Reading 21
Sugarcane

Sugarcane, *Saccharum officinarum* (Gramineae)

Sugarcane (Fig. 1) is a short-day crop of the warm tropical lowlands, adapted to a lengthy humid season followed (ideally) by a short dry season during which sucrose accumulates. It is one of the few species to store its carbohydrate reserves as sucrose. It has a great thirst, and it is said that about 2 metric tons of water is needed to produce each kilogram of sugar. (Drip irrigation has been introduced to the cane fields of Hawaii and elsewhere to conserve irrigation water.)

A little sugarcane is grown in southern Europe (Spain), a bit more in the southern continental United States (principally Florida and Louisiana), a fair amount in Africa (in a number of countries), and a great deal in South America (principally Brazil), the Caribbean (principally Cuba), Mexico, certain Pacific islands (especially Hawaii and the Philippines), and southern Asia (principally India and Pakistan). World production for 1977 was about 740 million metric tons.

Although sugarcane is identified botanically as *Saccharum officinarum*, most of the modern cultivars are derived from crosses of an original species (the *S. officinarum* "noble canes," probably native to New Guinea and possibly descended from *S. robustum*) with other species. *S. barberi* of northern India, itself perhaps a hybrid of *S. spontaneum* and *S. officinarum*, was long ago used for extraction and chewing, but today it is of no importance except as a germplasm source in breeding programs. Primitive chewing types were improved first by casual selection, then by intraspecific crop breeding, and finally by interspecific crossing that has yielded the prime clones so widely planted today. "Pure" *S. officinarum* has a diploid chromosome number of 80.

Breeding work with various sugarcanes began around 1885, particularly in Java. Crosses and backcrosses involving *S. spontaneum* and *S. sinense* (to confer disease resistance and vigor) yielded, in 1921, a markedly superior clone ('POJ 2878') that changed sugarcane production all over the world. Since then other improved cultivars have been bred, especially in Hawaii, with *S. robustum* "blood" entering the pedigree. The impact on sugar yields has been astounding. The average annual yield of crystal sugar in Java was 2 metric tons per hectare in 1840, 10 tons by 1910, and 20 tons by 1940. Of course, this phenomenal rate of increase is partly due to improved growing techniques, as well as breeding for higher yields and disease resistance. However, modern sugarcane is nonetheless one of the world's most productive crops, yielding 200 metric tons of canes per hectare (89 tons per acre) and 22 metric tons of sucrose per hectare (about 10 tons per acre) under good growing conditions.

Fig. 1. Sugarcane, a member of the grass family, as it appears in flower in Hawaii. [Courtesy J.C. Allen & Son.]

Sugarcane was apparently introduced into the Western World from India via ancient trade routes to the Mediterranean, where primitive types are still grown to some extent for chewing. Sugarcane was grown in the Canary Islands before 1493, when, it is reputed, Columbus took it thence to the New World, where it was soon widely planted. In 1509, sugarcane was harvested in Santo Domingo, Hispaniola, and it had spread to Mexico by 1520, to Brazil by 1532, and to Peru by 1533. Cultivars from Java did not supplant this low-yielding sugarcane until late in the nineteenth century. The first sugarcane raised in what is now the continental United States was in the former French colony of Louisiana, in 1753.

In less developed lands, sugarcane has long been planted and tended by hand (Fig. 2), with sections of stem merely being stuck in the ground and the weeds kept reasonably in check. (Sections of stem 8-12 months old, called setts, sprout readily from axillary buds and adventitious roots.) However, few tropical crops have been as thoroughly acclimated to large-scale plantation agriculture and as extensively affected by advanced technology. Soil testing and customized field preparation, machine planting, efficient cultivation and herbicidal weed control, generous fertilization, preharvest flaming, and mechanized gathering are all commonplace. More and more the crop is sprayed with a "ripening agent," or a compound to prevent flowering, since the determinate inflorescence draws upon sucrose reserves and the stem becomes more fibrous. It is reported that nearly half the Hawaiian crop is treated with Polaris growth regulator, and elsewhere the herbicide diquat is used to repress flowering.

Twelve to eighteen months are generally required to complete a planting cycle. On rich lands, subsequent crops may be obtained from rhizomes left in the soil, but more often the crop is replanted like an annual to systematize mass production, or at most allowed to regenerate (ratoon crops) for only two or three years before replanting.

Whether sugarcane is harvested by gigantic cutting machines on a modern plantation or hand-harvested by machete in a distant jungle, sugar extraction follows much the same procedure. Basically, the sugarcane is brought to a centralized location where the juice is squeezed from it and concentrated. This is accomplished by crushing the stems between fluted rollers-hand or animal powered in small local operations, or part of a well-engineered system in plantation factories. The cane may be subjected to several successive expressions to extract the last bit of juice, the final one being undertaken after the nearly spent cane has been remoistened with water. The sugar content of sugarcane is about 12%. The fibrous residue of the sugar cane stem (bagasse) may be burned in the factory boilers, used for making fiberboard or paper, or composted to form an organic fertilizer.

Fig. 2. Planting sugarcane, Rharb Plain, Morocco. Women strip the cane before it is cut into pieces about a foot long and laid in trenches. [Photograph by Bill and Christina Graham, courtesy World Bank.]

The extracted sugarcane juice is handled in much the same way as the juice from the sugar beet. Successive boilings concentrate the sucrose, which under primitive circumstances may merely be dried to a sticky residue (the *rapadura* of Brazil) containing small percentages of other carbohydrates, proteins, and minerals. As such it is a nourishing staple in some countries where the

refinements of technology are lacking. In technologically advanced societies the sugarcane juice is treated in modern mills with steam-heated chambers and vacuum pans, and is clarified by chemical precipitation of unwanted materials. The treated extract passes through filter presses to yield a solution that consists almost entirely of sucrose. When this is further concentrated, sugar crystallizes and is usually removed from the remaining syrup by centrifugation. The liquid portion, still containing a few brownish "impurities," is molasses. Molasses is used in foods (both human and animal) or is fermented to make rum, alcohol, or vinegar. The raw crystallized sugar, about 96% sucrose, is refined by repeated washings and recrystallizations to satisfy the demand for a pure white sugar, completely free from brown but nourishing "impurities."