAS), boll formation (125 DAS) and boll bursting (140 DAS). Depending on rainfall and soil types, the number of irrigations (each of 7.5 cm) may vary from 2 (sandy loam of Delhi and clay soils of Akola) to 13 in red sandy loam of Bhavanisagar. Thus, the quantity of irrigation water varies from 140-840 mm. The mean consumptive use is about 700 mm in the country. In heavy soils, cotton withstands up to 75% depletion of available soil moisture (DASM), while in sandy loams, it is 50% DASM only. For timely sowing of succeeding crops, irrigation should be withheld from 50% boll bursting stage onwards. Under limited water resources, irrigation in alternate furrows is recommended.

The drip irrigation is being increasingly adopted, and irrigation at 0.6 irrigation water (IW) / cumulative pan evaporation (CPE) ratio has been found promising. This ratio also holds good for flood irrigation.

Weed control

In wide spaced crops like cotton, weeds pose serious threat to realizing the optimum yields. A weed free period of 50-60 days from sowing is required. The profuse vegetative growth beyond this period may suppress the weed growth. Uncontrolled weeds may cause 60-80% reduction in yields.

In the northern cotton-wheat region, the major weeds are *Trianthema* sp.; *Echinochloa* sp.; *Digera arvensis*, and *Cyperus* sp. In the central region, *Celosia argentea*, *Cyanotis axillaris*, *Digitaria sanguinalis*, *Dinebra retroflexa*, *Euphorbia* sp., *Echinochloa* sp.; *Ipomea* and *Cyperus* sp. are commonly found. In the southern zone, the predominant weeds are *Trianthema portulacastrum* and *Cynodon dactylon*. Water loving weeds like *Portulaca oleraceae*, *T. portulacastrum* and *E. crusgalli* are major weeds in the rice fallows.

Manual, mechanical and chemical methods of weed control either alone or in combination are followed for effective weed management. The first manual hoeing 5-6 weeks after sowing or before first irrigation is essential for removal of weeds at an early stage. Later hoeings either by hand or bullock drawn implements should be done after each irrigation or rain. The interculture operations not only aid in weed control, but also help in creation of mulch, aeration of soil and better intake of water.

Among the herbicides, pendimethalin (pre-emergence) or fluchloralin (pre-plant incorporation) @ 1 kg/ha are found effective in controlling grassy weeds for the initial 2 months. For broad leaved weeds, post-emergence herbicides like diuron + paraquat (0.5 + 0.3 kg/ha) for directed spray against weeds was recommended. In developed countries, bromoxynil and glyphosate resistance has been introduced into cotton for spray for effective post-emergence weed control. Of the total cotton acreage of the world in 2002, 4.4 m ha (2.2 m ha is exclusively herbicide resistant cotton and 2.2 m ha is herbicide + Bt resistant cottons) is under herbicide resistant cottons.

Use of Plant Hormones

It has been observed that the cotton plant sheds the greater proportion of the buds at any stage between bud formation and boll maturity under normal growth conditions. Application of plant hormones such as *planofix* (α -NAA) and *cycocel* (CCC) at 10 ppm 80-90 days after sowing coinciding with square formation helps in more bud-retention besides helping in more sympodial branching in plants, and also inducing drought resistance.

Topping

It is also an important aspect to remove the terminal growing point (topping) once from each plant at a height of 1 to 1.2 m or between 80-90 days of crop growth. This practice arrests further terminal growth and encourages sympodial branching and boll development. It also facilitates spraying operations and picking of cotton.

Harvesting

Cotton is harvested in 3 or 4 pickings by hand as the bolls mature. The number of picking may vary with the maturity habit of the variety. The season of harvesting also varies with time of sowing and the duration of variety. Generally, crop sown in April-June is harvested in October-December, while those sown in June-September and September-October are harvested from November to March and March to June respectively. Generally, the crop in northern and central parts of India is harvested from October to December, whereas in Gujarat, from January to March/April. In the states of Tamil Nadu, Andhra Pradesh and Karnataka, the harvesting season is November to June.

Yield

By adopting improved package of practices, it is possible to harvest about 1.5-2.0 tonnes of seed cotton (kapas)/ha. However, much higher yields may be obtained from hybrid cottons.

Cotton lint production is $\frac{1}{3}$ of kapas production, while cotton to seed production is $\frac{2}{3}$ of kapas production. Oil to seeds crushed is 14-18% and cake to seeds crushed is 82-86%.

Ginning %:

Ginning is the process of separating the fibres from seed cotton. Ginning % is the ratio of the weight of fibres to seed cotton (kapas) expressed as %.

$$\text{Ginning \%} = \frac{\text{Weight of fibres}}{\text{Weight of seed cotton}} \times 100$$

It varies from 28-30% in *G.arboreum*, 34-38% in *G.hirsutum*, and 36-42% in *G.herbaceum* and *G.barbadense*.

Fibre (staple) length:

It is the most important quality parameter of fibres deciding their value. It is taken as arithmetic mean of the length of all fibres present in the sample. Cottons are classified based on staple length into the following classes.

Class	Staple length (mm)	Cotton zone
Short and medium staple	< 20 and 20.5 to 25.5	Northern zone
Medium long staple	26-27.5	Central and southern zone
Long staple	28-33.5	
Extra long	>35	Southern zone

Spinning potential:

It is measured as number of counts [i.e. number of hanks (1 hnk= 840 yards) that weigh to a pound (lb). it varies from as low as 6 S (*G.arboreum*) to the highest of 120 S (*G. barbadense*).

Micronaire value:

Micronaire value is used for judging the fibre strength. It is a measure of the air permeability of a unit mass of cotton under specified conditions, expressed in terms of an arbitrary scale (micronaire scale). In immature and dead fibres it is ≤ 2 . The metric equivalent of it is Tex. The units of tex are micrograms/ mm of fibre length.

Additional Reading:

<http://www.malvaceae.info/Genera/Gossypium/gallery.html>