Agronomy – Rabi Crops

Sugarcane

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SUGARCANE

Botanical name: *Saccharum* spp.

Family: Poaceae (Gramineae)

Chromosome Number: 2n=80 (*officinarum*)

2n=82 (*barberi*)

2n=124 (s*inus*)

Sugarcane is the main source of sugar (75%) globally and holds a prominent position as a cash crop. Sugarcane is one of the main crops of earning foreign exchange.

Sugar juice is used for making white sugar, brown sugar (*khandsari*) and jaggery (*gur*). The main by-products of sugarcane industry are bagasse and molasses. Bagasse is mainly used as fuel. It is also used for production of compressed fibre board paper, plastic and furfural. Molasses is used in distilleries for the manufacture of ethyl alcohol, butyl alcohol, citric acid etc. Rum is the best potable spirit made from molasses. Molasses is also used as an additive to feeds for livestock. Pressmud is used as a manure in alkaline and saline soils. Green tops of cane are good source of fodder for cattle. Sugar industry in China is next in importance only to the textile industry and provides gainful employment to a large number of people.

Origin and History

Based on abundance of genetic diversity of germplasm of *Saccharum* and its relatives and also cytogenetical and morphologic potential in the north-east region of India bordering Burma and China is believed to be the place of origin of *Saccharum officinarum*. The contention of Indian origin of sugarcane is ruled out with the lack of intermediate wild clone, such as *S. robustum* in India by Daniels and Roach (1987). New Guinea and the adjoining Island chains of Indonesian Archipelago are the two major centres of diversity for *S. officinarum* and *S. robustum*.

S. robustum (2n = 60, 80) is believed to be the wild progenitor of *S. officinarum* (2n = 80). *S. robustum*, distributed naturally from New Hybrids through New Guinea and Indonesia to Mindanao (Philippines) was believed to have evolved through introgression of *S. spontaneum*, *Erianthus* and *Miscanthus*.

S. spontaneum (2n = 40 to 80) another wild species is distributed mainly in areas from Afghanistan (in west) to Malay Peninsula, Taiwan and South Pacific Island (In East). Based on cytological evidences, it is believed to have originated from introgression between *Erianthus* and *Sclenostachya*.

The cultivated *S. barberi* is believed to have evolved through selection of *S. spontaneum* or through hybridization of *S. officinarum* and *S. spontaneum* in Bengal-Bihar-Orissa region of India.

Tropical cane might have originated in some of the larger Islands of Oceania, most probably in New Guinea. Brandas (1956) also concluded that it was originated in New Guinea, where various forms of thick, tall, tropical canes have been cultivated from ancient times.

From India, it probably entered into China, Arabia and Egypt and after the crusades, it was introduced in Sicily, Portugal, the Canary Islands state into the new world.

Geographic Distribution

Sugarcane is cultivated between latitudes 35^{o}N and 35^{o}S. Brazil, India, China and Mexico are leading sugarcane producers of the world (Table 1).

Table 1. Area Production and Productivity of Sugarcane in important countries of the world (2004)

Continent/counties	Area (m ha)	Production (m tonnes)	Yield (t/ha)
Africa	1.44	84.50	58.72
Mauritius	0.70	5.20	73.75
South Africa	0.32	19.09	59.37
North Central America	2.43	149.01	61.21
Cuba	0.70	24.00	34.28
Mexico	0.64	48.37	75.58
USA	0.38	26.32	69.32
South America	6.88	512.38	74.48
Brazil	5.63	416.26	73.91
Asia			
India	4.00	236.18	59.04
China	1.39	90.98	65.35
Indonesia	0.35	26.75	77.53
Pakistan	1.07	53.42	49.71
Oceania	0.52	40.41	77.92
Australia	0.45	36.99	82.57
World	**20.40**	**1332.14**	**65.30**

Source: FAO Production Year Book, 2004.

Of the total cane production in the country, Uttar Pradesh alone contributes 50%. Tamil Nadu, Maharashtra, Andhra Pradesh, Gujarat and Karnataka are other leading producers of sugarcane (Table 2).

Table 2. Area, production and productivity of sugarcane in important states of India in 2004-05

State	Area (000 ha)	Cane production (000 t)	Cane productivity (t/ha)
Andhra Pradesh	210.0	15739.0	74.95
Assam	23.9	883.9	36.46
Bihar	104.2	4111.7	39.46
Chattisgarh	6.3	15.6	2.48
Gujarat	196.7	14570.0	74.07
Haryana	130.0	8060.0	62.00
Himachal Pradesh	2.9	61.9	21.34
Jammu & Kashmir	0.1	0.5	5.00
Jharkhand	3.9	141.6	36.31
Karnataka	178.0	14276.0	80.20
Kerala	3.0	283.0	94.33
Madhya Pradesh	52.5	2148.0	40.91
Maharashtra	324.0	20475.0	63.19
Orissa	15.4	859.9	55.84
Punjab	86.0	5170.0	60.12
Rajasthan	5.7	276.6	48.53
Tamil Nadu	232.0	23396.0	100.84
Uttarakhand	107.0	6441.0	60.20
Uttar Pradesh	1954.7	118715.6	60.73
West Bengal	15.6	1033.2	66.23
India	**3661.5**	**237088.4**	**64.75**

Source: Fertilizer Association of India, 2006.

Classification

According to recent classification, many plants originally under *Saccharum* genus have been changed to separate allied genera viz. *Erianthus, Sclerostachya* and *Nareaga*. Thus *Saccharum* now consists of 5 species viz. *S. officinarum, S. barberi, S. sinense, S. sponteneum* Linn. and *S. robustum* Brand and Jesw.

Sugarcane and allied genera

(a) *Saccharum with* spp. *officinarum, spontaneum, barberi, sinense* and *robustum*

(b) *Erianthus* with spp. *vavennae, mungo,* and *arudianceum*

(c) *Nareaga* with spp. *prophy* and *recoma*

(d) *Sclerostachya* with spp. *nitroye* and *ridlelic*

Generally, *Erianthus, Nareaga* and *Sclerostachya* generas are closer to each other. *Saccharum barberi* species has been put into four groups viz., *Mungo, Saretha, Sunnabile* and Nargori. The thin canes of north India viz. "*Katha*" and "*Saretha*" and thicker canes i.e., *Mungo, Nargori and Sunnabile* are placed in *S. barberi*, while *Panashi* falls in *S. sinense*. According to Dr. Barber, the *Saccharum* in India falls in three groups viz. *S. officinarum, S. spontaneum* and *S. sinense*.

Cultivated sugarcane is classified into the following three species:

***Saccharum officinarum* Linn.** : These are noble canes known as 'Ponda' in north India and grown for chewing purposes. These canes are thin and juicy. This species includes the Tropical canes indigenous to New Guinea. They have higher percentage of sucrose than *Deshi* (local) varieties. These are resistant to smut, but are susceptible to red-rod and mosaic diseases. The cultivation of this species is limited to tropical areas. Recently, these canes have been succeeded by hybridization among *officinarum* and *spontaneum* and other species in sub-tropical regions of India. These cases have very low percentage of fibre, and are more preferred for chewing. These are less suitable for factories where bagasse (fibre after extraction from cane) is used for fuel purpose.

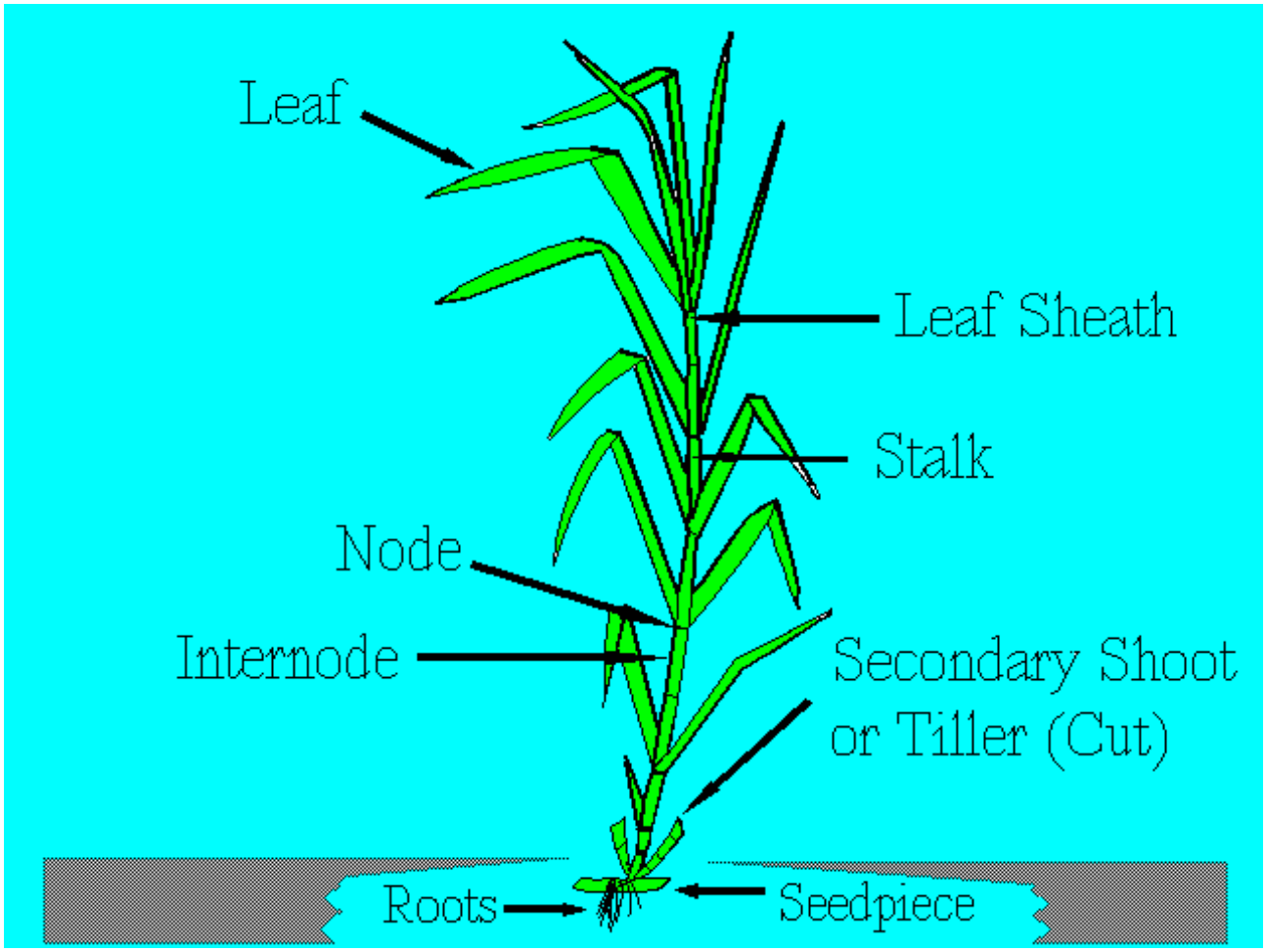
***Saccharum sinense* (Roxb) Jesw:** This species of cultivated sugarcane is indigenous to north-eastern India. This species is characterized by long and thin stalks, early maturity, broad leaves and low to maximum sucrose content. Internodes of these canes are long and more or less zig-zag and nodes are prominent. This species includes *pansoli, nargori* and *mungo* groups of sugarcane.

***Saccharum barberi* Jews.**: This species is also indigenous to north-eastern India. it is characterized by short and thin stalks, narrow leaves, low to medium sucrose content and very early maturity. This species includes *saretha* and *sunnabile* groups of sugarcane.

Botanical Description

Sugarcane is a tall perennial plant growing erect even up to 6-7 m. A detailed description of the plant parts are given below:

Root system: The sugarcane roots are fibrous and consist of 2 types of roots. The '*sett roots*' are those which develop from dormant roots of the root zone and mostly temporary. The '*shoot roots'* are produced from the base of shoot after the buds sprout and the sett roots vanish after the shoot roots have developed. Later this process occurs progressively in upper rings of the nodes near the soil surface. Those formed first go downwards, whereas those formed near the soil surface grow in the upper layer of soil providing anchorage for the plant. These roots produced from shoot are known as '*shoot root*'. These are permanent roots and are thick, fleshy and white in colour. New roots are continually produced from tillers.



Source: http://edis.ifas.ufl.edu/TOPIC_BOOK_Sugarcane_Handbook

Stalk: Sugarcane stalk above ground portion of the plant is roughly cylindrical and composed of many distinct nodes, internodes, bearing leaves and flowers. A small portion of the stalk is below ground, which is known as root stock. At each node there is a bud, sometimes called as an eye appearing on opposite sides of the cane. These buds are protected by leaf sheath, which is folded tightly around the internode. Just below the bud is a raised portion known as leaf sear, a point of attachment of the leaf sheath to the stalk. Internodes of most cultivars are coated with waxy material. Sugarcane produces branches that grow below the surface of the soil. The underground portion of the stem tapers rapidly and from the lateral buds of this region, the shoots develops. These are known as '*tillers*'. Single cane may produce as many as 20-40 tillers depending upon cultivar and environmental conditions.

Source: http://en.wikipedia.org/wiki/Sugarcane

Leaves: The sugarcane leaves, like those of grasses, are made up of the leaf blade (lamina) and the leaf sheath. The leaf sheath possesses certain characters as mark to identify different cane varieties such as (i) spines or hair on the back of sheath (present in some varieties), (ii) the ligule – a lateral extensions of the sheath, generally pointing upwards and develops at the juncture of sheath and lamina; and (iii) the auricle. The lamina is usually 5-8 cm wide and 1.0-1.2 m long. The mid-rib is usually whitish, but may be reddish or purplish in some cultivars.

Inflorescence: The inflorescence of sugarcane, generally known as the arrow, is an open panicle. It is long (30 cm or more) and tapering. The arrangement of the spikelets is acemose, that is, the oldest flowers are at the bottom and the youngest at the top). The flowers open in succession over a number of days. Flowers have both male and female organs but not all produce fertile pollen. Some of the cultivars have fertile pollens, but they are usually small and of low vitality. Sugarcane usually flowers at the age of 10-12 months, but some cultivars in north India do not flower at all. Due to this fact, cane has long been propagated vegetatively by cuttings of sugarcane. Cane produce from seed is not so vigorous, but it is important input for sugarcane breeders.

Climatic Requirements

Sugarcane is a tropical plant. It grows well in those regions, where the climate is more or less tropical. It can also grow in sub-tropics as in north India. Under warm humid conditions, it can continue its growth unless terminated by flowering. A mean temperature of 28-32^{o}C is best suited for the growth of sugarcane. Lower temperature reduces tillering. Temperature above 50^{o}C arrests its growth, whereas temperatures below 20^{o}C may slow down the growth. The areas with a minimum temperature <5^{o}C are not suitable for sugarcane cultivation.

The crop does well in tropical regions receiving an annual rainfall of 75-120 cm. Sugarcane requires a long growing season of 10-12 months. The ideal climate for sugarcane is in the southern parts of the country, such as Maharashtra, parts of Karnataka, Telangana area of Andhra Pradesh and Tamil Nadu. A relative humidity of 70-85% during growth and 55-75% during ripening phase is ideal. Relative humidity < 50% during growing season is not suitable for sugarcane cultivation.

Soil and its preparation

Sugarcane is though grown from sandy to loam and heavy soils in different parts of India, but moderately heavy loams with high water retention and good drainage, and containing high organic matter and plant nutrients content are the best. It can tolerate moderate acidity and alkalinity, but soils with slight acidity or having pH of 6.0-8.0 is preferred for optimum crop production. The soil should be deep (>100 cm). Waterlogging at early stages of crop may damage the crop. The deficiency of Ca and P may retard the growth and development of crop. Thus soils rich in Ca and P are good for better juice quality, lodging resistance. Soils rich in Fe are good for higher sugar recovery, whereas soils rich in P, Ca, N, K and organic matter are the best in all respects.

In northern India, it is grown largely on well-drained loams and clay loams of the Gangetic alluviums, whereas in Peninsular India, it is raised on brown or reddish loams, laterites and black cotton soils.

In recent times, minimum tillage is preferred as there is less turn around period between two successive crops. One deep ploughing by mould board plough followed by 2-3 shallow harrowings and cross planking are adequate to keep down the weeds, to incorporate and help in decomposing organic matter into the soil, to provide better aeration, to preserve moisture etc. The heavy soils may require more number of ploughing.

Seed and Sowing

Seed treatment

Since sugarcane is vegetatively propagated, it is prone to attack by insect-pests and diseases resulting in poor germination. It has been observed that even under satisfactory condition hardly 40-45% buds germinate. The poor germination is mainly due to the following reasons:

- More than 90% of the area under cane is planted during March to April. The atmospheric humidity during this time is very low, which results into fast drying of soil and setts, adversely affecting the germination.
- High rate of mortality due to prevailing soil and atmospheric drought associated with desiccating winds.
- Sowing of undesirable canes (flood, frost or drought affected canes).
- Widespread attack by insect pests and diseases due to sowing of untreated seeds.
- Poor conversion of fructose into glucose in cane setts due to shortage of moisture may reduce the sprouting of buds.
- Competition between the buds of the sett due to apical dominance.

The seed treatment may be classified into the following:

Seed treatment against insect-pests damage

To save the setts from the attack of termites and ants, any one of the following practices may be adopted.

- **Dipping of the whole sett**: In this case, neem cake slurry is prepared by taking 1 kg neem cake in 5 litres of water and the setts are dipped for a period of 18-24 hours. If neem cake is not available, an aldrin solution of 0.2-0.3% concentration is prepared in water and setts are soaked for 18-24 hours.
- **Treating the cut ends only**: The cut ends are treated with coaltar, Lindane solution, burnt crude oil mixed with aldrin etc. and setts are planted immediately.

Seed treatment against attack of diseases

In order to reduce the incidence of soil-borne diseases, setts must be treated with fungicides. The most commonly used fungicides are areton and agallol which are used @ 200 g/50 litres of water. The setts are first given heat treatment (50^{o}C for 20 minutes) and then treated with fungicide. The other fungicides are avinol, activine and tafasen (0.5% solution in water).

Seed treatment for higher germination

- **Soaking in water**: Soaking of canes in cold water for a period of 12-18 hours may improve germination by 12-20%. Soaking of whole cane has been found to be more beneficial than soaking the setts.
- **Hot water treatment**: The main objective of this treatment is to convert fructose into glucose, because glucose is essential for germination. The secondary object of this treatment is to control the chlorotic streak disease of the canes. The bottom and middle setts are soaked in hot water at 50^{o}C for 30 minutes and 20 minutes respectively, and the top setts are soaked at 52^{o}C for 5-7 minutes.
- **Mud or dung treatment**: Storing the canes in mud or cow dung for 12-24 hours reduces the water loss during cutting, planting and even later, which helps in higher germination. If the setts are to be stored after cutting for a few days, then covering the setts with fresh cow dung delays germination, but the buds remain viable.
- **Chemical treatment**: Sett treatment with 10% solution of $KMnO_4$, $MgSO_4$ or potassium ferrocyanide or 0.1-0.5% solution of ammonium sulphate for 12 to 24 hours gives better results, but the highest germination is obtained from fresh water treatment.
- Use of chlorohydrin and acetylene lowers the auxin, breaks the dormancy of the bud, and accelerates the bud sproutings. Soaking in cold saturated lime solution for 8-12 hours with or without 450g $MgSO_4$ in 125 litres of water gives more germination and thus enhances cane yield by about 25%.
- Aretan along with gamma HCH (Benzene) is also recommended in northern India. Aretan (6%) improves germination by keeping off fungal attack, while gamma HCH keeps away the termites and shoot borers.

Time of planting

Sugarcane requires about 25-32^{o}C temperature for germination. This temperature requirement is met twice in north Indian conditions, i.e., in October and February-March. Autumn planting of sugarcane is done in October. For higher yields, planting should be completed up to 20 October. Delay in planting may cause reduction in yield as germination of sugarcane is reduced due to low temperatures in late planting.

Spring cane is planted in February-March. March is the best time for cane planting in Punjab and Haryana, February-March in Uttar Pradesh and January-February in Bihar. The planting time is advanced as we move towards east. In Tamil Nadu, Andhra Pradesh, Maharashtra and Karnataka, cane planting is done in December-February.

Adsali planting is done during July-August in south and crop takes about 15-18 months for harvesting. *Eksali* planting is common in south India. The crop is planted during January-February and harvested after one year.

Method of sowing

1. **Planting in flat beds**: This is the simplest and cheapest of all the methods of planting. This method is usually adopted in low rainfall areas of India. In this method shallow

furrows (8-10 cm) are opened with a country plough or cultivator at a distance of 75-90 cm. The setts are planted end-to-end taking care that on 3-budded sett falls in each running 30 cm length of furrow. After sowing, the furrows are covered with 5-7 cm soil and the field is levelled by heavy planking. In most parts of northern India and some parts of Maharashtra, cane is planted by this method. It is essential that there should be adequate moisture in the field at the time of planting. After germination, 2-5 intercultures may be given at a proper interval to control the weeds and facilitate the tillering.

2. **Ridge and furrow method**: This method is usually adopted in areas of moderate rainfall, but have drainage problems. In this method, the furrows are made in 'V' shape about 90 cm apart and 20-25 cm deep. The setts are placed in horizontal position, usually with end-to-end system. If the seed stalk is not healthy and internodes are longer, eye-to-eye system of planting may be adopted. As soon as the canes start growing, the furrows are partly filled with soil and inter-row cultivation is carried out. This repeated row cultivation of cane results in levelling of the land by end of May or mid of June, which is known as first earthing. Further repetition of inter-row cultivation transforms the furrow into ridges by putting soil around the plants and inter-row space becomes furrow automatically, through which irrigation or drainage is provided for the growth and development of crop. The transformation of furrow into ridges is known as second earthing.

3. **Trench or Java method**: This method is usually adopted in coastal areas as well as other areas, where the crop grows very tall and the strong winds during rainy season cause lodging of cane. This method is commonly used in Java, hence known as Java method.

   In this method, trenches are dug at a distance of 75-90 cm, with the help of ridger or by manual labour. The trenches should be about 20-25 cm deep. The mixture of fertilizers (NPK) should be spread uniformly in the trenches and mixed thoroughly in the soil. The setts are planted end to end in trenches. Drench the setts with chlorpyriphos @ 0.05% to protect from the soil borne insects. The trenches are filled up with loose soil after planting.

   The cane planter developed by Indian Institute of Sugarcane Research (IISR), Lucknow (U.P.) can also be used for combining the operations of opening the furrows, placement of fertilizers and then planting setts in the rows.

4. **Rayungan method**: In this method, the seed stalks are decapitated (topped off) about 4-6 weeks before the planting time. As a consequence, lateral shoots arise into tailed Rayungan. These shoots are cut off and planted in the trenches. The removals of upper rayungans, made the lower buds sprout, which are similarly used. This method has been evolved by the IISR, Lucknow.

   The trenches are made 90 cm apart with 30 cm depth. The soil is put in the inter-row spaces at the time of detopping the standing crop. The bottom of the trenches stirred up to next 15 cm depth and fertilizers are mixed in the soil. The trenches are irrigated and the soil of the trench is mixed at 2-3 times before planting the setts (in vertical position 40-50 cm apart) and branched rayungans are cut off and placed vertically into these trenches. At least 2-3 nodes must be underground to promote effective rooting system. This method may provide 3 times higher yield than the methods mentioned above.

5. **Distance planting method**: In this method, the top setts are collected from the healthy crop and put in nursery after they have sprouted and rooted out. They are transplanted in the field at a spacing of 90 cm x 50 cm.
6. **Other methods of sugarcane planting**
    a. **Algin method**: In this method, the upper most nodes are collected while stripping the canes for crushing or for sending to the sugar factory. They are then planted in the wheat field in rows after every 4 rows of wheat at 90 cm row to row and 45 cm plant-to-plant spacing. The planting of the node under the soil is followed by irrigation. The sugarcane sprouts are taken due care along with wheat and after the wheat is harvested the sugarcane is fertilized and may be intercropped with urdbean or mungbean during summer.
    b. **Bud transplanting**: In this method, sugarcane buds with half of its stalk can be planted in small polythene are filled with leaf mould and soil. These are transplanted in the field after sprouting along with polythene bag (opened at bottom).
    c. **Sablaxg or spouting method**: In this method, plants are raised in fertile soil with adequate fertilization, wide spacing, shallow planting and frequent irrigations. One the tillers develop their own roots; these are separated from the mother plant and planted separately. After this mother plant continues tillering, and new tillers are also separated similarly and planted. This method is successfully followed in Java and Cuba.
    d. **Tjeblock method**: In this method, the stalk is cut off at its half-length and planted vertically with one node under the soil for rooting. The planted ones and the mother stalks are adequately fertilized and irrigated. Now the upper buds of both Tjeblocks and mother cane, which sprouts in due course of time are planted by cutting them into setts as rayungans. It is an improvement over the rayungan method, because it takes care of proper availability of energy and nutrients to all the buds.
    e. **Ridge type, pair-row-cum conventional cutter planter**: A ridger type, pair-row-cum conventional cutter planter was developed for planting sugarcane. All operations from cut of whole cane into setts to its covering with a blanket of soil and light trampling of soil cover and applying fertilizer, insecticide and fungicide are accomplished in a single pass of the equipment. It has an output of 0.25 ha/hour employing only 4 persons.

The seed rate varies with buds/setts and row spacing from 30,000 (In *adsali* crop planted with 3 budded setts) to a maximum of 1, 00,000/ha (north-western India with 2 budded setts). The seed rate of sugarcane used in different zones of India is given below:

State/Zone	Number of Setts/ha	No. of buds/sett
Haryana, Punjab, western Uttar Pradesh	88,000-1,00,000	2
Karnataka, Madhya Pradesh	25,000-30,000	3
Andhra Pradesh, Bihar, Gujarat, Maharashtra, Uttar Pradesh, Tamil Nadu	37,000-45,000	3
Rajasthan	40,000-45,000	3

Varieties

The *S. barberi* and *S. sinense* indigenous varieties were grown in the country initially. Hybrid sugarcanes replaced gradually these indigenous varieties since early twentieth century and at present all the varieties are hybrids only. The important sugarcane varieties recommended for different states are given below.

Sugarcane varieties recommended for different states of India

State	**Early ripening**	**Medium and late ripening**
Andhra Pradesh	Co 527, Co 997, Co 8013, Co 7805, CoA 8401, Co 7704, Co 7701, Co 997	Co 419, Co 449, Co 467, Co 853, Co 975, Co 6217, Co 62175, Co 7119, CoA 645, Co 7219, CoA 8402, CoA 7602, Co 6304, Co 6707, Co 453, Co 421, Co 86032, Co 87268, Pant 90223
Assam	Co 313, Co 997, Co 1108, Co 740, Bo 91, Bo 99, Bo 102, Bo 120	Co 419, Co 421, Co 449, Co 740, P.O.J. 2714, Co 8315, CoJor 1, CoJor 2, Co 1132, Co 961, Co 453, Co 6304, Co 877263
Bihar Water logged conditions	Co 313, Bo 10, Bo 34, Bo 43, Bo 47, Bo 19	Co 419, Co 617, Bo 15, Bo 17, Bo 19, Bo 29, Bo 32, Bo 50, Bo 51, Bo 65, B 104 Co 5767, Bo 109, Bo 87, CoS 918, CoS 8432, Bo 91, Bo 106, Bo 108, COLK 8504, Co 421 Co 453, Bo 120, Co 89029 Bo 109, CoS 767, Bo 91, Bo 110
Gujarat	Co 775, Co 995, CoS 671, Co 791	Co 419, Co 740, Co 7527, Co 8014, Co 62175, Co 8338, Co 453, Co 421, Co 6304, Co 87263
Haryana	CoL 9, CoJ 58, Co 6914, Co 7717, CoJ 64, Co 1185, CoH 56, Co 89029	Co 975, Co 114G, Co 1158, CoJ 46, CoS 767. CoS 7432, CoS 918, CoH 108, CoLK 8501, CoLK 8504, Co 7314, Co 7717, CoS 510, Co 453, CoS 8118, CoS 8119, CoS 8099. CoS 9529, CoS 9530, CoH 92201, CoS 91230
Karnataka	IC 225, Co 6415, Co 7704, Co 770, KHS 3296, Co 449	Co 419, Co 449, HM 320, IC 26, Co 8014, Co 8021, Co 62175, B 37172, Co 7318, KHS 2045, Co 740
Kerala	Co 658, Co 997	Co 419, Co 449, Co 740, Co 785, Co 853, Co 617, Co 61175, CoS 8432, CoS 918, CoLK 8001, Co 8707, Co 8304, Co 1307, CoS 510, Co 7318, CoLK 8501, CoLK 8504, CoLK 7901, CoLK 7810
Madhya Pradesh	Co 527, Co 954, Co 1101, Co 1169, Co 1307, Co 1305, Co 7314, Co 419, Co 775, Co 527, CoS 245	Co 617, Co 678, Co 683, Co 779, Co 853, Co 6304, Co 62175
Chattisgarh	Co 1169, CoS 245, CoS 321	Co 1317, Co 6304, Co 62175, Co 421, Co 453, Pant 90223

State	Early ripening	Medium and late ripening
Maharashtra	Co 775, Co 7219, CoS 671, Co 8909, Co 89004, Co 89013, Co 62175	Co 419, Co 838, Co 983, Co 1158, Co 6304, CoS 510, Co 7517, Co 8014, CoN 7125, Co 740, Co 1340, Co 791, CoM 8821, CoS 767
Nagaland	Co 740, Co 997	Co 419, Co 838, Co 961, Co 983, Co 1158, Co 6304, CoS 510, Co 1132, Co 8315, CoS 767
Orissa Waterlogged conditions	Co 527, Co 881, Co 997, Co 7508, Co 7704, Co 8401	**Co 419, Co 421, Co 872, Co 897, Co 1053, Co 7219, CoJ 8201, Co 75, Co 7706, Co 8402, Co 62175** Co 62175, Co 419, Co 6304
Pondicherry	Co 527, Co 658, Co 449, Co 740	**Co 419, Co 421, Co 785, Co 853, Co 872, Co 897, Co 1108, Co 1132, Co 62175, Co 6304, Co 6415, CoC 8201, Co 62198, Co 8201, Co 421, Co 453**
Punjab	Co 313, S 449-64, CoL 129, CoJ 58, CoJ 64, CoL29	**Co 975, Co 1148, Co 1158, Co 62399, CoL 9, CoJ 39, CoJ 46, S 480-64, CoJ 67, CoJ 81, CoS 8432, CoS 918, CoS 767, Pant 90223**
Rajasthan	Co 527, Co 997, CoL 29, Co 6617, Co 6314, Co 419, Co 1253	**Co 312, Co 419, Co 421, Co 449, Co 1111, Co 1253, Co 1307, CoS 245, Co 1107, Bo 17, Co 6304, CoS 510, Co 449, Co 858, Co 421, Co 997, Bo 17**
Tamil Nadu	Co 526, Co 658, CoC 671, CoC 771, CoC 772, CoC 773, CoC 8001, CoC 8561, Co 7704	**Co 419, Co 449, Co 740, Co 853, Co 6304, Co 8021, Co 62198, CoC 8201, CoC 779, Co 6304, CoC 775, CoSi 86071, CoBin 9605, Co 453, Co 421, Co 86249, CoM 88121**
Uttar Pradesh	Co 313, Co 395, Co 527, Co 859, Co 1236, CoS 416, CoS 570, CoS 541, Bo 10, Bo 47	**Co 393, Co 356, Co 846, Co 975, Co 1007, Co 1148, Co 1158, Co 1157, Co 1347, Co 6425, Co 6613, Co 6811, Co 6812, CoS 109, CoS 568, CoS 575, CoS 611, CoS 659, Bo 3, Bo 17, Bo 32, Bo 32, Bo 34, Bo. 54, Bo 70, Pant 90223, Bo 91, Co 453, Co 421, Co 86032, Co 87268**
West Bengasl	Co 313, Co 527, Co 622, Co 997, Co 62010, Bo 11, CoJ 64, Co 7218, Co 897, Co 7508, Co 7704, Co 8401, Co 62175	**Co 419, Co 1008, Co 1132, Bo 17, Co 7224, Co 961, Co 6391, Co 6315, Co 453, Co 421, Co 9605, Co 86249, Co 92423**

Manures and Fertilizers

The manure and fertilizer requirement of the sugarcane crop depends on the climatic conditions, rainfall, drainage, length of growing cycle and sink capacity of the variety.

Sugarcane, being a very long duration crop, needs plenty of organic manure for a long-term and continuous supply of plant nutrients. Therefore, FYM or compost or leaf mould @ 50-60 tonnes/ha along with 0.3-0.4 tonnes/ha of powdered neem cake should be applied at least 15-20 days before planting of the cane setts.

A crop producing 80 tonnes of cane/ha removes from the soil approximately 90-110 kg N, 180-300 kg P_2O_5, 60-80 kg K_2O and 80-90 kg calcium. Adequate and timely application of fertilizers is most essential for getting higher yield. In northern India, the N requirement of sugarcane is about 120-150 kg N/ha, whereas in southern India, it is 250-300 kg/ha. If soil test values are not available, apply 80 kg P_2O_5 and 60 kg K_2O/ha in north India and 100 kg P_2O_5/ha in southern parts of the country. The recommended fertilizer doses in different parts of India are given below.

Recommended dose of fertilizers in different states of India

State	**Fertilizer dose (kg/ha)**		
	N	**P**	**K**
Seru (Maharashtra)	250	115	115
Pre-seasonal (Maharashtra)	350	170	170
Adsali (Maharashtra)	400	170	170
Coastal districts (Andhra Pradesh)	122-224	0	0
Telangana region (Andhra Pradesh)	112-400	112	0
Coastal belt (Tamil Nadu)	110	0	0
Lift irrigation belt (Tamil Nadu)	90	0	45
Jaggery areas (Tamil Nadu)	70	0	45
Mandya (Karnataka)	247	99	124
Belgaum(Karnataka)	247	74	186
Tungbhadra project area (Karnataka)	247	74	74
Heavy rainfall area (Karnataka)	185	124	124
Orissa	200	100	60
Gujarat	250	125	125
Pandalam and Thiruvella area (Kerala)	165	165	82
Chittur area (Kerala)	225	75	75
Newly cleared forest area (Kerala)	15	75	90
West Bengal	160	60	60

State	Fertilizer dose (kg/ha)		
	N	P	K
Uttar Pradesh	150	45	0
Assam	135	70	60
North Bihar	120	85	30
South Bihar	140	70	30
Kota and Udaipur (Rajasthan)	150	50	On soil-test basis
Sriganganagar (Rajasthan)	100	50	On soil-test basis
Madhya Pradesh	120	34	24

The cane growth and development has also been found to be affected by B, Cu, Fe, S, Mg, Mn, Mo and Zn. Most of these are needed in small amounts, but necessary in case of their deficiency in soil. The calcareous soils require Zn and S for better growth and development of canes. An application of 20-30 kg $ZnSO_4$ and 10 kg S/ha (as basal application) should be applied for achieving higher yield of canes.

An integrated nutrient supply system for sugarcane consisting of organics to supply 25% of the recommended dose of N, chemical fertilizers to supply 50% of the recommended dose of NPK, *Azospirillum* and phosphobacteria each at 10 kg/ha in 2 equal split doses at 30 and 60 days after planting (DAP) and *dhaincha* as an intercrop on the top of the ridges and its *in situ* incorporation 45 DAP has been developed.

Water management

Number of irrigation in sugarcane depends upon the climatic condition, type of soil, method of sowing and manure and fertilizers. The hot weather associated with dry winds and drought increases the water requirement of the crop. The crop sown in trenches needs relatively less water. Sandy soils and the crop with more of fertilizers may need more water. On an average, one tonne cane needs about 60-70 tonnes of water. Thin varieties of cane need about 150 cm water, whereas thick canes require 200 cm water. *Adsali* planted canes require 200 cm in addition to 75 cm rainfall. The crop should be irrigated at 50% of available soil moisture.

First irrigation is applied at 20-25% germination or about 20 days after sowing. The irrigations are given at 10-15 days interval during summer, and 25-30 days interval during winter. In case of drought during rainy season, the crop should be irrigated as and when required. The crop needs maximum water at tillering stage and during elongation or grand growth phase. Thus sugarcane needs about 10-12 irrigations in western parts of Uttar Pradesh, 6-8 in eastern Uttar Pradesh, and 4-6 irrigations in *tarai* areas.

Drainage is also equally important in waterlogged areas. Waterlogged conditions may deteriorate the quality of cane. Drainage greatly helps not only in higher yields, but also sucrose content of the cane.

Furrow method of irrigation is mot commonly used in the country. In areas of water scarcity, sprinkler or drip irrigation is preferred.

Weed control

Most common weeds of sugarcane in India are *Sorghum halepense, Cynodon dactylon, Cyperus rotundus, Commelina benghalensis, Digera arvensis, Eleusine indica, Euphorbia hirta, Digitaria sanguinallis, Phyllanthus niruri, Saccharum spontaneum, Trianthema, Monogyna* etc.

The most critical period of weed competition in sugarcane is up to 3 months after sowing. If weeds are not controlled from very beginning, the reduction in yield may be as high as 70%.

Weed control in sugarcane is accomplished by adopting mechanical or chemical methods. Mechanical methods include cultural practices like hot weather ploughing, hoeing and weeding, mulching, cropping system etc. These methods are, however, time consuming and expensive, and also become difficult due to non-availability of labour and unfavourable climatic conditions. Mechanical methods can be practiced effectively during the pre-monsoon period, but their use during monsoon period, but their use during monsoon period is generally not effective.

Chemical control offers a good substitute of mechanical measures. Pre-palnt incorporation of fluchloralin @ 1.0-1.5 kg/ha or Atrazine or simazine, ametryne, prometryne, diuron, alachlor, tafazine, metribuzine @ 2 kg/ha at 3-8 days after planting take care of weeds in sugarcane effectively. 2,4-D application @ 1.0-1.5 kg/ha at 5-10 days after planting was effective in broadleaved weeds management. For control of perennial weeds, dalopon @ 3 kg/ha ia recommended.

Cropping Systems

In north India, sugarcane is generally grown after harvest of cotton, maize, sorghum, paddy, *toria*, potato, pea, wheat etc. The common rotations followed in north India are:

Cotton-sugarcane-wheat	Maize-sugarcane-wheat
Cotton-sugarcane-ratoon	Sorghum (fodder)-potato-sugarcane-wheat
Maize-potato-sugarcane	Paddy-*toria*-sugarcane-ratoon-wheat
Paddy-gram-sugarcane-ratoon-wheat	Maize-wheat-sugarcane-ratoon-wheat

In southern India, sugarcane is usually rotated with rice. The common rotations of southern India are:

Paddy-groundnut-sorghum-*rabi* sugarcane	Paddy-sugarcane-ratoon-wheat
Cotton-sugarcane-*rabi* sorghum	Sugarcane-ratoon-*kharif* paddy-winter paddy
Cotton-sugarcane-gram	Cotton-sugarcane-ratoon-wheat

Innovative overlapping cropping system

In this system, 3 rows of wheat in November are grown on raised beds, and sugarcane is planted in 80 cm apart furrows in February in the furrow irrigated raised beds (FIRB) system. Sugarcane gives about 30% higher cane yield as compared to wheat-sugarcane sequential system, without reduction in wheat yield. In this system, irrigation is applied only in furrows, requiring less volume of water, which work out to be a 20% water saving.

Hoeing and earthing

Hoeing and earthing are two main operations in sugarcane cultivation. Hoeing is done with the help of *Savel* or cultivators. It starts just after one week of sowing (blind hoeing), the second about 3 weeks after sowing, and subsequent hoeings after every irrigation. Blind hoeings helps in breaking the hard crust at surface, which might create problems to the sprouting seedlings. Besides covering the exposed setts, it also helps in uprooting the weeds, and replacing the damaged setts by diseases or insects.The crop requires about 4-6 hoeings. The hoeings are necessary for better aeration, moisture conservation and control of weeds.

Earthing is also required in sugarcane cultivation. It is done to facilitate irrigation and economise water, to drain out the excess water from the field, to control weed infestation and to protect the crop from lodging.

Tying, Wrapping and protection of sugarcane

These operations are most essential in sugarcane cultivation just to provide mechanical support to the grown up plants to prevent lodging. The leaves are removed from the plants and wrapped together by taking all canes in one bundle. By wrapping the distribution of CO_2 becomes easy and proper to all plants through out the field. After wrapping the clumps in adjacent rows are tied together (cross-wise). Tying should be done in August, when cane reaches about 2 m height. Green leaves should not be tied up together while tying up the crop.

Harvesting

The sugarcane crop matures within 10-12 months in north India and 18-20 months in south India. The crop should be harvested when brix value reaches to 12-18 or when glucose content is less than 0.5% (tested by Fehlings solution. Usually this stage arrives during December-January, when atmospheric temperature is about or below 20^oC. Under high temperature conditions, the sucrose gets converted into glucose resulting in poor quality of produce. The yellowing of leaves, emergence of arrows, cane become brittle & brakes easily, cane produce metallic sound, and swelling out of buds from nodes are the other indicators of crop maturity.

Yield

In north India, a good crop yields about 60-100 tonnes/ha but in south India (*adsali* crop) it may yield about 80-130 tonnes/ha. The economic constituents are:

(i) Juice percentage in ordinary crusher	50-60%
by power crusher	60-70%
by vacuum crusher	70-75%
(ii) Products from juice	18-21% (11% of sugarcane juice)
Jaggery	9-10% (maximum 15-18%) in juice
Sugar	6-10% in juice
(iii) Sucrose content in cane	13-24%
(iv) Molasses	3.5%

Tips to Ratoon Management

Ratoon is a crop which is allowed to grow in the same field from the roots of the previous crop.

Merits and demerits of ratooning in sugarcane

Merits	Demerits
Cost of seed bed, cost of seed and sowing is saved.	The ratoon crop is invariably attacked by insects, pests and diseases.
The ratoon crop utilizes the residual fertility of the previous crop.	The soil becomes poor in fertility when ratooning is taken for more than 2 years.
The ratoon crop matures earlier and helps in running sugar mills earlier. Thus the field is vacated earlier for the next crop.	
The quality of the produce is superior to planted canes.	
The yield is similar or more than planted crop.	
Total cost of cultivation is less as compared to planted one.	

Ratooning ability is a genotypic character. In India Co 1148, Co 419, Co 740 and Co M8814 are best vasrieties for ratooning. Though only one ratoon is taken in major parts of the country, but 10-11 (Cuba), 4-6 (South Africa, USA) and 2-3 ratoons (Australia, Hawaii) are taken in other countries.

The following points should be kept in mind while taking a ratoon crop.

- Short-duration varieties should be selected for the purpose of ratooning, e.g., Co 421,m Co 453, Co 1336, CoS 767, CoS 54, CoS 7918, CoS 8118, Co 740, CoS 767, CoS 510, CoS 88230, CoS 8009, CoS 8016, CsO 8207, CoLK 8102, CoLK 8501, CoLK 8504 etc.
- The plant crop should be harvested early, preferably in January-February.
- The plant crop should be harvested close to the ground.
- The left over trashes should be burnt in the field soon after harvesting. This helps in destroying eggs and larvae of insect-pests. This also destroys the weeds and disease pathogens. The burning evolves heat, which converts sucrose of stubble into gluclose for quick sprouting of tillers.
- After burning of trashes, the bunds should be dismantled and field be given irrigation and inter-cultivation by running harrow or cultivator for providing better aeration to roots, making soil loose and for root pruning. This helps in a quick development of roots and sprouts.

- When plant crop is harvested over a larger period, the tillers of different ages are produced. These tillers of different ages should be cut from close to the soil before burning so that uniform tillers are produced.
- After the above operations, the field should be irrigated according to the crop requirement. Usually first irrigation is applied 6-7 weeks after harvesting of planted cane. Rests of the irrigations are applied as for plant crop.
- The crop should be provided an efficient drainage to drain out excess water from the field.
- If there are gaps in rows, these must be filled by planting rooted slips of the ratoons by lifting them from crowded places or by planting setts.
- Fertilizers should be applied in inter-row spaces about 15-30 cm away from plant rows. The crop should be applied 180-250 kg N, 80 kg P_2O_5 and 80 kg K_2O/ha as first application after first irrigation. The crop should also be applied 80-100 kg N/ha in July.
- The weed control, earthing, hoeing and plant protection measures should be followed as of the plant crop.
- The crop matures earlier, usually in October-November. Therefore, it should be harvested earlier.

Additional Material:

http://en.wikipedia.org/wiki/Sugarcane

http://www.sugarcane-breeding.tn.nic.in/

http://edis.ifas.ufl.edu/TOPIC_BOOK_Sugarcane_Handbook

http://www.britannica.com/eb/art-16731/Sugarcane-harvesting-and-processing-in-Brazil?articleTypeId=1 (VIDEO)