

## SUGARCANE

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### Importance

- 62% world's sugar is met from cane
- Sugar requirement is projected at 150 million tonnes for the world
- India alone requires 16-20 million t
- Sugar industry is the largest agro-based industry next only to textiles in India
- At present there are 450 sugar factories
- Average productivity is 14.2 million t (1998)
- Average sugar recovery of 11% By products in sugarcane industry
- There are many end uses - probably more than 150
- But many of them are of negligible economic interest
- 38 end-products are potentially important
- But four main byproducts of the sugarcane are:
  - Cane tops
  - Bagasse
  - Filter mud / press mud and Spent Wash
  - Molasses
- Cane tops
  - Cane tops have no real market value
  - They can be compared to fair quality fodder with an average feed value, when fresh, of about 2.8 MJ of metabolizable energy per kilo of drymatter.
  - However cane tops should be collected and transported from the canefields to the feedlot
- Bagasse
  - It is the fibrous residue of the cane stalk left after crushing and extraction of the juice
    - It consists of fibres, water and relatively small quantities of soluble solids - mostly sugar
  - Utilizations are:
    - Electricity
    - Particle board
    - Paper
    - Furfural
      - It is a colorless, inflammable, volatile, aromatic liquid
      - 25 tonnes of bagasse to produce 1 tonne of furfural
      - Furfural has many industrial uses:
        - Selective solvent for the refining of lubricating oils
        - As an intermediate in the production of nylon and resins
    - Methane

- Filter mud / pressmud
  - The precipitated impurities contained in the cane juice, after removal by filtration, form a cake of varying moisture content called filter mud
  - This cake contains much of the colloidal organic matter anions that precipitate during clarification, as well as certain non-sugars occluded in these precipitates
- Filter mud / pressmud...
  - The use of filter mud
    - As animal feed has not proved economically rewarding, the main constraints being the magnitude of the drying process involved and the low digestibility of the dried scums
    - As soil nutrient there are limitations
      - Higher values of C.O.D. and B.O.D .
      - Wax percentage in substantial quantity which prevents microbial action
      - High concentration of various chemicals which are detrimental to survival of beneficial microflora
      - Bio-degradation being an exothermic reaction survival of microbes except thermophiles is difficult
      - Due to above mentioned difficulties, bio-degradation of pressmud and spent wash is a difficult process
- Molasses
  - Molasses is the final effluent obtained in the preparation of sugar by repeated crystallization
  - It is the residual syrup from which no crystalline sucrose can be obtained by simple means
  - The yield of molasses is approximately 3.0 percent per tonne of cane
    - but it is influenced by a number of factors (2.2 to 3.7 percent)
    - The specific gravity varies between 1.39 and 1.49, with 1.43 as indicative average
  - The composition of molasses varies but, on average, would be as follows:
 

▪ Water	20%
▪ Other carbohydrates	4%
▪ Sucrose	35%
▪ Nitrogenous compounds	4.5%
▪ Fructose	9%
▪ Non-nitrogenous acids	5%
▪ Glucose	7%
▪ Ash	12%
▪ Other reducing sugars	3%
  - For distillery industry
  - Alcohol and related products
  - Export to some developed countries as raw materials
  - It is an ingredient to animal feed

## Origin

- India is considered as native to thin cane
- Tropical thick canes from larger islands of Oceania with New Guinea as possible nucleus
  - Brandes (1956) – three different movements
    - Introduction to Solomon islands - 8000 BC
    - Westerly direction to Indonesia and Philippines – 6000 BC
    - Fiji, Tonga, Samoa, the Cook islands & Hawaii – 600-1100 AD

## World Scenario (Area, production, productivity, in million ha, tonne and t/ha)

Country	Area	Production	Productivity
Brazil	4.92	338.7	68.7
India	3.96	265.0	66.9
China	1.21	85.7	71.3
Pak	1.14	53.0	46.7
Asia	8.67	536.7	61.9
S. America	6.05	419.6	69.4
N. C. America	3.21	166.7	52.0
Africa	1.43	85.7	57.9
World	19.90	1254.9	63.1

## Indian Scenario (Area, production, productivity, in million ha, tonne and t/ha)

State	Area	Production	Productivity
UP	2.10	124.8	59.4
Maharashtra	0.52	41.8	81.0
TN	0.27	26.9	99.3
Karnataka	0.25	21.9	85.9
AP	0.20	14.9	75.1
Punjab	0.17	11.0	63.8
Gujarat	0.16	11.4	68.8
Haryana	0.16	9.0	55.0
Bihar	0.14	6.3	45.2
MP	0.06	2.2	38.1
India	3.96	265.0	66.9

## Species of sugarcane

- Cultivated
  - *Saccharum officinarum*
  - *S. barberi*
  - *S. sinense*
- Wild species
  - *S. spontaneum*
  - *S. robustum*

## The plant

- Grass family with tillering capacity

- Above ground parts are
  - Stem of stalk with nodes and internodes
  - Leaves
  - Inflorescence
- Roots
  - Sett roots developed from root primordial
  - Shoot root , thicker branched
  - Buttress roots, fibrous branched

#### Varieties

- After the introduction of hybridization programme in early 20th century many improved varieties are available
- Varieties for region and season are available in plenty
- SBI, Coimbatore in collaboration with NARS has set up breeding programme
- Breeders of NARS will visit and at a specified period and carry materials

#### Seasons

- There are four main seasons in TN
  - Early – Dec-Jan
  - Mid-season – Feb-Mar
  - Late – Apr – may
  - Special season – June-July
- All India
  - Spring – Feb-Mar
    - *Suru* in Maharastra, *Eksali* in Gujarat & AP
  - Autumn – Sep-Oct-
    - 13-15 months, supplies sugar for early crushing
  - Adsali – July Aug
    - 16-18 months
    - Increase in yield & sugar recovery
    - Though advantageous area is declining due to water problem
  - Late planting – beyond March, reduction in duration and yield

#### Soils

- Cultivated in wide range of soils
- Moderately heavy medium deep (1-2m) loams are better than
  - Heavier and shallow soils
- The soil must be of good depth and drainage
- No salt and compaction

#### Seed bed

- **Preparation of good seed bed is essential**
  - Since the same field is retained for 2-3 years
  - Deep ploughing / sub-soiling is needed
- **Field Layout**
  - In India - by adopting two systems viz.,
    - Ridge and furrows system
    - Flat system.
  - There are some special systems
    - Trench system

- Deep Trench system
- Paired - row system
- Ring or pit system etc.

### **Planting materials**

- **Vegetative propagation**
  - Known as seed pieces or setts
  - Buds on sugarcane germinate and give plants
  - Planting materials may be
    - Single bud sett or Chip bud
    - Two budded setts
    - Three budded
    - Seedlings raised from nursery
    - Seedlings raised by poly bags or
    - Tissue cultured seedlings
  - For sett planting
    - Sugarcane setts are prepared from nursery cane
    - Nursery cane is younger than (6-8 months) juice cane

### **Ideal cane sett**

- Ultimate plant stand and yield depends on the type of seed material used. The characteristics of good seed cane material are
  - Free from disease and pest infestation
  - Age of seed crop is around eight months
  - Setts should have healthy buds without any damage in handling and transport
  - Buds with higher moisture content, adequate nutrients, higher amount of reducing sugars
  - Cane should be free from aerial roots and splits
  - Pure in quality

### **Preparation of setts**

- Use of sharp knife to cut setts
- Treat the setts immediately with fungicide solution
- Machine cutting and mechanical planting is also followed in developed countries
- **Seed rates & spacing**
- Depends up on the spacing
- Spacing varies due to
  - Climate
  - Method of establishment
- In TN
  - 50,000 three budded setts
  - 75,000 two budded setts
  - 187,500 single budded setts
- Row spacing may vary
  - 0.9m to 1.5m and 2.4m

### **Method of planting**

#### **Flat Planting**

- In this method, shallow (8-10 cm deep) furrows are opened with a local plough

- orcultivator at a distance of 75 to 90 cm
- There should be adequate moisture in the field at the time of planting
- The setts are planted in them end to end
- Furrows are covered with 5-7 cm soil
- In most parts of northern India and some tracts of Maharashtra, cane is planted by this method

#### **Furrow Planting**

- In this method furrows are made with a sugarcane ridger about 10-15 cm deep in northern India and about 20 cm in south India
- Setts are planted end to end
- The furrows are covered with 5-6 cm soil, leaving upper portion of furrows unfilled
- Immediately after covering the setts water is let into furrows
- This method is practiced in parts of eastern UP and in Peninsular India, particularly in heavy soils

#### **Trench Method**

- In some coastal areas as well as in other areas where the crop grows very tall and the strong winds during rainy season cause lodging of cane, trench method is adopted to save the crop from lodging
- Trenches at a distance of 75-90 cm are dug with the help of ridger or by manual labour
- Trenches should be about 20-25 cm deep
- Fertilizers (NPK) are spread uniformly in the trenches and mixed thoroughly in the soil
- The setts are planted end to end in trenches
- The tractor-drawn sugarcane planter is a very suitable device for planting cane in trenches

#### **Modified trench system**

- Ridges and furrows are opened at 120 cm using a tractor drawn ridger
- The furrow bottom is widened
- As the crop grows while each manuring, only slight earthing up is done so that a trough is maintained through the crop growth
  - Here irrigation is given in the cane row itself
- The system has been found highly useful under :
  - Saline water irrigated and saline soil conditions
  - The salts are leached down from the root zone
  - Higher cane yield compared to conventional ridges and furrows
  - FYM or pressmud application and trash mulching in this system can further improve cane yield

#### **Special methods of establishment**

##### Single bud direct planting

- In this system single bud setts are planted directly in the field in the furrows at 30-45 cm spacing
- This method is highly economical and sowing of seed material.

- The buds should be healthy

#### **Transplanting technique (STP technique)**

- Seedlings are raised in a nursery bed using single bud setts.
- About 6 weeks old seedlings are transplanted
- Advantages by adopting this system are
  - Saving in the seed cost
    - Only about 2-3 t/ha against the normal 8-10 tonnes/ha.
  - Synchronous tillering leading to uniform maturity
  - Sufficient time availability to prepare the main field
  - Saving of 2-3 irrigations
  - Possibility of increased cane yield
  - Better weed management
  - Efficient fertilizer management

#### **Partha" method**

- A technique developed by Mr. S.V. Parthasaradhy an eminent sugarcane scientist.
- Suggested for water logged or excess soil moisture conditions (coastal AndhraPradesh and Tamil Nadu during N-E monsoon period)
- In this method
  - three eye budded setts are planted in a slanting position, 60° to the vertical, in the wet furrow or half-way on the ridges
  - Usually one eye bud is thrust into the soil and the remaining two will be above, which will sprout
  - Once the monsoon recedes, the *in situ* sprouted setts are pressed down into the soil and made to lie horizontally
  - Soil is put to the base
  - At this stage, the crop is manured

#### **Measures to obtain higher germination**

- Using disease free healthy setts
- Careful preparation of setts without damaging the buds or setts
- Planting freshly prepared and treated
- Trash mulching under
  - moisture stress and hot weather and late planted conditions
- Seed treatment using a

#### **fungicide Manures for Sugarcane**

- Apply FYM / Compost during field preparation
- Inorganic fertilizers:
  - For Coastal and flow irrigated areas
    - 270 : 112.5: 60 N: P2O5: K2O kg /ha
      - N & K applied in three equal quantities at
      - 30, 60 and 90 DAG
      - N may be coated with neem cake @20%
  - For Lift irrigated areas
    - 225 : 112.5: 60 N: P2O5: K2O kg /ha
  - For Jaggery producing areas
    - 175 : 112.5: 60 N: P2O5: K2O kg /ha
- For those soils deficient in ...

- In iron : 100 kg ferrous sulphate /ha
- In Zinc : 37.5 kg Zinc sulphate
- Foliar application and drip fertigation can
  - Reduce N dose
  - Increase cane yield
  - Save ground water pollution by fertilizers
- Azospirillum application can enhance the growth
- Band placement of fertilizer is another method by which losses can be minimized

### **Irrigation**

- To support and sustain a vigorous nursery crop, irrigating at optimum levels inimportant
- Any shortage in the irrigation would lead to reduced sett yield
- Moisture stress would pre-dispose the crop to the attack of some pests anddiseases
- Irrigation at IW/CPE ratio of 1.0 is ideal
  - According to moisture depletion irrigating at 25% depletion of availablesoil moisture (ASM) may be ideal
  - This in practical terms means:
    - Once in 6-7days in a loamy soil and
    - At around 10-12 days in heavy day soil

### **Weed control**

- A weed-free environment is absolutely essential
- Deep ploughing and removal of perennial weeds
- Pre-emergence application of
  - Atrazine 1.75kg or Oxyflurofen 0.75 lit/ha on 3-4 days of planting using knapsack sprayer
- Post-emergence application of
  - Gramaxone 2.5 lit + 2-4,D Sodium salt 2.5 lit/ha as directed spray on 21 DAP
- Hand weeding before each manuring
- Other cultural operations and precautions

### **Cultural operations**

- Important cultural operations in sugarcane in addition to weeding, manuring andirrigation are
  - Earthing up
  - Detrashing
  - Propping and
  - Flowering control

### **Earthing-Up**

- This practice is followed where furrows are practiced
- Earthing up are 2-3times during crop period.
  - The first earthing-up is known as "partial earthing-up and
    - To cover the fertilizers
    - To provide anchorage to root system
  - The second operation is "full earthing-up".



- Full earthing-up is done after final manuring (90-120 days coinciding with peak tillering)
- The soil from the ridge is thrown on both sides towards cane rows and the furrows will become as ridges and ridges as furrows
- The furrows so formed are used for irrigation

#### Wet earthing up

- Done around 6 months age of the crop
- The furrows are irrigated and the wet soil from furrows is taken and plastered on the ridges
  - It checks late tillering and watery shoots
- Heavy earthing up is useful during floods
  - When the flood water recedes, the excess water from earthed-up soil drains out quickly thus providing aeration

#### Hoeing

- This operation is done where soil crust formation is very common
- In sub-tropics hoeing is done after germination is over using a bullock drawn or tractor-drawn harrows

#### Hoeing

- While carrying out this operation some of the germinated setts may be uprooted and they are pressed down manually

#### Detrashing

- On an average a stalk may produce 30-35 leaves
- All are not useful for effective photosynthesis
  - Only the top 8-10 leaves are sufficient
  - Most of the bottom leaves are dried and will not participate in photosynthesis
  - At the same time they drain out the food materials which otherwise could be used for stalk growth
- Therefore it is important to remove the dry and lower leaves
- This operation is known as detrashing
- Detrashing helps in clean cultivation
- Easy movement of air within the crop canopy
- Reduce certain pests like scales, mealy bugs, white fly etc.,
- Easy entry into the field
- Avoids bud germination due to accumulation of water in the leaf sheath
- Easy to take up cultural operations including sprayings
- Easy to harvest, obtaining clean canes for milling
- Detrashed leaves can be used for
  - Mulching in the furrows or
  - Used for composting
  - Infested leaves with pest or disease may be burnt out

#### Propping

- Tying the canes by using the lower bottom leaves to check lodging of cane
- Propping can be either done for each row or two rows can be brought together and tied
- It is for:

- Prevention the lodging
- Extensively followed in coastal belt where cyclone effect is very severe
- Lodging also very common in
  - Tall varieties
  - Top growth is heavy and where the growth habit is not erect, and
  - The varieties with less fibre content

#### **Lodging leads to several problems**

- Cane breakage and thus loss of stalk number at harvest loss
- Lodged canes are easily infested by certain pests and diseases
- Damage by rats and rodents
- Bud sprouting leads to reduced cane quality
- Aerial root formation affects cane quality
- difficult to irrigate and harvest the cup

#### **To prevent lodging**

- Heavy earthing up
- Propping
- Paired row planting with earthing up
- Deep trench planting
- Selection of varieties resist lodging
- Raising wind breaks along the field borders
- Application of potassium

#### **Removal of water shoots**

- Water shoots are late formed tillers or side shoots which are robust and fastgrowing.
- They originate mainly due to excess water supply, heavy and late manuring, inadequate earthing up
- These water shoots contain lot of water, low sucrose and more of reducing sugars
- Water shoots affect the growth of adjacent stalks
- They harbor insect pests and when they are milled sugar recoveries are low because of reduced juice quality
  - Therefore removal of water shoots whenever they appear
  - Water shoots can be used as cattle feed

#### **Control of flowering**

- In commercial sugarcane cultivation, flowering is not desirable
- Once the plant flowered the cane growth stops and starts ripening
- If not harvested immediately reversion of sugars, increase in fibre, pith formation, cane breakage etc.
- The deterioration is much faster if it is summer
- Solution
  - Non-flowering or shy flowering varieties can be used where flowering is a severe problem
  - Controlled irrigation
  - Change of planting period
  - Use of growth regulating substances
    - Spraying of etrel at 500ppm, twice or 1000ppm once at floral initiation

## Ratoon Management

- The crop raised from planting cane sett is called plant crop
- After the harvest of plant crop stubble sprouts and gives rise to succeeding crop called as ratoon crop
- The practice of taking up ratoon crop is called

### 'ratooning'

Ratooning ability

- Is generic, based upon ability ratoon varieties are classified as:
  - Good or poor ratooner
  - Co 1148, Co 419, Co 740 are some examples for good ratooners
- Ratooning has following advantages:
  - Reduction in the cost of field preparation, planting material, operation cost
  - Saving in field duration – ratoon matures earlier than plant crop
  - Ratoon may give equal yield that of plant

### Ratooning is common practice

- Number ratoon varies
  - In Cuba 10-11 crops
  - South Africa & USA 4-6 crops
  - Hawaii, Brazil and Australia 2-3
  - In India ratoon yield is generally poor since
    - Very little attention to manure ratoon
    - 30-40% area is under ratoon in India
    - The average productivity is low

### Ratoon management

- Select variety suitable during plant crop
- Plant crop should be harvested at right maturity
  - Delayed harvest to be avoided
- Harvesting close to the ground with sharp cutting
  - Stubble shaving to 4-6cm is recommended if no uniform cut at harvest
- Remove the trash but do not burn it
- Irrigated the field properly
- Shoulder breaking or off-barring to remove decayed stubbles
- Gap filling with sprouted setts or seedlings
- Ratoon is less efficient in N utilization hence 25% additional N from 5-7 days after ratooning is desirable
- P & K should be judiciously
- Spraying of FeSO<sub>4</sub> @ 2.5kg/ha in 150 litres on 15th day if chlorotic symptom is noticed
  - If persists repeat twice at 15 days interval
  - In the last spray add 12.5kg urea
- After cultivation practices to be done more effectively
- Ratoon requires more plant protection
  - Grassy shoot disease, ratoon

### stunting

Maturity and harvest

- Ripening of sugarcane refers to rapid synthesis and storage of sucrose in the stalk
- Accumulation of sugar in the stalk starts soon after completion of

elongation phase

- Glucose produced during photosynthesis is not utilized for conversion but stored as sucrose
- When the concentration exceeds 16% in the juice and 85% purity the cane is said to be matured
- As the crop advances in maturity:
  - Water content decreases
  - Sucrose content increases
  - Reducing sugars decreases
    - Both organic and inorganic non-sugars also decrease
  - At peak maturity sucrose content is at maximum and non-sugars at minimum
- Assessing maturity
  - Use of hand refractometer - Brix reading
  - Assess the maturity by HR meter survey – 18-25% indicates optimum maturity
  - When the reading between top and bottom is 1:1 – is right time to harvest
    - If delayed
      - Sucrose content decreases
      - Non-sugars increase
      - Fibre content increases
- Ripening is influenced by number of factors
  - Climate
  - Nutrition
  - Variety
- Cool dry weather is the key factor
  - Bright sunshine
  - Day temp 28-30C
  - Night temp 12-14C
    - RTD (Relative temp disparity) decides
- Ripeners
  - Spray Sodium metasilicate 4kg in 750 litres /ha 6 months after planting
  - Repeat at 8th & 10th months
    - and not at declining phase
  - Polaris and Ethrel are most extensively used in Hawaii
    - Polaris @ 5 kg in 600 l /ha

Cropping systems

- Intercropping
  - Since a slow grower during initial 2-3 months may be an intercrop raised
  - The crop should not affect cane yield
  - Marketability, ability and feasibility decides the short crops
  - Pulses, potato, onion etc are some
- Sequential cropping - Rotations
  - After sugarcane 1 or 2 or 3 crops
    - Rice based cropping system for one year
    - Wheat based