

B.SC. SEM- IV (H)- CC 9

ECONOMIC BOTANY

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Morphology and processing of sugarcane

Sugarcane, or sugar cane, or simply cane, are several species of tall perennial true grasses of the genus *Saccharum*, tribe Andropogoneae of Poaceae or Gramineae family used for sugar production.



Sugarcane is the world's largest crop by production quantity, with 1.8 billion tonnes produced in 2017, with Brazil accounting for 40% of the world total. In 2012, the Food and Agriculture Organization estimated it was cultivated on about 26 million hectares (64 million acres), in more than 90 countries.



Sugarcane accounts for 79% of sugar produced; most of the rest is made from sugar beets. While sugarcane predominantly grows in tropical and subtropical regions, sugar beets typically grow in colder temperate regions.



Origin of Sugarcane



There are two centers of domestication for sugarcane: one for *Saccharum officinarum* by Papuans in New Guinea and another for *Saccharum sinense* by Austronesians in Taiwan and southern China. Papuans and Austronesians originally primarily used sugarcane as food for domesticated pigs. The spread of both *S. officinarum* and *S. sinense* is closely linked to the migrations of the Austronesian peoples. *Saccharum barberi* was only cultivated in India after the introduction of *S. officinarum*.

The earliest known production of crystalline sugar began in northern India. The exact date of the first cane sugar production is unclear. The earliest evidence of sugar production comes from ancient Sanskrit and Pali texts. Around the 8th century, Muslim and Arab traders introduced sugar from medieval India to the other parts of the Abbasid Caliphate in the Mediterranean, Mesopotamia, Egypt, North Africa, and Andalusia.



Morphology of Sugarcane

Morphology

Root system

Sugarcane has fibrous roots and these roots are of two types i.e. **sett roots** and **shoot roots**. Sett roots are produced from root primordia (at the base of cane) after planting and covering of cane setts from soil. These roots are thin in nature, have many branching roots and remain active for specific period of time. The main function of these roots is to provide water and nutrients to the primary shoot.

After this, these roots are died and new roots are formed from the lower rings of lower nodes of shoot. Lower ring's roots move downward and upper ring's roots move upward near the soil surface to support the cane stalk. These roots are known as shoot roots.

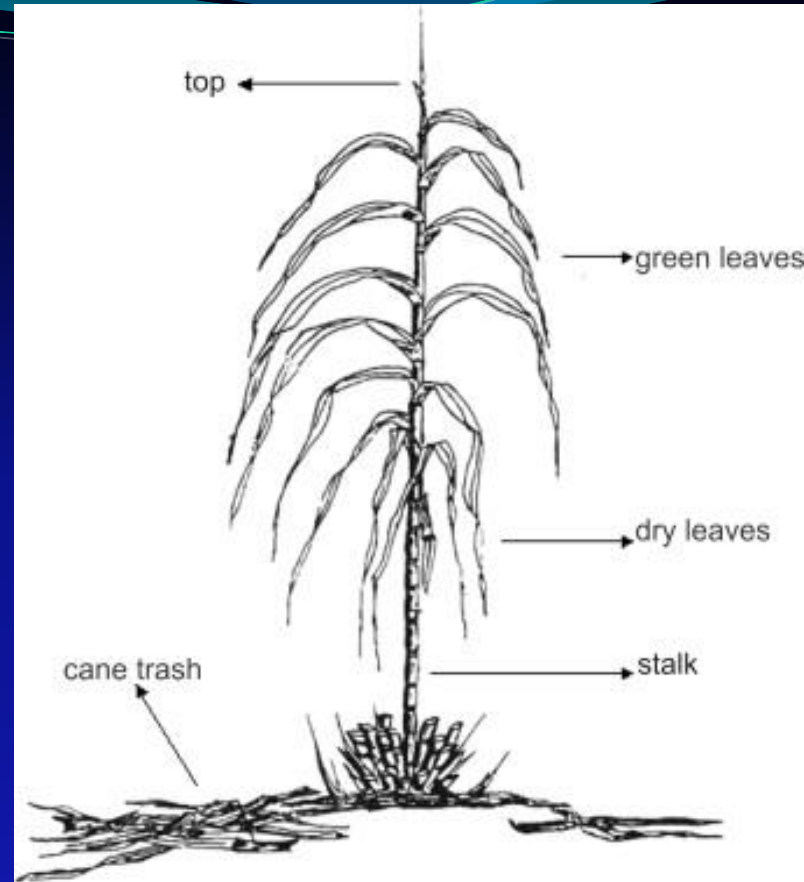


Stalk

It is also known as “**millable cane**” and produced from the cane setts containing 1-3 buds/cane, after planting. Primary stalk is produced from the sprouting of these buds and secondary stalk is produced from the primary stalk.

Cane has small portion below the soil known as rootstalk. Sugarcane stalk contains nodes, internodes, flowers and leaves. Node contains a root band, bud, wax band and growth ring. Root band from which root primordia is formed, laterly, it develops into sett roots.

The internodes are covered with the leaf sheath and are of different shapes like curved, bobbin, cylindrical and conidial. These shoots are called as tillers.



Leaves

Leaves of sugarcane consist of a leaf blade and a leaf sheath. Each leaf is produced from the node of cane stalk and grow, alternately. Leaf sheath completely, covers the internode and usually, hairy on the outside. It is dark green in color. Leaf blade is 1-2 meters in length and 0.05-0.07 meters in width. Its edges are serrated and midrib is well prominent. There are auricles (often hairy) on the outside and one ligule inside.



Inflorescence

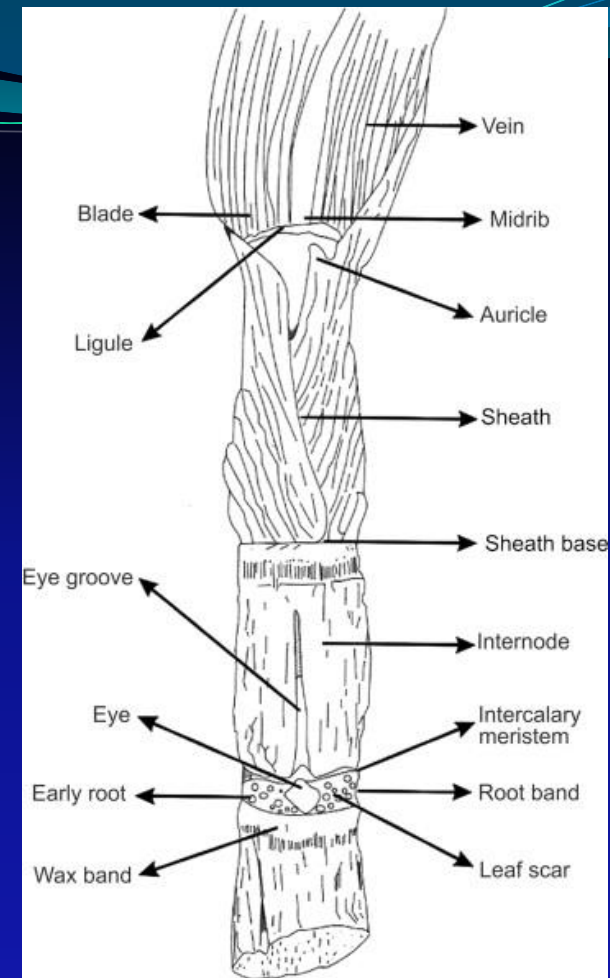
It is known as arrow which is an open panicle. It is 0.3m in length and tapered. Recemose is the spikelets arrangement and both male and female parts are present on the stalk but not all produce fertile pollen.

sugarcane is thus grown vegetatively, by using the cuttings/setts of cane.

Cane

It is thick, oval in shape and slightly staggered. It has a small cavity known as pith, hard rind, red blotches and growth ring yellowish and root zone purplish yellow in color. Growth ring is slightly swollen. Usually, the width of growth ring and root zone is equal.

It is cylindrical to conical in shape. Cane contains a wax band which is tapered and often merges with general bloom. Root zone present on cane is narrow, tapered and having two rows of eyes.



Maturity and ripening phase

This stage starts from 270 days after planting and continues till about 360 days. In this phase, vegetative growth is reduced and accumulation of sugar is increased and cane stalks convert simple sugars (fructose, glucose) into sucrose.

There is more quantity of sugar in the lower parts and low in the higher or upper parts of sugarcane because sugarcane stalk ripening starts from bottom to top.

Harvesting and Processing

Harvesting of sugarcane at a proper time i.e. peak maturity, by adopting right technique is necessary to realize maximum weight of the millable canes (thus sugar) produced with least possible field losses under the given growing environment.

Harvesting: Sugarcane matures in 10-12 month in North India and 18-20 month in South India. Different Indicators of harvesting are leaves become yellow, plants stops growing and arrows come out, cane produces metallic sounds, buds swell out and eyes start sprouting.

In India harvesting of sugarcane is carried out at 10 to 18 months stage, depending upon the planting time and crop maturity.

Types of harvesting

Manual Harvesting

Hand knives, cutting blade or hand axes are used for manual harvesting.

Mechanical Harvesting

Sugarcane is harvested by mechanical harvester which move along the rows of cane removing the leafy tops of the cane and cutting the stalk into short pieces or "billets". Billets are loaded into bins which are towed alongside the harvester. When full, the bins are taken by road or tramway to the sugar mill.



Prevention of Moisture loss in the Harvested cane

- To harvest the cane at peak maturity (i.e., avoiding cutting of either over-matured or under-matured cane)
- Early varieties have to be harvested at 10 to 11 months age and mid-season varieties at 11 to 12 months age.
- Cutting cane to ground level so that the bottom sugar rich internodes are harvested which add to yield and sugar
- De-topping at appropriate height so that the top immature internodes are eliminated.
- Proper cleaning of the cane i.e., removing the extraneous matter such as leaves, trash, roots etc.
- Quick disposal of the harvested cane to factory

PROCESSING OF SUGARCANE

1. Collecting the harvested cane: Mature canes are gathered by a combination of manual and mechanical methods. Canes are cut at ground level, its leaves are removed and the top is trimmed off by cutting off the last mature joint. Cane is then placed into large piles and picked up, tied, and transported to a sugar factory.

2. Prevention of moisture loss in the harvested cane: Covering the harvested cane with trash and sprinkling with water both under sun and shade reduced the moisture loss and prevented quality deterioration.

3. Cleaning and Crushing: Stalks are thoroughly washed and cut when reaching the sugar mill. After the cleaning process, a machine led by a series of rotating knives, shreds the cane into pieces. This is known as "grinding." During grinding, hot water is sprayed on to the sugarcane to dissolve any remaining hard sugar. The smaller pieces of cane are then spread out on a conveyer belt.

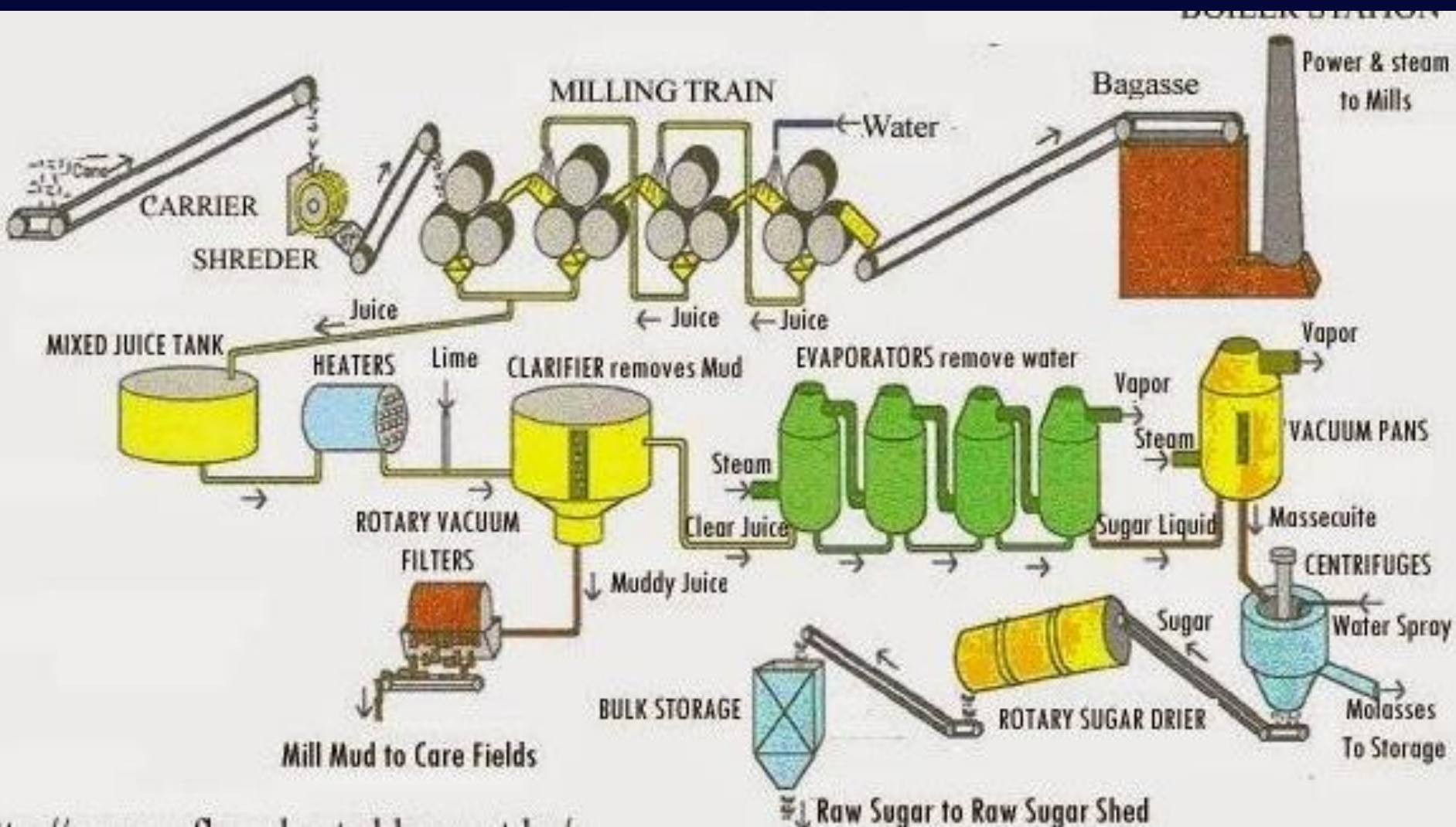
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4. Juicing: The shredded pieces of sugarcane travel on the conveyer belt through a series of heavy-duty rollers, which extract juice from the pulp. The pulp that remains or "bagasse" is dried and used as fuel. The raw juice moves on through the mill to be clarified.

5. Clarifying: Carbon dioxide and the milk of a lime are added to the liquid sugar mixture and it is heated to the boiling point, as the process of clarifying begins. As the carbon dioxide travels through the liquid it forms calcium carbonate, which attracts non-sugar debris (fats, gums, and wax) from the juice, and pulls them away from the sugar juice. The juice is then pushed through a series of filters to remove any remaining impurities.

6. Evaporation: The clear juice which results from the clarifying process is put under a vacuum, where the juice boils at a low temperature and begins to evaporate. It is heated until it forms into thick, brown syrup.



7. Crystallization: By evaporating what little water is left in the sugar syrup, crystallization takes place. Inside a sterilized vacuum pan, pulverized sugar is fed into the pan as the liquid evaporates, causing the formation of crystals. The remaining mixture is a thick mass of large crystals, which is sent to a centrifuge to spin and dry the crystals. The dried product is raw sugar, still inedible.

8. Refinery: Raw sugar is transported to a Cane Sugar Refinery for the removal molasses, minerals and other non-sugars, which still contaminate the sugar. This is known as the purification process. Raw sugar is mixed with a solution of sugar and water to loosen the molasses from the outside of the raw sugar crystals, producing a thick matter known as "magma." Large machines then spin the magma, which separate the molasses from the crystals. Crystals are promptly washed, dissolved and filtered to remove impurities. The golden syrup which is produced is then sent through filters to remove the color and water. What's left is concentrated, clear syrup, which is again fed into a vacuum pan.

9. Separation and Packaging: Once the final evaporation and drying process is done, screens separate the different sized sugar crystals. Large and small crystals are packaged and shipped, labeled as white, refined sugar.

By- Products

1. Raw sugar

- ❑ Raw sugar is obtained from the processing of the sugar cane juice extracted from the sugar cane stalks.
- ❑ The juice is clarified with lime and subsequently concentrated to produce massecuites which is a mixture of crystals and surrounding dense, dark brown liquid called molasses.
- ❑ The crystals (raw sugar) are separated from the molasses by centrifugation.

2. Sugarcane Juice

It is preferable to remove the rind portion of the cane by suitable means as the pigments present in the rind contribute to dark colour and unpleasant taste to the juice.

3. Gur or Jaggery

The result of the milling process is pure whole unrefined non-centrifugal cane sugar, called **Panela (right)**. The earliest modern record of Panela is around 3000BC in India, where Panela was known as Gur Jaggery, or more commonly today Gur, or 'poor people's sugar'.

Procedure for Preparation of jaggery:

1. Fresh sugarcanes are cut from the fields, canes are cut in such a way that the head and tail are chopped off. They are carefully brought in a plastic sack, to the place where they are made juice.
2. To extract juice from the sugarcane, they use a small power run machine, where at one side four or five canes are fed, and at the other end, extracted sugar cane juice is directly feed to the vessel.
3. Next step involved is boiling the extracted juice, juice is feed to a large big iron vessel, which is usually called as kadai.



4. Molasses

Molasses is a viscous byproduct of the processing of sugar cane. To make molasses, the sugar cane juice is extracted from the canes, usually by crushing or mashing. The juice is boiled to concentrate it, which promotes the crystallization of the sugar. The result of this first boiling and removal of the sugar crystals is first molasses.



5. Bagasse

The bagasse (or the crushed cane fibres), which results from the milling, is used in the boilers for steam production which is used to power the process. The surplus bagasse is used in industry, to produce power, make paper, building materials, as a fuel and even as stock feeds.



6. Ethanol

Sugarcane can also be used to make ethanol, a liquid that can be used as an automotive fuel or a gasoline additive. Sugarcane is an excellent feedstock because the biomass of the sugarcane plant is relatively rich in the sugar that can be readily turned into fuel.

7. Syrup

Sugar cane syrup is a thick syrup that is created by evaporating the juice extracted from sections of sugar cane. The preparation of this type of cane syrup usually involves boiling the juice for several hours, and making sure to skim the surface of the juice throughout the process. When prepared properly, this approach yields a thick syrup that is extremely sweet, making it ideal for use in both home cooking and the preparation of commercial foods



8. Candy

Candy is a type of confectionery mineral composed of relatively large sugar crystals. The candy is formed by allowing a supersaturated solution of sugar and water to crystallize onto a surface suitable for crystal nucleation, such as a string or stick.



9. Rum (40% alcohol)

Rum is a distilled beverage made from sugarcane by products such as molasses and sugarcane juice by a process of fermentation and distillation.

10. Filter cake or mud press

Filter cake or mud press is a chocolate, sticky waste during juice extraction of cane stalks containing 5-15 % protein, calcium and phosphorus; 5-15 % sugar; 10-30% fiber; 10-20% ash and other micronutrients. It is a by-product with high potential as important component of organic fertilizer and animal feed and as source of sugarcane wax and methane (gas for fuel) when process.





Thank You

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