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Sugar cane

Gramineae, Poaceae *Saccharum officinarum* L.

Source: Magness et al. 1971

Sugar cane is the source of sugar in all tropical and subtropical countries of the world. Estimates for 1966 and 1967 indicate world production of cane sugar was between 40 and 41 million tons. Production in the United States, excluding Puerto Rico, averaged 2,550,000 tons during those years - from 592,000 acres of cane in Hawaii, Florida and Louisiana. Sugar production in Puerto Rico averaged 850,000 tons for the two years.

Several species of *Saccharum* are found in Southeast Asia and neighboring islands, and from these cultivated cane probably originated. The sweet juice and crystallized sugar were known in China and India some 2500 years ago. Sugar cane reached the Mediterranean countries in the eighth century A.D., and reached the Americas in early colonial times.

The cane plant is a coarse growing member of the grass family with juice or sap high in sugar content. It is tender to cold, the tops being killed by temperatures a little below freezing. In continental United States, where freezing may occur during the winter, it is mainly planted in late summer or early fall and harvested a year later. In tropical countries it may be planted at almost any time of the year since the plant does not have a rest period. The season of active growth in continental United States is 7 to 8 months while in tropical countries growth is near continuous until harvest. This results in heavier yields of cane and sugar under tropical conditions. For example, yields of cane and sugar per acre in Hawaii, where the cane is grown for about 2 years before harvesting, are from 3 to 4 times vields in Louisiana and Florida from one season's growth.

Sugar cane plants are propagated by planting sections of the stem. The mature stems may vary from 4 to 12 feet or more ill height, and in commercial varieties are from 0.75 to 2 inches in diameter. The stem has joints or nodes as in other grasses. These range from 4 to 10 inches apart along the above-ground section of the stem. At each node a broad leaf rises which consists of a sheaf or base and the leaf blade. The sheaf is attached to the stem at the node and at that point entirely surrounds the stem with edges overlapping. The sheath from one node encircles the stem up to the next node above and may overlap the base of the leaf on the next higher node. The leaf blade is very long and narrow, varying in width from 1 to 3 inches and up to 5 feet or more in length. Also, at each node along the stem is a bud, protected under the leaf sheath. When stem sections are planted by laying them horizontally and covering with soil a new stem grows from the bud, and roots grow from the base of the new stem. The stem branches below ground so several may rise as a clump from the growth of the bud at a node.

In planting cane fields, mature cane stalks are cut into sections and laid horizontally in furrows. In continental United States sections with several nodes are laid while in tropical countries sections with 2 or 3 nodes are commonly used - since temperatures for growth are more favorable. Usually only one node on a stem piece develops. a new plant because of polarity along the stem piece.

Planting is in rows about 6 feet apart to make possible cultivation and use of herbicides for early weed control. As plants become tall lower leaves along the stems are sbaded and die. These ultimately drop off, so only leaves toward the top remain green and active. Between the nodes the stems have a hard, thin, outer tissue or rind and a softer center. The high-sugar-containing juice is in this center. More than one crop is harvested from a planting. After the first crop is removed two or more so-called stubble crops are obtained. These result from growth of new stalks from the bases of stalks cut near the ground level in harvesting.

Harvesting

Harvesting of cane in Hawaii and Louisiana is highly mechanized. Machines top the canes at a uniform height, cut them off at ground level, and deposit them in rows. In Florida, cane is mainly cut by hand. Leaves .and trash are burned from the cane in the rows by use of flame thrower type machines. An alternate method is to burn the leaves from the standing cane, after which it is cut and taken directly to the mill. Delay between cutting and milling in either case should be as short as possible since delay results in loss of sugar content. Machines are under development that will cut, clean and load the cane so it can be taken directly to the mill.

In continental United States, where winter freezing is a hazard, cane harvest must start earlier than is desirable for maximum yields. When plants are killed by freezing sugar loss occurs rapidly. While such plants are suitable for sugar extraction if harvested promptly after freezing, this may not be possible when large acreages are involved. In non-mechanized areas cane is still cut and the leaves stripped off by using cane knives. This is arduous and time consuming work.

Sugar Manufacture

Sugar is obtained from the cane at mills located near centers of production. The cane first goes through a washer, then is cut into small pieces by revolving knives. These cut pieces may then be shredded or may move to crushers directly. The crushers consist of two large grooved rollers mounted horizontally, one above the other. The crushed, macerated cane then goes through three or more roller mills which consist of grooved rollers with heavy hydrolic pressure maintained on the upper roller. Water, equal to about 20 percent, is added before the mixture is passed through each set of rollers except the last one. Efficient mills extract at least 90 percent of the sugar in the cane. The cane residue, called 'bagasse', can be used as feed.

The mixture of plant sap and water, with the sugar in solution, collected from the roller mills is slightly acid in reaction with a pH of 5 to 5.5. It is neutralized with lime, which precipitates some of the colloids and other nonsugars and also stops conversion of sucrose to reducing sugars. The limed juice is then heated to boiling, which results in further formation of precipitates that settle to the bottom of the tanks. These are drawn off and filtered to remove more juice. The nearly clear juice is continuously drawn off from the top of the tank and goes to the evaporators.

The evaporators are a set of three vacuum pans or "bodies" arranged in series, with each successive pan maintained under higher vacuum. The juice enters the first pan at 16 to 180 Brix and leaves the third at 55 to 750 Brix. It then goes to high-vacuum boiling pans - about 25 inches of mercury - there it is further concentrated to 900 Brix and contains sugar crystals. It then is centrifuged to remove most of the liquid or molasses. The remaining raw or brown sugar is then ready for final refining. Much of the imported sugar enters this country as raw sugar and is further refined here before being marketed.

The final refining steps include melting the brown or raw sugar, decoloring by passing through carbon filters, recrystallizing in vacuum boiling pans, and drying by centrifuging. A hundred pounds of raw sugar produces about 96 pounds of refined. A ton of cane yields from less than 170 to more than 225 pounds of raw sugar, depending on such factors as variety, maturity when harvested, promptness of milling, and incidence of diseases on the cane in the field. Average per acre cane yields in 1966 and 67 were 23.5 tons in Louisiana, 32.1 tons in Florida, and 95.9 tons in Hawaii.

The molasses obtained in milling totals around 150 million gallons in the United States and near 60 million in Puerto Rico. It is used as an additive in livestock feed, in the manufacture of alcohol and alcoholic beverages - as run. and to some extent in foods. The fibrous plant residue from the roller mills may be used as fuel at the mill, made into paper or insulating board, or used as plant mulches or bedding for livestock.

Sugar Cane Syrup

Sugar cane for syrup is grown over a somewhat wider area in the United States than cane for sugar. The area extends from eastem Texas east to South Carolina. The culture is essentially the same as for sugar

cane and some of the varieties are the same. Since most production is in areas with a shorter growing season than the sugar producing areas, early maturing varieties are essential. Most of the cane grown for syrup is in small acreages and the syrup is manufactured on a small scale, although there are a few sizable factories.

For best yield and quality of syrup, harvest should be delayed until the cane is mature, but before it is killed by freezing. Leaves are stripped from the standing cane either by beating off with a cane stripper, cutting, off or pulling off by hand. Stems are topped and cut near ground level. Delay of up to 30 days between cutting and making the syrup does not impair either yield or quality of the syrup, provided the cane does not freeze.

In general, mills with three horizontal rollers turned by motors are used to extract the juice. Larger mills may use rollers under hydraulic pressure. From 50 to 60 pounds of juice should be obtained from 100 pounds of cane. Open-type, continuous flow evaporators are generally used to concentraate the juice. The cold juice enters the lower end of the evaporator which is heated by fire beneath or, in larger installations, by steam coils. When the juice is heated, proteins and some other nonsugar constituents coagulate, float on the surface, and are skimmed off at the upper end. In manufactured apparatus a final finishing or evaporating vat may be used. Proper density of the finished product is determined by using a hydrometer (35-360 Baume), or determining the boiling point with a thermometer (226-228 F.). The finished syrup is then filtered and placed in containers while hot. Production of cane syrup has fluctuated widely reaching more than 28 million gallons in 1945 when sugar was scarce because of World War II. Production in 1966 and 1967 averaged 2,151,000 gallons annually. All is used as food. With good varieties and good agronomic practices an acre of cane should produce from 500 to 600 gallons of finished syrup. Average yields, however, are only about half this amount.

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