Package of Practices of Commercial Crops

9. PACKAGE OF PRACTICES OF COMMERCIAL CROPS

COTTON

1. Introduction

Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fibre) to cotton textile industry. Cotton in India provides direct livelihood to 6 million farmers and about 40 -50 million people are employed in cotton trade and its processing.

In India, there are ten major cotton growing states which are divided into three zones, viz. north zone, central zone and south zone. North zone consists of Punjab, Haryana, and Rajasthan. Central zone includes Madhya Pradesh, Maharashtra and Gujarat. South zone comprises Andhra Pradesh, Telangana, Karnataka and Tamil Nadu. Besides these ten States, cotton cultivation has gained momentum in the Eastern State of Orissa. Cotton is also cultivated in small areas of non-traditional States such as Uttar Pradesh, West Bengal & Tripura.

2. Cultivated Species

There are four cultivated species of cotton viz. *Gossypium arboreum*, *G.herbaceum*, *G.hirsutum* and *G.barbadense*. The first two species are diploid (2n=26) and are native to old world. They are also known as Asiatic cottons because they are grown in Asia. The last two species are tetraploid (2n=52) and are also referred to as New World Cottons. *G.hirsutum* is also known as American cotton or upland cotton and *G.barbadense* as Egyptian cotton or Sea Island cotton or Peruvian Cotton or Tanguish Cotton or quality cotton. *G.hirsutum* is the predominant species which alone contributes about 90% to the global production. Perhaps, India is the only country in the world where all the four cultivated species are grown on commercial scale.

3. **Seed rate & Spacing of cotton**

Species	Growing conditions	Cotton Zone	Seed rate (kg. / ha.)	Spacing (Cm)
G.hirsutum	Irrigated	Northern	20 - 22	75 x 15
		Southern	10 - 15	75 x 30
				75 x 45
	Rainfed	Northern	18 – 20	60 x 30
		Central	18 - 20	60 x 30
		Southern	18 - 20	60 x 30
G.arboreum	Irrigated	Northern	10 - 12	60 x 30
		Central	10 - 12	60 x 30
G.herbaceum	Rain fed	Central	12 - 15	45 x 30
		Southern	12 - 15	60 x 30
G.barbadense	Irrigated	Southern	8 - 10	90 x 30
			12 - 15	75 x 30
Hybrids	Irrigated	Southern	2 - 3	45 x 60
				90 x 60
				45 x 30
		Central	2 – 3.5	120 x 40
				120 x 60
		Northern	3 – 3.5	67.5 x 67.5
	Rain fed	Central	3 – 3.5	150 x 60
		Southern	2.5 - 3	120 x 60
Bt hybrids	Irrigated		1.5*	90 x 60**
				120 x 40
				120 x 60

* Which includes 150 gm of non Bt seed **spacing differ depending on growth habit of particular hybrid.

4. **Climate & Soil Requirement**

Cotton, a semi-xerophyte, is grown in tropical & sub tropical conditions. A minimum temperature of 15^{o}C is required for better germination at field conditions. The optimum temperature for vegetative growth is 21-27^{o}C & it can tolerate temperature to the extent of 43^{o}C but temperature below 21^{o}C is detrimental to the crop. Warm days of cool nights with large diurnal variations during the period of fruiting are conducive to good boll & fibre development.

Cotton is grown on a variety of soils ranging from well drained deep alluvial soils in the north to black clayey soils of varying depth in central region and in black and mixed black and red soils in south zone. Cotton is semi-tolerant to salinity and sensitive to water logging and thus prefers well drained soils.

5. Crop Season

The sowing season of cotton varies considerably from tract to tract and is generally early (April-May) in northern India and is delayed as we proceed to down south (monsoon based in southern zone). Cotton is a Kharif crop in the major parts of the country viz. Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra and parts of Andhra Pradesh & Karnataka. In these areas, the irrigated crop is sown from March-May and the rain fed crop in June-July with the commencement of the monsoon. In Tamil Nadu, the major portion of the irrigated and rain fed crop is planted in September-October, whereas the sowing of the rain fed crop in the southern districts is extended up to November. In parts of Karnataka and Andhra Pradesh, the desi cotton is usually sown in August-September. In addition, summer sowings in Tamil Nadu are done during February-March. The sowings of cotton in the rice fallows of Andhra Pradesh and Tamil Nadu extent from the second half of December to the middle of January.

6. Preparation of land

The time available for land preparation following the harvest of wheat is limited in the north zone. Pre-sowing irrigation is undertaken after the harvest of wheat. The land is worked upon with tractor-drawn implements, then levelled & planked before preparing ridges upon which sowing is done.

In central and southern zone of India where cotton is a rainfed crop, deep ploughing recommended to destroy perennial weeds once in 4 years. The field is prepared by repeated harrowing with a blade harrow prior to the onset of pre-monsoon rains. Sowing is undertaken on ridges & furrows in drylands for moisture conservation & weed management.

7. **Method of sowing**

Cotton is sown using tractor or bullock drawn seed drill or by dibbling. Hand dibbling of seeds at recommended spacing is commonly practiced in rainfed areas particularly for hybrids. This system ensures proper plant stand, uniform geometry and also saves seeds. This is now main system of sowing of Bt. Hybrids. Cotton cultivation on ridges across the slopes conserves more water, reduces soil erosion and improves yield.

8. **Irrigation Scheduling**

Depending upon the climate & crop-growing period, cotton needs 700-1,200 mm water to meet its maximum water requirement. The water requirement is low during first 60-70 days after sowing & highest during flowering & boll development.

Cotton is commonly flood irrigated although irrigation by furrow or alternate furrow method is more effective and water saving. Drip irrigation is becoming popular particularly in the hybrids for central and southern zones. Cotton needs to be irrigated at 50-70% depletion of available soil moisture. On sandy loam soils of northern zone 3-5 irrigations are commonly given. On red sandy loam soils of Tamil Nadu with low water retention capacity, 4-13 light irrigations may be necessary.

9. **Inter cultivation & weed control**

Inter-cultivation is done fairly regularly by either a blade harrow with a three tined hoe or a desi plough. In the crop sown by broadcasting, one or two hand hoeing's are given to remove weeds, inter-cultivation not only checks the growth of weeds but also leads to better soil aeration and soil moisture conservation.

Weeds compete with cotton crop for nutrients, light and moisture. Cotton is susceptible to weed competition from sowing to about 70 days when the canopy covers the inter-spaces. Cotton yields are reduced by 50 to 85% if weed growth is unchecked. Fluchloralin or pendimethalin @ 1 kg ai/ha. as pre-plant incorporation with one hand weeding and crosswise hoeing has been recommended for satisfactory weed control. Deep rooted perennial weeds are removed by summer ploughing.

The thinning of the cotton crop is a special feature of the irrigated crop sown on ridges in Peninsular India and in parts of southern Gujarat. Thinning is desirable for

maintaining the optimum population of plants to obtain a high yield. During thinning, the vigorous seedlings are retained and weak seedlings and off types are removed.

10. **Fertilizer doses and method of application recommended for cotton crop in different zones**

Cultural Practices	Northern cotton zone	Central cotton zone	Southern cotton zone
Fertilizers	N - 60 - 100 kg / ha. P and K dose as per soil test. No P need be applied if previous wheat received recommended P. 5.5 kg.Zn / ha. as ZnSo4 once in two cotton - wheat cycles	N : P : K 40 - 20 - 20, 50 - 25 - 25, 80 - 40 - 40 for varieties 100 - 50 - 50, 160 - 80 - 80, 240 - 120 - 120, for hybrids	N : P : K 40 - 20 - 20,60 - 30 - 30, 90 - 45 - 45 for varieties 100 - 50 - 50, 120 - 60 - 60, 150 - 60 - 60 for hybrids
Method of fertilizer application	i) Half N at thinning and remaining at first flowering; ii) Half N at sowing time in late sown crop; iii) Foliar application of N if needed; P to be drilled at sowing.	N in three splits at sowing, squaring and peak flowering stages. (P & K according to soil test). Application of 2 % urea or DAP at flowering and early boll development.	N at squaring and peak flowering, P & K at sowing. In Karnataka entire NPK at planting (rain fed cotton), Half N and entire P & K at planting, remaining N at flowering (irrigated cotton) N in 4 splits in irrigated hybrid cotton.
Bio fertilizer		Seed treatment with azotobacter is beneficial.	Seed and soil treatment with Azospirillium in Tamil Nadu.

JUTE

1. Introduction

Jute is an important natural fibre crop in India next to cotton. In trade and industry, jute and mesta crop together known as raw jute as their uses are almost same. Raw jute plays an important role in the country's economy. Raw jute was originally considered as a source of raw material for packaging industries only. But it has now emerged as a versatile raw material for diverse applications, such as, textile industries, paper industries, building and automotive industries, use as soil saver, use as decorative and furnishing materials, etc. Raw jute being biodegradable and annually renewable source, it is considered as an environment friendly crop and it helps in the maintenance of the environment and ecological balance. Jute as a natural fibre has some definite inherent advantages. Its silky lusture, high tensile strength, low exhaustibility, considerable heat resistance and long staple length are the qualities that cannot be matched by synthetic fibre. Further attraction of Jute lies in its easy availability, inexhaustible quantity at a comparatively cheaper rate. Moreover, it can easily be blended with other natural and man-made fibres. Jute cultivation is mainly concentrated in the eastern and north eastern India while that of Mesta cultivation is spread almost throughout the country.

It is estimated that the jute industry provides direct employment to 0.37 million workers in organized mills and in diversified units including tertiary sector and allied activities and supports the livelihood of around 4.0 million farm families. In addition there are a large number of persons engaged in the trade of jute. There are around 97 jute mills out of which the state of West Bengal has 70 jute mills, Andhra Pradesh 13 mills, Uttar Pradesh 3 mills, Bihar 3 mills, Orissa 3 mills, Assam 2 mills, Chhattisgarh 2 mills and Tripura 1 Jute Mill.

2. Climatic and Soil Requirement

2.1 Climatic requirement for cultivation of Jute/Mesta:

Jute is a crop of humid tropical climates. It thrives well in areas with well distributed rainfall of 2,500 mm spread over vegetative growth period of the crop with no cloudiness. Locations with a mean rainfall of <1,000 mm, incessant rainfall and water logging are not suitable for its cultivation. For better growth, a mean maximum and minimum temperature of 34^{o}C and 15^{o}C and a mean relative humidity of 65% are required. Temperatures below

15^{o}C and above 43^{o}C during growth are not suitable for jute crop. *Corchorus olitorius (Tossa jute)* cannot withstand water logging, however, *C. capsularis (White jute)* can withstand water logging, but its fibre quality is impaired with prolonged water stagnation. At a temperature below 10^{o}C, no germination occurs in both the species. *C. capsularis* can withstand higher temperature at germination (up to 32^{o}C), while *C. olitorius* is sensitive to such high temperatures.

Warm and humid climate are best suited to both the species of mesta i.e. *Hibiscus cannabinus* and *Hibiscus sabdariffa. Cannabinus* mesta is of short duration and suitable for higher rainfall areas and has got less drought tolerance capacity. S*abdariffa* mesta is of longer duration and got better drought tolerance capacity. The crop can grow in temperature range of 20^{o}C to 40^{o}C but optimum temperature for its growth is 30^{o}C to 34^{o}C. The crop can grow in high rainfall areas provided good drainage is there. On the other hand it can grow in low rainfall areas to the tune of even 500 mm rainfall per annum. However, a rainfall of about 125 to 150 mm per month distributed well is required during the growth period. Alternate rain and sunshine is good for better growth.

2.2 Soils :

Jute can be raised on all kinds of soils from clay to sandy loam, but loamy alluvial are best suited. Laterite and gravel soils are not suitable for this crop. The new grey alluvial soils of good depth, receiving silt from the annual floods are the best for jute cultivation. A soil pH of 5.0-7.4 is within the tolerable limit of soil reaction. Soils with acidic pH (<4.5), effective soil depth <50 cm, electrical conductivity >2 dS/m and exchangeable sodium percentage >15 are not suitable for the crop. The crop is raised successfully on old alluvial soils of Bihar, mild acidic soils of Assam, Orissa, and light alkaline soils of tarai districts of Uttar Pradesh. It has been observed that clay loam for *C. capsularis* and sandy loam for *C.olitorius* are most suitable soil types.

3. Crop Production Practices:

3.1 Time of sowing:

Sowing time of jute may differ from area to area on the basis of the receipt of pre-monsoon showers, availability of residual moisture and variety. Generally, sowing in middle of March is optimum for all *Capsularis* varieties and the *Olitorius* varieties like JRO524, JRO878 and JRO7835 while JRO632 should be sown only after middle of April. *Olitorius* sowing may be staggered upto May. In Bihar and Uttar Pradesh, sowing is done up to mid June or some time upto end June as per the onset of monsoon.

The recommended sowing for mesta crop is May-June for main season crop. However, in some areas particularly in some areas of Andhra Pradesh, rabi mesta is also raised. Sowing time for rabi mesta is February-March and usually sown with the subsoil moisture. Sowing should be done when there is sufficient moisture in the soil. A minimum of 21 per cent soil moisture content is required for germination.

3.2. Methods of sowing:

Sowing of jute can be done either by broadcast method or by line sowing method. For line sowing, the land is prepared well and sowing is done with row to row spacing of: *Capsularis* – 30 cm, *Olitorius*– 25 cm and plant to plant spacing is maintained at 5 to 7 cm and this is done by mechanical means i.e. seed drill. The depth of sowing is maintained at 2.5 to 3 cm.

Mesta is usually sown by broadcasting method. But as criteria of improved production technology, it is advocated to sow the crop in line. Line sowing can be undertaken with the help of seed drill. Line sowing has got certain advantages over broadcasting method such as i) Plant growth is uniform since uniform spacing is maintained, ii) Intercultural operation like weeding, hoeing, etc. become easier and cheaper. iii) Application of pesticides and top dressing of fertilizer is easier, iv) Yield is higher by about 15-20%, v) Requirement of seed is less etc.

3.3. Land preparation:

Jute seeds being small require very fine tilth. The land can be prepared by ploughing and cross-harrowing 3-5 times followed by planking. In acidic soils (pH <6.0),

incorporation of 1-1.5t/ha of lime, 30-40days before sowing is necessary for better crop performance. Soil moisture between 21-45% is considered ideal for proper germination.

Mesta being a rainfed crop, land preparation is usually done with the receipt of pre-monsoon showers. However, in Andhra Pradesh, for raising rabi mesta, the land preparation is done early in February for sowing the crop with the help of sub-soil moisture.

3.4. Seeding technologies:

Depending upon the species of jute and method of sowing, the seed rate of the two species recommended is under:

Species	**Broadcast**	**Line Sowing**
C. capsularis	10kg/ha	7kg/ha
C.olitorius	7kg/ha	5kg/ha

The seeds are sown in row 20 cm (*olitorius*) and 30 cm (*capsularis*) apart. The plants within the row should be thinned manually at two stages. First thinning is done 20 days after sowing (DAS), when the plants are of 5-10 cm height . At this stage, plants are thinned to a distance of 5 cm. In second and final thinning 35 DAS, when plants are of 12-15 cm height, and are thinned to a distance of 10 cm. Thus the optimum population varies from 3.33 (*capsularis*) to 5.0 lakh/ha (*olitorius*).

The optimum plant population for mesta is about 4 to 5 lakh per hectare. The recommended row to row spacing is 25 to 30 cm and plant to plant spacing is 7 to 10 cm. For maintaining optimum plant population the seed rate for the two species varies. However, the recommended seed rate is higher than the actual requirement for maintaining the desired plant population. This is done because of getting uniform plant population. After emergence, the excess plants are thinned out to get desired spacing. The seed rate of the two species in two method of sowings are as under:

Species	**Broadcast**	**Line Sowing**
H. cannabinus	15-17 kg/ha	13-15 kg/ha
H. sabdariffa	13-15 kg/ha	11-13 kg/ha

3.5. Fertilizer management:

In general, the nutrient requirement of *capsularis* is more than that of *olitorius*. In soils with low organic carbon content, FYM application @ 5-10t/ha, a month prior to crop sowing is recommended. The leaf fall from the standing crop and also root stubbles left in the soil after harvest results in recycling of handsome amount of nutrients besides organic matter in intensive cropping systems. The recommended doses of fertilizers are 40 to 80, 20 to 40, 20 to 40 kg/ha (*olitorius*) and 60 to 80, 30 to 40, 30 to 40 kg/ha (*capsularis*) of N:P:K respectively (as per CRIJAF).

In heavy soils with low to moderate rainfall, all nutrients are applied as basal. In light soils and high rainfall situations, N is applied in 2 equal splits, ½ basal and ½ top dressing, i.e. preferably after weeding and thinning operations. Seed inoculation with *Azotobacter chroococum* and *Azospirillum brasilense* has been found promising to supplement part of N fertilizer. Foliar application of 20 kg N through urea solution with teepol as sticker at pre-flowering stage is promising.

In acid soils and regions with high rainfall, calcium and magnesium deficiency is common. Liming of soil @ 2-5t/ha, once in 4 years or Dolomite application (40 kg/ha) is found promising as it supplies both calcium and magnesium.

In a medium fertile soil, the recommended dose of fertilizer for mesta is N-40kg/ha, P – 20 kg/ha and K-20kg/ha. Since, mesta is raised mainly under rainfed condition, the recommended dose of N in such cases is 25 kg/ha and it is mainly recommended for Andhra Pradesh.

3.6. Water management:

Jute requires about 50 cm water for its growth and development. In India about 15% jute area is irrigated and the remaining area is rainfed. If the rainfall is not sufficient, the water requirement has to be supplemented through irrigation. For germination of jute seed, about 18-20% soil moisture is required. At sowing time, if the soil moisture is not sufficient, then one pre-sowing irrigation is to be given. After sowing, usually one or two irrigations at an interval of about 20 days is required at the initial stages of growth. Jute is sensitive to both drought and water logging. At germination and knee-high stages, adequate soil moisture must be ensured by irrigation. During rainy season, the crop

experiences water logging that adversely affects fibre quality. Provision of quick drainage in uplands will be beneficial to the crop. However, in lowlands, it may not be feasible.

In India, mesta is mainly raised as a rainfed crop. Since the pattern of rainfall during the sowing and growth period is highly erratic, desired yield is not obtained in mesta crop. For obtaining good yield, along with other inputs, the water requirement of the crop is to be fulfilled. The water requirement of mesta is about 50 cm, if the rainfall is highly uncertain, in that case it is desirable to give one or two irrigation to mesta crop at an interval of 15 to 20 days.

3.7. Weed management:

Jute crop suffers from heavy weed infestation in the initial 6-8 weeks after sowing. Two-three hand weedings or mechanical hoeings are required to arrest weed menace. The first 2 manual weedings are combined with thinning operations at 20 and 35 DAS. The third weeding should be done 55-60 DAS. Due to continuous rains, sometimes manual weeding may not be possible. In such a situation, herbicide integrated with manual weeding is promising. Butachlor 50% EC or Pretilachlor 50% EC (preemergence,applied during sowing) @ 0.9-1.0 kg ai/ha combined with one hand weeding at 35DAS may effectively control the weeds. Recommended post-emergence herbicides for weed control include Quitalofop ethyl 5% @ 40-60g ai/ha and should be applied 20 days after sowing.

Mesta is very susceptible to weed competition at early stage of growth. The growth rate of mesta is slower at this stage and over powered by weeds. The crop requires about two to three weeding/thinning operations depending upon the weed infestations. While two weedings are practiced, the first one is done about three weeks after sowing and the second one is done at about five weeks after sowing. In row-cropping, wheel hoe is used for weeding operations and thinning is done manually. Weeding may also be done with the application of herbicides. Amongst the various herbicides, Basalin gave better result for mesta crop. Application of Basalin (Fluchloralin) @ 2 litres per hectare as pre-sowing (3days before sowing) will kill almost all the weeds except sedges. However, application of Basalin as above followed by one manual weeding will give good result.

3.8. Harvesting and post-harvest operations:

3.8.1. Harvesting:

Jute is a bast fibre crop and can be harvested at any stage after a certain period of vegetative growth, usually between 100 to 150 days. Harvesting of jute crop at pre-bud or bud stage gives best quality fibre; however, the yields are low and older crop yields more quantity of fibre but the fibre becomes coarse and the stem does not ret properly. Hence, as a compromise between quality and quantity, early pod formation stage has been found best for harvesting. Harvesting is done by cutting the plants at or close to the ground level with sharp sickles. In flooded lands, the plants are uprooted. The harvested plants are left in the field for 2-3 days for the leaves to shed. Next, the plants are tied into bundles 20-25cm of diameter and the branching tops are lipped off to rot in the field.

The best time of harvesting is small pod stage for *cannabinus* mesta which usually occurs in October while for *sabdariffa* mesta it is at 50 per cent flowering which occurs in November. If the plants are harvested earlier to this, fibre yield will be low and many of the fibre are immature and soft and may loss at the time of extraction If the harvesting is delayed or it is done at the maturity of the crop, the yield may be more but produces poor quality fibre which is brittle and less flexible as the cellulose reserves decline due to its utilization by developing fruits and seeds.

3.8.2. Retting:

Retting is one of the important operations governing the quality of fibre as prevailed at present. The bundles are kept in 30 cm deep water, and later placed side by side in retting water, usually in 23 layers and tied together. They are covered with water-hyacinth or any other weed that does not release tannin and iron. The float is then weighed down with seasoned logs or with concrete blocks or are kept emerged (at least 10 cm below the surface of water) with bamboo-crating. Clods of earth used as a covering material or as weighing agent produce dark fibre of low value. Retting is best done in slow moving large volume of clean water. The optimum temperature is around 34^{o}C. If fibre comes out easily from the wood on pressure from the thumb and fingers, retting is considered complete.

The traditional method of retting is commonly known as Steep method of retting as described above and the same method is being followed widely. Some of the other and improved methods have been developed or are in the stage of development like Ribbon Retting, Dry Retting, Use of Microbial Consortium in retting, etc but these methods are yet to be standardized and to make cost effective for adoption by the farmers.

3.8.3. Extraction of fibre:

Two methods of fibre extraction are practiced – single plant extraction method and beat-break-jerk method.

Single plant extraction method: In single plant extraction method, four or five reeds are taken out and stripping started from the bottom; the fibre of each of the reeds is slipped out free from the stick up to 8-10 cm, then gripped and pulled out slowly from the rest of the stick. Extracted strips of the bundles are washed in clean water.

Beat-break-jerk method: In beat-break-jerk method, a handful retted stems in left hand are gently beaten at the base with a mallet, then the woody core is broken and the extractor twist the bundles at the middle, grips the fibre where the bundle is broken and shakes the bundles vigorously to and fro in water. The broken sticks slip out and water wrung out of the fibre. The fibre is then washed in clean water, rung and eventually spread to dry, preferably in shade or mild sun. The beat-break-jerk method often leaves the broken sticks and make fibre somewhat entangled resulting in sticky fibre.

Single plant extraction method is better and recommended for extraction of fibre as it gives better quality fibre. On the other hand in beat-break-jerk method, the fibre become entangled and as a result the quality of fibre is affected.

3.8.4. Grading:

Grading of fibre is done based on six parameters namely, strength, defect, root content, colour, fineness and density. As per BIS specification there were eight grade classification of jute, i.e., W1/TD1 to W8/TD8 (W indicates white jute and TD indicates Tossa jute). Presently jute has been categorized into 5 gradesTDN_1 to TDN_5.

SUGARCANE

1. Introduction

Sugarcane is a most important cash crop of India. It involves less risk and farmers are assured up to some extent about return even in adverse condition. Sugarcane provides raw material for the second largest agro-based industry after textile. The sugar industry is an instrumental in generating the sizable employment in the rural sector directly and through its ancillary units. It is estimated that about 50 million farmers and their dependents are engaged in the cultivation of sugarcane and about 0.5 million skilled and unskilled workers are engaged in sugar factories and its allied industries. The sugar industry in India has been a focal point for socio-economic development in the rural areas by mobilizing rural resources, generating employment and enhancing farm income.

2. Major Sugarcane Growing States

Sugarcane is grown in various states in subtropical and tropical regions of the country. Main sugarcane growing States are:

a) **Sub Tropical**: Uttar Pradesh, Uttarakhand, Haryana, Punjab, Bihar with an annual rainfall of 180 to 2000 mm. The climate ranges from humid, moist sub-humid and dry sub-humid to cold arid, semiarid and arid.

b) **Tropical region**: Karnataka, Tamil Nadu, Maharashtra, Andhra Pradesh, Gujarat, Madhya Pradesh with an annual rainfall of 602 to 3640 mm having moist to dry sub-humid and semi-arid to dry semi-arid climates.

3. Temperature requirement for different growth stages of sugarcane

S.No	Critical Stages of sugarcane	Max. Temp. (ºC)	Min. Temp. (ºC)	Relative Humidity (%)
1	Germination	32.0	20.0	-
2	Tillering	35.0	18.0	-
3	Grand growth	30.0	14.0	80.85
4	Ripening	30.0	20.0	50-55

4. Soil: Heavy soils with good drainage are preferred for sugarcane cultivation, though it grows well on medium & light-textured soils also with assured irrigation. Soils with 0.5-0.6 % carbon content & pH 6.5 to 7.5 are most suitable for sugarcane growth. In northern India, it is cultivated largely on the loams & clay loams of Gangetic & other alluviums, and in peninsular India, it is grown on brown or reddish loams, laterites and black cotton soils.

5. Method of planting: Sugarcane can be planted as per the recommendation for the region i.e. Autumn Planting (15 Sept. to Oct.) and Spring Planting (Feb. to March). Improved method of planting should be adopted like, deep furrow, trench methods, ring pit method and paired row method instead of furrow system.

6. Seeding technologies

Seed rate: Seed rate in sugarcane varies from region to region. Generally higher seed rate are used in north western India (Punjab, Haryana and Rajasthan) because of the lower germination percent and also adverse climatic condition (very hot weather with desiccating winds) during tillering phase. A northern region seed rate generally varies from 40,000 to 60,000 three budded setts per hectares while in southern region it range between 25,000 to 40,000 three budded setts.

Row spacing: Effect of row spacing from 45 to 120 cm has been tried on growth, yield and quality of sugarcane. Optimum inter rows spacing range between 60-100 cm under different situation and location.

Depth: About 80% of the sugarcane roots go up to a depth 60 cm. Hence deep ploughing of sugarcane fields is necessary. Initially one or two deep ploughings with tractor drawn disc plough or mould board plough or animal drawn mould board plough have to be done at least to a depth of 30 cm. This has to be followed by ploughing with other light tillage implements.

7. Water management

In sugarcane, maintenance of optimum soil moisture during all stages of crop growth is one of the essential requisites for obtaining high yield. The crop should, therefore, be grown in areas of well-distributed rainfall or under assured and adequate irrigation. In tropical India, total water requirement of the crop for optimum growth varies from 2000 to 3000 mm inclusive of rainfall. The requirement of an adsali crop is

proportionately higher (3200 to 3500 mm). In sub-tropical India, the water requirement is 1400-1800 mm.

In tropical area, irrigations are to be given once in 7 days during germination phase (1 –35 days after planting), once in 10 days during tillering phase (36 – 100 days after planting), again once in 7 days during grand growth phase (101 – 270 days after planting) and once in 15 days during maturity phase (271 days after planting up to harvest) adjusting it to the rain fall pattern of the area. About 30 to 40 irrigations are needed. About 250 tonnes of water is needed to produce one tonne of sugarcane. Methods like alternate furrow irrigation, drip irrigation and trash mulching could be of use to economize irrigation water during water scarcity periods. Foliar spraying of a solution containing 2.5% urea and 2.5% muriate of potash 3 or 4 times at fortnightly intervals during drought periods would help to reduce the impact of drought on the crop. Critical stages are those during which sugarcane is affected severely due to water stress and the loss cannot be restituted by adequate water supply at later stages. These stages are: sprouting (germination), formative stage or tillering, ripening and initiation of sprouting in ratoons. In case of limited water availability, one may sustain sugarcane productivity by irrigating at critical stages of growth.

8. Fertilizer Requirement

The nitrogen requirement of sugarcane depends upon the soil & climate. It ranges from 150 kg/ha in Uttar Pradesh to 270 kg/ha in Tamil Nadu and 300 to 500 kg/ha in Maharashtra & Karnataka. Nitrogen is given in the form of urea applied one-third at planting & the remaining two-thirds in 2 equal splits at tillering & at the commencement of grand growth stage. The fertilizers may also be applied as basal dose through diammonium phosphate to supply full P & part of N.

The phosphorous is required at 40-60 kg of P_2O_5/ha. The response of sugarcane to potassium has been obtained only in localized pockets of light soils. Nowadays deficiency of sulphur is constantly increasing in Indian soils & it has become a limiting factor in sugarcane culture. In marginally deficient soils, the application of 40-60 kg S/ha has been found to be useful. 20-30 kg $ZnSo_4$/ha and FYM/Compost of 10 tonnes/ha may be applied.

9. Weed Management in Pure Crop of Sugarcane

i. Spray Atrazine 2 kg or Oxyflurofen 750 ml/ha mixed in 500 ltr. of water as pre emergence herbicide on the 3rd day of planting, using deflector or fan type nozzle.

ii. If pre-emergence spray is not carried out, go in for post-emergence spray of Grammaxone 2.5 litre + 2,4-D sodium salt 2.5 kg/ha in 500 litre of water on 21st day of planting.

iii. If the parasitic weed striga is a problem, post-emergence application of 2,4-D sodium salt @ 1.25 kg/ha in 500 litre of water/ha may be done. 2, 4-D spraying should be avoided when neighbouring crop is cotton or bhendi.

iv. Apply 20% urea also for the control of striga as direct spray.

v. Pre- plant application of glyphosate at 2.0 kg/ha along with 2% ammonium sulphate at 21 days before planting of sugarcane followed by post emergence direct spraying of glyphosate at 2.0 kg/ha along with 2% ammonium sulphate with a special hood on 30 DAP suppressed the nut sedges *(Cyperus rotundas*) and provided weed free environment.

vi. If herbicide is not applied work the junior-hoe along the ridges on 25, 55 and 85 days after planting for removal of weeds and proper stirring.

vii. Remove the weeds along the furrows with hand hoe. Otherwise operate power tiller fitted with tynes for intercultivation.

Weed management in Sugarcane intercropping system

Pre-emergence application of Thiobencarb @ 1.25 kg ai/ha under intercropping system in Sugarcane with Soybean, blackgram or groundnut gives effective weed control.

10. Products and by- products of Sugarcane

Sugarcane based Sugar industry is one of the largest and important industry in tropical and sub tropical countries of the world. The Sugarcane plant offers a huge potential, not only as the sucrose of a very important food but also as a source of energy and valuable commercial products from fermentation and chemical synthesis. Sugarcane processing is focused on the production of cane sugar from sugarcane. Sugarcane is considered as one of the best converters of solar energy into biomass and Sugar. Sugarcane is a rich source of food (Sucrose, jiggery and syrups), fiber (cellulose), fodder (green top, bagasse, molasses) fuel and chemicals (Bagasse molasses & alcohol). During the process of sugar production, the main by product of cane sugar industry are Bagasse, Molasses and Press mud. The other co-products and by products of less commercial value are Green leaves, green tops, trash, Boiler ash and effluents generated by sugar industry and distillery. There are many other industries which are based on sugarcane by diversification and utilization of co-products and by products of the sugar industry, instead of merely depending on production of sugar. Thus the effort should be for integral utilization of sugarcane, its co products and by products to produce many value added products, to derive maximum benefits from sugarcane crop.

Ethanol from Sugarcane

The major source of ethanol production in the country is via sugarcane-sugar-molasses route. This provides better economy by sale of sugar and molasses becomes the by-product of the sugar. A tonne of sugarcane produces 100 kg. sugar as well as 40 kg. molasses; the latter will produce about 10 litres of ethanol. On the other hand, one tonne sugarcane will produce 72-75 litres of ethanol. Likewise, a tonne of molasses produces about 220-250 litres of ethanol.

The 10% blending requires about 266.50 crore litres of Ethanol. If this Ethanol is produced directly from cane juice, around 5 lakh ha area under sugarcane is needed. In case (as the case today in the country) Ethanol is produced from molasses route, about 38 lakh ha sugarcane area is needed. Under molasses route, it will not affect sugar production as molasses is byproduct during production of sugar.

Cotton

Crop	Cotton *Gossypium arboreum& G.herbaceum* (Diploid species) *G.hirsutum & G.barbadense* (Tetraploid species) Family: Malvaceae
Seed Rate	Varieties: 10-20 kg/ha Hybrids: 2-3.5 kg/ha Bt Hybrids: 1.5 kg/ha
Spacing	Varieties: 60-90 x 15-30 cm Hybrids: 45-120 x 30-60 cm Bt Hybrids: 90-120 x 40-60 cm
Fertilizers	Northern Zone: 60-100 kg N/ha, P&K dose as per soil test. Central Zone: N : P : K 40 - 20 - 20, 50 - 25 - 25, 80 - 40 - 40 for varieties 100 - 50 - 50, 160 - 80 - 80, 240 - 120 - 120 for hybrids Southern Zone: N : P : K 40 - 20 - 20,60 - 30 - 30, 90 - 45 -45 for varieties 100 - 50 - 50, 120 - 60 - 60, 150 - 60 - 60 for hybrids
Water Requirement	700-1200 mm
Yield	480-520 kg lint/ha

Jute

Crop	Jute *Corchorus capsularis* (White Jute) *C. olitorius* (Tossa Jute) Family: Sparrmanniaceae		
Seed Rate	**Species** *C.capsularis* *C.olitorius*	**Broadcast** 10 kg/ha 7kg/ha	**Line Sowing** 7kg/ha 5kg/ha
Spacing	25-30 x 7-10 cm		
Fertilizers	*C.capsularis* : 60-80:30-40:30-40 N:P:K kg/ha *C.olitorius* : 40-80:20-40:20-40 N:P:K kg/ha		
Water Requirement	50 cm		
Yield	22-25 q/ha		

Sugarcane

Crop	Sugarcane (*Saccharum spp*) Family: Gramineae (Poaceae)
Seed Rate	35,000-40,000 setts (3-bud)/ha
Spacing	Optimum inter row spacing is 60-100 cm
Fertilizers	Nitrogen: 150-500 kg/ha Phosphorus: 40-60 kg/ha Sulphur: 40-60 kg/ha Zinc: 20-30 kg/ha FYM/Compost: 10 tonnes/ha
Water Requirement	Tropical India: 2000-3000 mm Sub-Tropical India: 1400-1800 mm Adsali Crop: 3200-3500 mm
Yield	Tropical States: 78.56 tonnes/ha Sub-Tropical States: 56.56 tonnes/ha