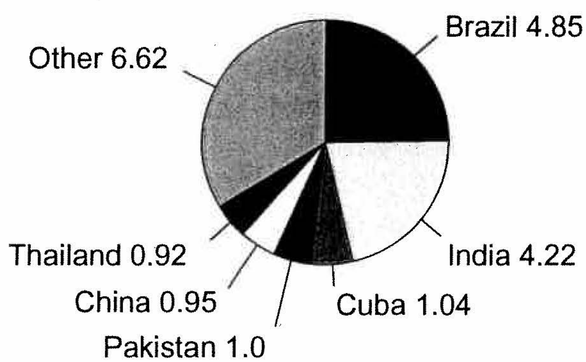
Sugarcane *Saccharum offcinarum*

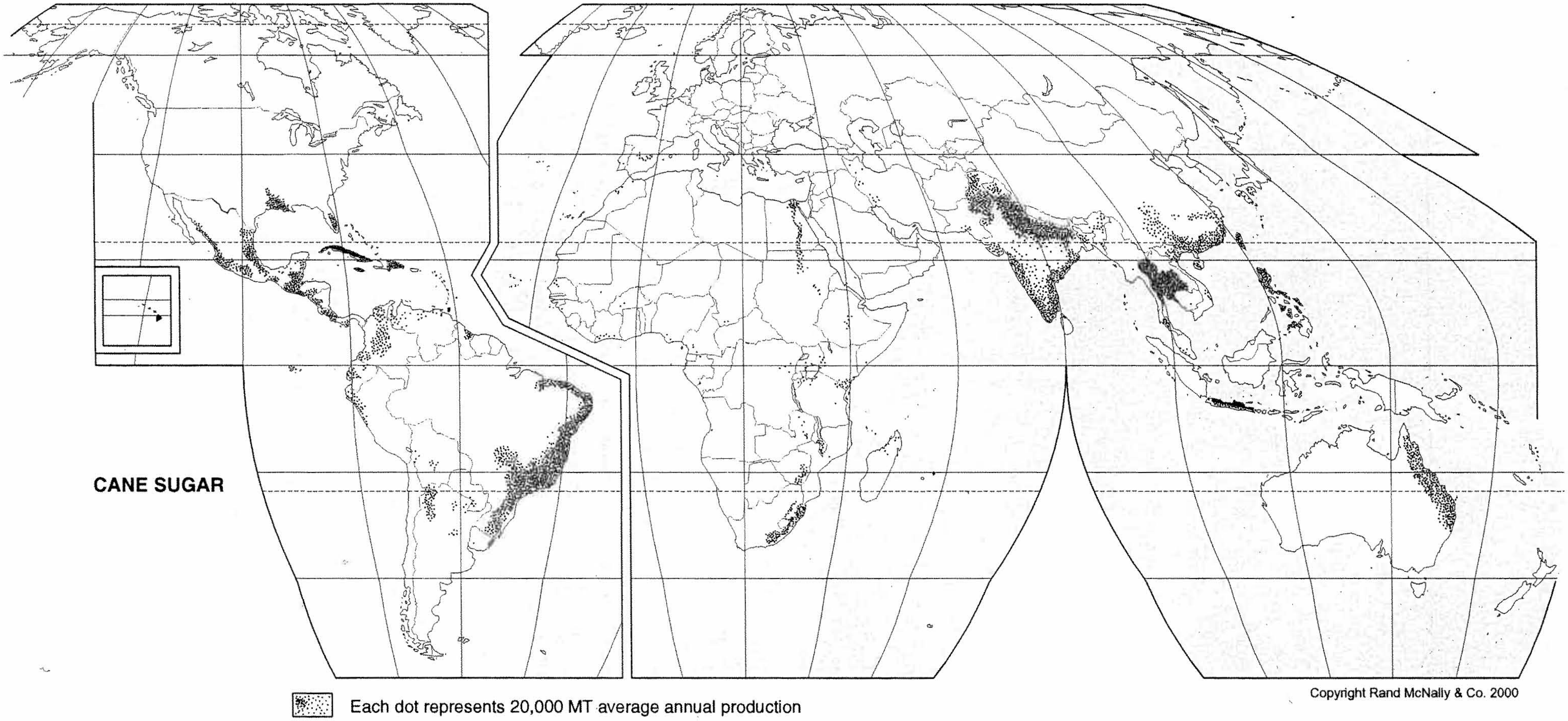
Production	
Area Under Cultivation	19.6 million ha
Global Production	1,255.8 million MT sugarcane 131.96 million MT sugar (from beet and cane)
Average Productivity	64,071 kg sugarcane/ha
Producer Price	$21 per MT
Producer Production Value	$26,217 million
International Trade	
Share of World Production	16%
Exports	35.0 million MT
Average Price	$229 MT
Value	$8,016 million
Principal Producing Countries/Blocs (of sugarcane by weight)	Brazil, India, China, Thailand, Pakistan, Mexico, Australia
Principal Exporting Countries/Blocs (of sugar from cane)	Brazil, Australia, Thailand, Cuba, South Africa, Guatemala,
Principal Importing Countries/Blocs (of sugar)	Russia, Indonesia, Japan, Korea, United States, United Kingdom, Malaysia
Major Environmental Impacts	Conversion of primary forest habitat Soil erosion and degradation Agrochemical use Organic matter from processing effluents
Potential to Improve	Poor Price too low to improve industry or genetics BMPs are known but producers are set in their ways Subsidies for sugar beets and market barriers in developed countries are disincentives for producers to change

Source: FAO 2002. All data for 2000.
Note: Raw sugar is equal to 17% of sugar cane by weight.
Sugar is produced from sugarcane and sugar beets. Sugarcane is a grasslike plant grown in the tropics. Sugar beet is a tuber grown in temperate climates. While this chapter focuses on sugar cane, FAO statistics do not distinguish sugar from cane or from beet.

Sugar

Area in Production (MMha)





CANE SUGAR

Each dot represents 20,000 MT average annual production

Chapter 7

Sugarcane

Overview

It is not known precisely when sugar was first made by boiling the stems of the plant *Saccharum officinarum*. However, the plant and the technology are known to have originated in India. The word "sugar" has been traced back to Arabic (*sukkar*) and Sanskrit (*sarkara*). Initially, sugar was used for religious ceremonies and as a medicine to treat ailments ranging from leprosy to gallstones (Swahn 1995).

It appears that in about 500 B.C. residents of present-day India began to make sugar syrup, which was then cooled in large flat bowls to make crystals that were easier to transport and store. In the local language the pieces of crystal were called *khanda*, which is the source for our word candy (Swahn 1995). These pieces were lifted out of the bowls and put in bags where they were squeezed to remove the remaining liquid. These cakes of dried crystals were ideal for transport and trade.

By the fourth century A.D., sugar production had spread throughout India. By the fifth century, the Chinese were growing and making sugar. In the sixth century, sugarcane was cultivated in Persia. The Persians invented sugar loaves, which took their classic cone shape from the conical clay vessels used to crystallize the sugar. These vessels had holes in the bottom to allow liquid to escape. The conical loaves were associated with the sugar trade for more than a thousand years. In fact, Rio de Janeiro's distinctive mountain is known as Sugar Loaf because of its distinctive conical shape and because sugar was an early and commercially important product of the colony (Swahn 1995).

When the Arabs conquered Mesopotamia, they also gained access to sugar production technology that was subsequently spread by the Moors throughout northern Africa, Sicily, the Middle East, and even into Spain. However, sugar's breakthrough into non-Moslem Europe owed more to the Crusades than to Spain. Crusaders to the Middle East became acquainted with and liked sugar. This subsequently created demand for the product. When the Normans conquered Sicily in 1072, Europeans controlled their first sugar-producing area. As demand emerged, the Italian ports of Genoa and Venice became the main trade ports for Europe (Swahn 1995).

Spain and Portugal gained considerable knowledge of sugar from the occupying Moors. After the Moors were expelled, they used this knowledge to spread sugar use and production throughout the tropics. Within fifteen years of Columbus discovering the Americas, the Spaniards began to plant sugar in Hispaniola (modern Haiti and the Dominican Republic) (Swahn 1995). Sugar, more than any other crop, encouraged the rapid expansion of the slave trade. Because of Spain's control of the Low Country (Holland), all sugar from the New World came into Europe through Rotterdam, where it was processed from brown, conical loaves into white sugar. At that time, sugar was so expensive that it was only consumed by the elite. As a status symbol and during special occasions, sugar crystals were often tied in small bundles and suspended over the tables of those who could not afford to consume it.

Today, although sugar has very little nutritional value, it (or other sweeteners) is found in almost all processed foods. Sugar makes up 20 percent of the calories consumed by Americans, who eat nearly half a kilogram (about a pound), on average, every 2.5 days.

Producing Countries

Sugar is produced from sugarcane and also from sugar beets. Sugar produced from cane is the focus of this chapter, except where the statistics cannot be separated or when discussing subsidies or product substitutes that have an impact on cane sugar prices and/or production. The Food and Agriculture Organization of the UN (FAO 2002) identifies 103 countries that produce sugarcane. Globally, 19.6 million hectares were devoted to the crop in 2000. Brazil and India have by far the most land devoted to sugarcane with 4.8 million and 4.2 million hectares, respectively. Four other significant producers—Cuba, Pakistan, China, and Thailand—each have around a million hectares. Brazil and India account for 46 percent of all land globally devoted to the production of sugarcane. Cuba, Pakistan, China, and Thailand collectively account for 21 percent of all land planted to sugarcane. The total of these six countries, 67 percent of all production, is precisely the same proportion they represent of land planted to sugarcane. Table 7.1 shows that in several smaller countries sugarcane occupies more than half of all land devoted to agriculture.

Table 7.1 Percentage of Agricultural Land Devoted to Sugarcane Production, 1994

50 Percent or More	25–49 Percent	10–24 Percent
Antigua	Cuba	Congo
Bahamas	Fiji	Costa Rica
Barbados	Jamaica	Dominican Republic
Belize	Martinique	Haiti
Guadeloupe	Puerto Rico	Liberia
Mauritius	St. Kitts/Nevis	Papua New Guinea
Réunion	St. Vincent	Swaziland
	Trinidad/Tobago	

Source: FAO 1996.

In 2000, average yields, globally, for sugarcane were 64,071 kilograms per hectare per year. While no country produces twice the global average, several—Burkina Faso, Chad, Egypt, Ethiopia, Malawi, Peru, Senegal, Swaziland, and Zambia—average production of more than 100,000 kilograms per hectare per year. The overall uniformity of yields globally implies that there are no significant new technologies or innovative production systems available that are sufficiently widespread to boost yields in a whole country and that most of the existing technology is fairly well distributed throughout the world.

The FAO reported global production to be 1.26 billion metric tons of sugarcane or 132 million metric tons of sugar in 2000. Global sugar production by volume (including sugar beets) is dominated by the European Union, India, Brazil, United States, China, Thailand, Australia, Mexico, Cuba, South Africa, and Pakistan; these countries combined account for some 70 percent of production globally. World exports are dominated by Brazil, the European Union, Australia, Thailand, and Cuba.

As Table 7.2 demonstrates, sugar is Cuba's leading export, as well as a primary export for a number of countries that are not among the top producers of sugar or sugarcane. Annual sugar exports represent some 30 percent of global production (FAO 2002).

Table 7.2
Sugar's Ranking of Total Exports by Value for Selected Countries, 1990–1991

Leading Export	Second Largest Export	Third Largest Export
Cuba	Dominican Republic	Bahamas
Guyana	Guadeloupe	Jamaica
Belize	Trinidad/Tobago	Panama
St. Kitts/Nevis	El Salvador	Cape Verde
R<\#142>union	Guatemala	Congo
Fiji	Barbados	Malawi
	Antigua/Barbados	Mauritius

Source: UNCTAD 1994.

World sugar production has exceeded consumption for the past six consecutive years according to the International Sugar Organization (ISO). This has led to a fourteen-year price low. The last time this happened was in the mid-1980s. It took three years for the surplus to be sold when the markets turned around. The previous surplus happened even when Brazil, the largest producer, had reduced sugar exports in order to produce fuel alcohol from sugarcane because of increasing petroleum prices. The current overproduction is related to Brazil's reentry into the international sugar market through the reduction of fuel alcohol production after successful efforts to find petroleum and lower world prices for oil. There is simply too much productive capacity throughout the world at this time, so chances of sugar prices increasing are slim for the near future.

Consuming Countries

Globally, sugar is considered a staple food by many consumers. Sugar, refined or otherwise, is used in most processed foods currently on the market globally. While there have been considerable efforts to find cheaper vegetable and chemical substitutes as well as more expensive organic or healthy alternatives, the rate of consumer acceptance is less than expected. Perhaps part of the reason is that the cost of some substitutes for conventional sugar, e.g. organic sugar, is five to ten times the price of sugar on the world market. For most consumers, the flavor of substitutes, their availability or price, or the changes of consistency or texture that they impart on finished products are not acceptable. Consequently, hundreds of billions of pounds of sugar are consumed each year.

India is the leading sugar consuming country, followed closely by the European Union. The United States, Brazil, and China also have high per-capita levels of sugar consumption.

The main importers of both raw and refined sugar are Russia, Indonesia, Japan, Korea, the United States, the United Kingdom, and Malaysia. The U.S. quota system for imports limits total supply to U.S. markets. Imports from China, Indonesia, and Russia have not been enough to reduce the overall stocks on world sugar markets.

Price supports in the United States and the European Union keep sugar at just over 44 cents per kilogram (20 cents a pound). The international price, however, is usually half or even less than that. In 1998 raw sugar prices fell to 15.4 cents per kilogram (7 cents per pound), and in 1999 prices fell to less than 9 cents per kilogram (4 cents per pound). These are the lowest sugar prices since the mid-1980s. There are specific reasons. In addition to Brazil's increased sales mentioned in the previous section, the Russians and Indonesians are importing less sugar due to their financial crises.

Production Systems

Sugarcane is grown in tropical lowland climates. It is produced almost exclusively between latitudes of 30 degrees south and 30 degrees north and is most concentrated between 20-degrees. While sugarcane production is often thought of as being produced only on islands or in coastal areas, it is also grown on extensive areas of former tropical forests in countries such as Uganda. Because sugarcane is a grass, most producers feel that it can be grown even on the steepest hillsides. Sugarcane requires intense sunlight and at least 1,650 millimeters of rainfall. Furthermore, the rainfall must be distributed throughout the year. Otherwise sugarcane requires considerable irrigation. The plant performs best in nutrient-rich soils with a high water retention capacity and with pH values that are weakly acidic to neutral. Overall nutrient requirements are quite high. While pest and disease problems have been reduced through breeding programs, biological pest controls are increasingly important at least in part because they lower overall production costs. Sugarcane is mostly grown in large monocrop plantations.

The first planting of cane matures in fourteen to eighteen months. Subsequent harvests occur every twelve to fourteen months. Productivity declines after each harvest, so the useful life of a planting does not exceed four to five harvests. This can be reduced even further through mechanical harvesting, which can pull up as many as 10 percent of the plants per harvest.

Throughout the world, most of the activities associated with planting, cultivating, and harvesting sugarcane are done by hand. After digging a shallow trench, cuttings of sugarcane stalks are laid side by side, slightly overlapping, and then covered with soil. The cane soon sends up shoots that can grow to as tall as 6 meters with stalks that are 5 centimeters thick. Rows are planted in a parallel pattern, separated by a meter or less of land. Sugarcane fields are weeded, usually by hand, two to three times during the first year, and then harvested after twelve to eighteen months. One metric ton of cane produces as much as 125 kilograms of refined sugar.

Fields must be weeded between each cutting. Production declines over time, but the overall return on investment makes it cheaper to harvest the declining yields than to replant the crop each year. Nitrogen-based fertilizers are applied to increase production, especially during subsequent years of production. In most parts of the world, sugar plantations are burned to eliminate the dead lower leaves of the plant and to kill or remove snakes before harvesting by hand.

Machines have been developed to open the furrows for planting, to cultivate the crop between harvests, and even to harvest the cane. However, in many areas where sugar is grown, labor is cheaper than machinery and more efficient. Furthermore, the most efficient machinery is too large to negotiate many of the hilly areas or is too heavy and sinks into the soft wet soils that are considered ideal for sugarcane cultivation. Mechanical harvesters are used in parts of the United States and in places such as southern Brazil, but the mechanical harvesters pull up much of the cane, forcing landowners to replant in half the time. In addition, about 10 percent of the harvest from mechanical harvesters is waste material compared with 1 percent when harvested by hand.

The major technological innovations regarding sugar production have occurred during the past century, particularly with regard to transportation and processing systems. Prior to these innovations, a single animal walking around a small screw press was the way most sugarcane was pressed. The juice was then cooked down and poured into molds to form hard brown cakes ("rapadura") of a uniform size and weight. For local trade, the molds used were often made from wood and were flat and rectangular so that smaller amounts could be sold. These processes were not very efficient. The presses, for example, left a lot of juice in the cane as well as impurities in the extracted juice. Much of the innovation of the past 150 years has focused on improving the process of refining pure white sugar on or near the plantations where the cane is produced.

Over the past century, more efficient metal roller presses were developed that increased the quality of production. In addition, the technology allowed far more cane to be processed. However, these innovations were much more expensive and required larger quantities of cane in order to be economical in operation. This had the net effect of bringing much larger areas of cane under the influence of single factories that were owned by individuals wealthy enough to afford the up-front investments in the new technologies.

As the areas brought under the control of these sugar factories increased (and, consequently, as the market standards of refined sugar increased as well), the ability of small farmers to continue to compete in sugar processing declined. In the past, sugarcane workers had been given land to grow their own food and animals. As the competition for land for sugar increased, as local populations increased, and as the global markets for sugar both increased and became more competitive, the compensation for workers shifted to wages. Increasingly, sugarcane was cultivated as a monocrop for as far as the eyes could see.

Over decades the production of sugarcane has expanded and contracted depending on the global price for sugar as well as the price for other crops that could be produced on the same land. Cotton was one of the crops often substituted for sugarcane, depending on how favorable the international price was for one vis-á-vis the other.

During this process of the consolidation of the industry, sugar-producing areas became characterized as the "haves" and the "have-nots". As technology improved sugar cultivation and processing, as other regions of the world have been brought into production, and as a number of natural and chemical substitutes have been developed, the price of sugar has fallen. Individual landowners and/or factory owners have been able to maintain their standards of living only by eliminating competition from their own ranks as well by as maintaining their work force in conditions of semislavery. Many analysts have suggested that the production of sugarcane has caused more misery than any other crop on the planet.

International prices are low and workers are paid poorly. In some cases, their wages do not cover the calories that they burn on the job. Working conditions, whether on the production or processing side, are among the most hazardous of any agricultural industry. In Northeast Brazil—the largest and most populous impoverished area in the Western Hemisphere and one of the longest standing sugar producing regions of the world—sugarcane workers have the lowest life expectancy of any group and their children have the highest infant mortality rates. Even in the United States, where sugar prices are usually double and sometimes triple international levels, traditional sugar harvesting has been described as "the most perilous work in America" due to the snakes, sharp machetes, dust and ash, and heavy raw materials (Wilkinson 1989).

Processing

The cane is cut in the field and transported to the sugar mills. Timing is essential. The longer the cane sits the more the sugar in the stalk converts to starch, and as a consequence less sugar can be extracted. Farmers are paid for the quality of their cane. At the factory, the cane is crushed between heavy, toothed metal rollers. This yields most of the sugar juice that is subsequently refined into sugar. In addition, however, the ground plant parts are subsequently leached to yield even more sugar.

Sugar represents a mere 17 percent of the biomass of the sugarcane plant; the remaining 83 percent is discarded as "bagasse"—the generic term for everything that is left after the sugar has been extracted. Bagasse is often incinerated and therefore can contribute to global warming. It is sometimes sold and used for fuel, animal fodder, or soil amendments. Burning is not necessarily bad; the burning of bagasse as fuel can reduce the need for other fuels that may release more carbon. In addition, if the bagasse is allowed to decompose it may produce methane that could be even worse for global warming.

When sugar mills are flushed—usually once a year—a tremendous amount of organic matter is released. Usually the mills are washed out and the organic matter is dumped straight into streams. The decomposition of this matter reduces the oxygen levels in the water and can result in fish kills. This is a particular problem in tropical rivers that are already low in oxygen. For example, in 1995 the annual cleaning of sugar mills in the Santa Cruz region of Bolivia resulted in the deaths of millions of fish in local rivers.

Substitutes

There are several other crops that produce sugar and sweeteners. These crops include sugar beets as well as corn or sorghum, which produce nonsugar sweeteners. Sugar from beets, however, is identical for all intents and purposes with sugar produced from cane. It is substitutable in recipes and confections and the two are substituted for each other globally. Beet sugar could not be produced competitively, much less exported without subsidies.

In general these sugar substitutes developed as a way to avoid dependence on imported sugar from the tropics. The environmental impacts of each are somewhat different from those of sugarcane, but because the substitutes can be substituted in the marketplace for many different uses depending on price, it is important that they be discussed in any overall discussion of sugar.

More than fifty countries produce sugar from beets cultivated on 6.8 million hectares. Sugar beets tend to be produced in countries with cooler climates and limited growing seasons (e.g. countries with frosts and/or distinct rainy seasons). The countries that dominate sugar beet production are in temperate climates, e.g. the Ukraine, Russia, the United States, Germany, and Turkey. All have 500,000 hectares or more of production. These five producers account for half of all land in sugar beet production. In general, however, sugar beet production appears to be undertaken on a fairly limited basis primarily aimed at supplying domestic markets.

Sugar beets can be grown in any area that supports root crops. In the United States, they tend to be grown in drier areas and are often irrigated. In other parts of the world, they are only produced in rain-fed areas.

Another substitute for cane sugar as a sweetener is corn syrup. The United States is one of the largest corn syrup producers in the world. The market for corn syrup (and sugar beets) in the United States was created as a result of a policy of price supports for sugar. The artificially high sugar price has stimulated the production of corn syrup and sugar beets, and it is doubtful that much sugar from beets or sweetener from corn would be produced if the United States dropped its price support subsidy for sugar.

Sorghum can also be used to make molasses and other sugar substitutes. It is not clear how much of the current sorghum planted in the world is being used for this purpose. Sorghum can be grown in rotation with corn, but due to its lesser value tends to be grown on the drier edges of corn producing regions or within less productive areas.

A number of artificial sweeteners have also been discovered. NutraSweet and saccharin have both been developed as calorie-free substitutes for natural sugar produced from either sugar beets or cane.

Finally, a number of natural sweeteners are being developed. Stevia has been extracted from the plant of the same name in Paraguay and Bolivia. It has 3,000 times the sweetening power of sugar. It is being grown in Canada as a crop substitute for tobacco. Monsanto and other corporations are interested in developing it if they can find a way to patent the process for extracting it. (Their patent on NutraSweet recently ran out.) In addition, Xylitol, another natural sweetener, has recently been introduced into the market. It is extracted from hydrolyzed hemicellulose, the "black liquor" from the waste from pulp and paper mills. Xylitol is 50 percent sweeter than sugar, does not create plaque on teeth, and is low in calories. It is quite likely that within a decade a viable alternative to sugar will be discovered. Whether it is widely accepted or not will depend on how it substitutes for sugar chemically in baking and manufacturing processes. Any significant substitution, however, would generally lead to lower sugar prices and the conversion of some producers, at least, to other crops.

Market Chain

Much of the sugar in the world is produced on land that is owned by the same companies as the factories that refine the sugar and add value to the production. In Florida, for example, two corporations grow more than 65 percent of the sugarcane produced statewide. However, most sugarcane in the world is produced by growers who sell it to the sugar mills. There are rarely two or more mills close to growers. As a consequence, there is no significant competition between buyers for cane. Factories determine prices and often use out-sourced sugar from independent cane growers to improve their overall profitability.

Traditionally, factories sell their sugar to national suppliers, wholesalers, distributors, or traders. The larger factories and traders tend to export whatever quotas or allotments are allowed from the country. In the past, governments tended to dominate sugar markets, both internal and external.

Most sugar goes into confections, whose manufacturers tend to want just-in-time delivery. While many will forward-contract product to ensure delivery and to lock in prices, they do not want their capital tied up in stored product that also requires expensive space. For this reason, traders, wholesalers, and distributors tend to hold most of the product until required by others. Only a small proportion of all sugar is sold directly to the consumer.

Market Trends

World sugar production has increased 181 percent since 1961. International trade in sugar has grown from 20.6 million metric tons to 35 million metric tons over the same period, an increase of 70 percent. Meanwhile prices have declined in real terms by 46 percent during the same period (FAO 2002).

The world sugar market is suffering from oversupply. This is partly the result of decreased consumption of sugar in developed countries. It also results from the increased production of sugar in developing countries and stable production of sugar in developed countries as a result of agricultural subsidies and market protection. In addition, the increasing presence of artificial sweeteners has dampened overall demand for sugar.

Sugarcane and sugar beets would not be grown in developed countries but for subsidies and market barriers. In the United States, for example, subsidies guarantee domestic prices and import policies keep cheaper, foreign sugar out of the country. As a consequence, U.S. prices are normally twice that of global prices and sometimes as much as three or four times as high. Ultimately, it is the U.S. consumer who pays this price.

Such subsidies and price supports also ensure the production of sugarcane in areas where it should not be planted. This includes the Everglades. There are more than 180,000 hectares of sugar planted in the Everglades Agricultural Area, which blocks the natural flow of water through the Everglades. According to the U.S. General Accounting Office, Americans pay an average of $800 million to $1.9 billion in subsidies and price supports for two main companies (and other smaller ones) to plant sugarcane in the area. In addition, the government pays millions of dollars more to buy back the sugar that these companies cannot sell. The industry also uses hundreds of billions of gallons of South Florida water for irrigation and processing and pays only minimal water taxes (Grunwald 2002).

The contradictions of the sugar economy are clear. The price of U.S. sugar is set at two to four times the international price. Americans are forced to buy sugar that domestic companies could not sell anywhere else. In addition, however, they are also required to pay to clean up the environmental problems of the industry. Finally, they will be asked to buy the lands that are valued at artificially high prices due, at least in part, to sugar subsidies.

Like the United States, Europe also pays farmers to produce sugar beets at an artificially high price. However, Europe goes even further to encourage more production than can be consumed in Europe. It then subsidizes the export of this sugar onto the world market, where it competes directly with unsubsidized production from developing countries. Thus, the European Union not only denies developing countries access to its sugar market, but it competes with them for other markets as well. In both cases, subsidized domestic prices and reduced access to developed-country markets reduce the price paid for sugar in the rest of the world and, as a consequence, tend to increase the environmental impacts of its production.

Sugar from sugar beets cannot compete with sugar from cane in the global marketplace unless sugar beet production is subsidized or cane sugar is subjected to a tariff. This works the same as subsidies but distributes costs differently. Governments, especially those of the United States and the European Union, continue to subsidize sugar beet production. It is not clear how long such subsidies will be tolerated under the regulations of the World Trade Organization. In addition, both the United States and the European Union protect domestic sugar production in developed countries through production subsidies and market barriers. Europe even supports subsidized exports of beet sugar that compete internationally with exports of cane sugar from developing countries. If there is political will to negotiate these issues in overall trade policy, then the production of sugar beets will decline and much of that nearly 7 million hectares will gradually be converted to other uses. More importantly, sugar markets in developed countries will open up to cane sugar from tropical producers.

Environmental Impacts of Production

Sugar has arguably had as great an impact on the environment as any other agricultural commodity. Most of the environmental damage was loss of biodiversity, the result of wholesale conversion of habitat on tropical islands and on coastal areas. While the impact of this conversion can never be documented because it happened hundreds of years ago, in all likelihood considerable endemic flora and fauna unique to the many thousands of islands on which sugar was planted was lost.

The cultivation of sugar has also resulted in considerable soil erosion and degradation as well as the use of chemical inputs to correct the resulting problems. As a consequence, sugar has also had an important impact on other ecosystems. For example, sugar production has changed coastal hydrology. Siltation from soil erosion has clogged coastal ecosystems, especially coral reefs and sea grass beds, which are important to a wide range of species. Nutrient runoff from sugar cultivation has led to nutrient loading and eutrophication of freshwater and marine systems. Finally, sugar mills are cleaned periodically, and the organic matter that is flushed can tie up all oxygen in nearby rivers as it decomposes. This in turn asphyxiates fish and other aquatic organisms.

Habitat Loss

It is quite likely that the production of sugarcane has caused a greater loss of biodiveristy on the planet than any other single agricultural crop. First, with nearly 20 million hectares in cultivation, sugarcane has more area devoted to it than most cash crops produced in the tropics. Second, sugarcane production has caused the clearing of some of the most unique and biodiverse regions on the planet. For nearly 500 years, tropical forests, the entire natural habitat of thousands of islands, and millions of hectares of fragile coastal wetlands around the world have been cleared or otherwise converted for planting sugarcane.

In fact, it is quite likely that but for sugarcane, any map of globally significant, biodiverse ecoregions would look quite different. For example, because of sugarcane, the Caribbean is not considered significant biologically, nor are any of the islands (except New Guinea) in greater Southeast Asia. Even in areas where sugarcane is grown that have been identified for priority biodiversity salvage work, its cultivation has shaped the strategic prioritization of ecologically significant sites for conservation activities. Priorities in the Everglades, for example, do not include the sugarcane production areas, nor do the priorities in the Atlantic coastal forest of Brazil, the largest sugarcane producing area in the world.

In short, sugarcane production has altered forever the landscape in many unique parts of the world. A brief glance back at Table 7.1 indicates the overall importance of the crop relative to all other forms of agricultural land use in a number of countries. A dozen countries around the world devote 25 percent or more of all their agricultural land to the production of sugarcane.

Soil Erosion and Degradation

During land preparation, there is a tremendous impact on soils as they are laid bare to be planted with cane. Aside from being stripped of any protective cover, the soils dry out, affecting overall microorganism diversity and mass, both of which are essential to fertility. Exposed topsoil is easily washed off of sloping land, and even on lands with minimal slope nutrients may be leached from the topsoil.

In some areas, such as the Everglades in the United States, the production of sugarcane has contributed to the subsidence of the land. This can result both from the removal of groundwater for irrigation, or the drying out and compaction of land that had previously contained high levels of organic matter.

Sugar processing harms the soil as well. The continual removal of cane from the fields gradually reduces fertility and forces growers to rely increasingly on fertilizers to replace it. The removal of plant matter from the fields makes the production of sugarcane unsustainable as it is currently practiced. In most of the world, sugarcane production is little more than a "mining" operation that strips the resource base. Bagasse, the organic matter left after crushing the liquid from it, is put to work as fuel for the cauldrons or sold as animal feed. If returned to the fields at all it is only in the form of ash, which is of little benefit to soil microorganisms.

Effluents

Silt from eroded soils and nutrients from applied fertilizers often foul local water supplies. Another problem with sugarcane production is nonpoint-source pollution of water with pesticides, which is caused either by drift from spraying or by percolation of water through the soil. Effluents are also created from sugarcane processing, as discussed in the next section. Effluent flows into water supplies, and into important ecological areas such as the Everglades, need to be reduced. However, corrective measures may have their own environmental costs. From 1980 to the crop year 2000–01, acreage planted to sugar in Florida increased from 130,000 to 183,000 hectares (320,700 to 460,000 acres). There has even been a 10 percent increase in the area planted to sugar since 1995. Because of environmental concerns with water quality, large areas previously planted to sugarcane have been removed from production. Consequently, production has intensified in the remaining areas and expanded onto sandy soils, which by 2001 represented 22 percent of all sugarcane cultivation. Production in those areas is high initially, but because such soils are easily leached, production can only be maintained over time with increasing applications of fertilizer (University of Florida 2002).

Processing Waste, Emissions, and Wastewater

In addition to the impacts from production, there are a number of environmental problems at the mill. These fall into three categories--wastewater, emissions, and solid waste. Wastewater includes the water used to wash all incoming cane (10 cubic meters for each metric ton of cane), water from the boiler house used to concentrate the sugar and evaporate the water, and water from cleaning all the equipment. Perhaps the greatest environmental threat from processing occurs when mills are cleaned and thoroughly washed out, which occurs once or twice per year. The resultant impacts are not from toxic chemicals, but rather from the release of massive quantities of plant matter and sludge. As these decompose in freshwater bodies they absorb all the available oxygen, which in turn leads to massive fish kills.

In addition, mills release flue gases from the combustion in the boiler rooms. The flue emissions also include soot, ash, and other solid substances. Ammonia is released during the concentration process.

Better Management Practices

Sugarcane growers in a number of different countries have been attempting to reduce the impacts of sugarcane production, both with and without the help of government. On the one hand, cane growers in Australia have developed two separate sets of guidelines to meet and exceed government environmental requirements, the Canegrowers Code of Practice for Sustainable Cane Growing in Queensland and the Canegrowers Fish Habitat Code of Practice (see http://www.qff.org.au/) (Canegrowers 1998). Similarly, growers in

Florida and Louisiana have developed their own improved practices to meet increasingly strict environmental regulations. On the other hand, sugarcane producers in countries such as Zambia have been forced to address some of their effluent issues because they threaten the assets of other downstream resource users (e.g. hydroelectric dams, local communities).

Most of the better management practices for sugar production involve the reduction of soil erosion and the building of soil to ensure long-term production with the use of fewer inputs. Building up levels of organic matter in the soil can also reduce the need for other key inputs such as pesticides, fertilizers, and water. One of the key ways to reduce the input use and to build the soil is to increase organic matter by not burning sugar fields prior to harvest. Finally, there are a number of ways to reduce wastes and effluents from processing. Each of these better management practices is discussed below.

Implement Soil Conservation Practices

Sugarcane is currently grown on many steep slopes and hillsides (as in Northeast Brazil and many other regions). Many of these areas should be taken out of production because of the high rates of soil erosion that result from cultivating them. In a number of instances, removing these areas from production and replanting them to trees (e.g. fruit, nuts, wood) would actually encourage increased production in the adjacent, better-suited agricultural lands. Increased attention of producers on their better lands would tend to increase total production more than when producers focus on reducing losses on poorer soils. Put another way, producers will increase overall production when they focus on raising the average production level on the better lands rather than trying to obtain marginal production levels on less productive lands. In addition, reforesting hillsides would improve overall water retention and hydrology and provide more gradual water release, which could improve yields and reduce the need for supplemental irrigation.

At the very least, implementing standard conservation techniques, such as contour plowing and terracing, in many parts of the world would decrease soil erosion and degradation and actually allow soil to be rebuilt over time. Such practices would also contribute to greater water retention. Soils should be covered at all times to keep topsoil from washing away, so that soil composition and vitality is not degraded. Any areas of slope should be planted before periods of heavy rains and irrigated, if necessary, until the rains arrive. Riparian areas should be left intact so that the plantings are not washed out, the soil eroded, biodiversity lost, and wildlife corridors destroyed.

Additional practices can be incorporated into overall management strategies to improve productivity in the short, medium, and long term. These include crop rotation, green manuring, and enriched fallowing or nutrient banking. These practices should be considered as investments for future savings and increased profits, as they will reduce the need for purchased agrochemicals in the future. Enriched fallowing, for example, uses deep rooted perennials to draw nutrients up to the surface where they can be utilized more effectively by shallow rooted commercial crops such as sugarcane.

Several conservation strategies could contribute to greater income for sugar plantations. The planting of fruit trees, for example, would not only provide food for wildlife, it would also give sugar plantations the ability to do value-added processing of jams, jellies, and juices. Cellulose from trees grown on such areas could be fed into paper pulp processing plants along with the bagasse to make the quality and consistency of paper more uniform.

Improve Pest Control and Management

Most sugar producers can improve their overall pest control and management systems. One way to do this is through integrated pest management (IPM) practices that allow producers to reduce the overall impacts of pesticide use. First and foremost, producers should plant pest-resistant cane varieties to reduce the need for pesticides. When pesticides are necessary, producers should identify and use those that are least toxic to control the pests on their crop. The pesticide used should be the most targeted one available rather than a broad-spectrum formulation. This will reduce the potential build-up of pest resistance, particularly of nontarget species. Similarly, there should be no prophylactic use of pesticides. Scouting and periodic monitoring allows producers to apply pesticides only when and where they are most needed, thus reducing overall use. Economic thresholds can be used to determine when pesticide applications are used. In other words, the losses from some pests may not justify the use of pesticides at all. Pesticides should only be applied at or below recommended dosages. They should not be applied when wind will cause drift and should be avoided during the rainy season or just prior to large forecasted rains. Finally, filter strips of vegetation should be planted around fields not only to control erosion, but also to reduce dissolved pesticide flows into surface or ground water (LSU 2002).

Eliminate Burning Prior to Harvest

Burning of cane fields prior to harvest should be abandoned. The practice of burning fields prior to harvest kills much of the wildlife that has managed to survive in sugarcane fields to that point. If the fires are not monitored, they can easily get out of control and burn into neighboring areas. Often what is burned are riparian areas or slopes that are too steep to plant. Both of these areas, however, can be rich in biodiversity that can be destroyed by uncontrolled fires. In some countries it is against the law to burn cane fields and violators are fined severely. But this is not the case in most developing countries.

More important from the point of view of producers, not burning fields prior to harvest improves profits. When growers abandon burning practices, they can harvest some 5 percent more sugar that had previously been lost as a result of burning. This more than compensates for the marginal labor increases involved in harvesting.

Finally, when fields are not burned, organic matter builds up, as much as 20 metric tons of organic matter per hectare from the leaves that are left in the field. Spraying the cane debris with microorganisms that hasten decomposition can break up the vegetable matter into manageable fractions that are more quickly reintegrated into the soil. This partially decomposed organic matter can act as a mulch for the crop. Mulch offers the advantage of holding in moisture, bonding with fertilizers and pesticides, reducing weed growth, and increasing productivity and net profits by reducing overall input use.

Reduce Nutrient Loading and Water Pollution

In some areas, progress has been made in reducing the water pollution from sugarcane production. As a result of a lawsuit, the Everglades Forever Act was created to require the state of Florida to build the world's largest system of artificial marshes to act as biological filters (biofilters) to remove nutrients in runoff entering the Everglades. In addition, the sugar industry was required to reduce the phosphorus content of its effluent by 25 percent. Over the past six years, the industry has actually reduced the phosphorus in its effluent by more than 56 percent (Grunwald 2002). Companies were able to achieve these results by reducing their overall use of fertilizers, using retention basins to hold water longer on the properties, and cleaning their ditches and canals more often.

In 2001, phosphorous levels in farm effluent were 64 parts per billion. This level was reduced to 30 parts per billion after the water left the constructed biofilters. While this is a good start, and well below the concentrations of 400 parts per billion in Miami tap water, most scientists agree that levels in the Everglades need to be reduced to 10 parts per billion or less if the ecosystem is to recover (Grunwald 2002).

While it is clear that the sugar companies are working to reduce their impacts, many still question whether it is enough. The industry, for example, is paying only one third of the cost of creating the artificial wetland biofilters. Instead of funding the cleanup, the industry spent $30 million to fight a proposal of taxing sugar $0.01 per pound to pay for the cleanup. There are now plans for the government to buy and retire 24,000 hectares of sugarcane land (Grunwald 2002).

Reduce Wastes and Effluents from Processing

Sugar processing wastes can also be treated so that they have far fewer harmful impacts. For example, before it is released to streams or waterways sludge can be treated with microorganisms ("activated") so that it decomposes more quickly. Microorganisms already exist that can be used to accelerate decomposition. A redesign of holding lagoons would allow them to be activated more easily for early and rapid decomposition. The treated effluent could then be returned (pumped) back to the soil both as a fertilizer and a source of energy for soil microorganisms.

Bagasse is another 20 metric tons of organic matter that is produced per hectare. Fiber represents almost 50 percent of the biomass of bagasse. This fiber could be used to make paper (as is already done in India), or alternatively for cement board additives. Sugarcane produces a fiber harvest once a year. But sugarcane plantations in any given area tend to be harvested over much of the year. If sugarcane came to be used as fiber, it is not clear whether the sugar or the fiber would have the highest value.

Outlook

Sugar consumption is increasing globally. Economic growth and increases in disposable income in developing countries will increase sugar consumption because sugar is an ingredient that is used increasingly in fast food, prepared foods, and drinks of all kinds, the types of food that are consumed more as income increases. However, production has increased even faster than consumption, and this is likely to continue as many producers in many parts of the world have made significant investments in the cultivation of sugar.

The one outstanding factor that could affect sugar production globally would be a change in policies in the United States and the European Union. These would include the elimination of production subsidies, price supports, market barriers, and export subsidies. If these policies were altered in such a way that eliminated market protection, then sugar in developed countries (from beets or from cane) would have to compete with cane sugar produced in the tropics. While it is clear that production in the tropics would expand, it is not clear that a significant portion of that expansion would be at the expense of natural habitat. However, the price of sugar would probably increase to the point that production would be intensified in many developing countries. This would have harmful environmental impacts, but at least there would be more money available to address those impacts. Furthermore, markets in developed countries might play an instrumental role in providing incentives to clean up the industry.

Resources

Web Resources

www.sugarinfo.co.uk
www.canegrowers.com.au
www.sugaronline.com/iso
www.sugartraders.co.uk
www.sugar.jcu.edu.au
www.sugaralliance.org

Additional resources can be obtained by searching on "sugar" or "sugar cane" on the WWF International Intranet:
http://intranet.panda.org/documents/index.cfm

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