

SUGARCANE PRODUCTION AND RESEARCH IN CHINA

By

CHEN RUKAI and ZHAONIAN YUAN

Key Lab of Genetic Improvement for Sugarcane, Ministry of Agriculture, Fuzhou 350002
yzn05@sina.com

KEYWORDS: Industry, History, China, Research, Production.

Abstract

THIS PAPER describes the progress of the sugarcane industry in China, as well as the major characteristics of sugarcane production systems and R&D. Over the past 8 years, production area expanded by 47.87%, total sugarcane production increased by 79.54%, cane yield per hectare by 21.26% and annual sugar production by 83.12%. Sugar consumption in China has also grown steadily. Sugarcane was mainly grown in Central-South Guangxi, Southwest Yunnan, West of Guangdong and Northern Hainan. For energy production from sugarcane, national research projects have been carried out. Pilot study showed that the cost of ethanol production from sugarcane could be reduced to US\$0.50/L, which was more economic than gasoline at US\$70 per barrel. The problems facing the industry and their possible solutions are also discussed.

The history of sugarcane production in China

China is one of the original producers of sugarcane. Bamboo Cane (*Saccharum sinense*) and wild species (*S. spontaneum*) are widely distributed, from the North Qinling Mountains to the South Hainan Island. Sugarcane cultivation has a long history; since the late 4th century BC, China has used sugarcane to produce syrup.

Since the establishment of new China, sugarcane production has increased significantly. From 1949 to 2008, the total area of sugarcane plantation extended from 0.108 million to 1.475 million ha, cane production from 2.643 million to 113.0 million tonnes, cane yield per ha from 24 to 75 tonnes and total sugar production from 0.15 million to 13.697 million tonnes.

Sugarcane status of China

Major statistics for sugarcane production from 1997 to 2008 are listed in Table 1, and similar information for major production provinces from 2001 to 2008 in Table 2. In 2008, sugarcane plantation area was 1.521 million ha, which accounted for 71.4% of the total area for sugar plantations.

Total sugarcane production was 110.711 million tonnes, which produced 13.697 million tonnes of cane sugar. Compared with the 2001/2002 crushing season, production area expanded by 47.87%, total sugarcane production increased by 79.54%, cane yield per hectare by 21.26%, and annual sugar by 83.12% (Tables 1 and 2).

In December 2001, the State Council launched the Food and Nutrition Development Plan in China (2001–2010). This Plan aimed to increase sugar intake by 9 kg per person by 2010, which was equivalent to a total of 12 million tonnes of white sugar.

Before 2000, Chinese sugar consumption averaged about 8 Mt/y. It then increased to 10 Mt in 2003 and 11.4 Mt in 2004.

The average consumption of sugar per person per year in China was about 8.4 kg, which was among the lowest in the world. For sugar consumed in China, 72.6% was used in the food industry, 26.2% by households, and less than 1.2% for export. Sugar consumption has been increasing steadily due to the rapid development in the food, restaurant and catering industry (Table 1).

Table 1—Sugarcane industry in China from 1997–2008.

Items	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Area (M ha)	1.058	1.149	1.012	0.975	1.029	1.092	1.174	1.205	1.214	1.318	1.521
Cane processed (M t)	64.461	69.119	58.871	56.995	66.499	83.071	76.552	69.369	66.199	87.713	114.790
Total sugar yield (M t)	6.779	7.568	6.207	5.506	7.470	9.396	9.438	8.571	8.008	10.745	13.697
Sugar output (%)	10.52	10.95	10.54	9.66	11.23	11.31	12.33	12.36	12.10	12.25	11.92
Cane/sugar ratio	9.51	9.13	9.49	10.35	8.90	8.84	8.11	8.09	8.26	8.16	8.40
Consumption (Mt)	8.30	8.00	8.10	8.50	9.15	10.00	11.40	10.50	10.80	12.50	13.50

Sugarcane growing areas in China

The major sugarcane production area in China is located between latitude 18.5° to 32°N and longitude 92° to 122°E that includes Guangxi, Yunnan, Guangdong, Hainan, Fujian, Taiwan, Zhejiang, Sichuan, Guizhou, Hunan and Jiangxi provinces (or Autonomous Regions). Before the late 1980s, coastal areas in southeastern China such as Guangdong and Fujian were the main sugarcane producing areas. Since then, sugarcane production gradually shifted to the west to more sustainable production. So the current major production areas include Guangxi, Yunnan, Guangdong and Hainan provinces. In 2007/2008 season, 9.37 million tonnes of sugar was produced in Guangxi, which was equal to 68.5% of total sugar production, the largest producer in China. Yunnan produced 2.163 million tonnes, or 15.8% of the total production, which made it the second largest. Sugar production in western Guangdong was 1.454 million tonnes per year, the third largest. The combined sugar production from these three provinces accounted for 94.8% of the total production in China. Dominant production regions in these provinces were central-south in Guangxi, southwest in Yunnan, western in Guangdong and northern in Hainan (Figure 1).



Fig. 1—Major sugar producing areas (shaded) in China

Main features of sugarcane production systems

There were about 5 million farms. The average farm size was only about 0.27 ha and produced an average of 18 t cane. Planting, weeding, cultivation, fertilising, spraying and harvesting were still done by hand. Fertiliser was used excessively, especially nitrogen, at three times the world average, while the usage efficiency was low. It resulted in soil acidification and degradation as well as pollution. Most of the sugarcane fields were dry slopes with infertile soil. The average available irrigation was below 20 percent irrigation. Rainfall distribution was uneven and seasonal natural disasters such as drought and frost happened frequently. All these had an adverse impact on sugarcane production. For example, the frost in 1998–1999 and the drought in 2005–2006 caused serious damage to sugar production. Sugarcane smut, ratoon stunting disease, mosaic and other diseases caused more than a 20 percent reduction in production. Borers and soil-borne pests (e.g. *Dorysthenes granulosis*, grub) were found in over 60% of sugarcane plantations, which caused the loss of sugar content of over 0.5%. Improper usage of pesticides polluted the environment. Varieties from Taiwan Sugar were grown in more than 70% of the total sugarcane plantation area, varieties bred in mainland China less than 30%.

In 2006–2007, China had 212 sugar mills, of which 90% were in Guangdong, Guangxi and Yunnan. They were able to process 780 000 tonnes of cane per day, 18.2% higher than the capacity at the beginning of this century. There were 17 sugar enterprises with daily processing capacity exceeding 10 000 t cane, such as South China Sugar Co., Guangxi Farming Co., Fengtang Biochemistry Co., Yingmao Sugar Co. and Zhanjiang Farming Co. Energy consumption for processing 100 t cane was equivalent to 4.97 t standard coal, which was 20.5% less than 2002 or the lowest in history. Processing of 1 tonne of cane consumed 30.86 kWh of power, 2.7% less than 2002. Ratio of white sugar to cane was 12.23%, 1.28% higher than the beginning of this century. The sugar industry saved energy and increased efficiency remarkably. The major statistics of the industry are presented in Tables 2 and 3.

Main institutes doing sugarcane R&D in China

In China, the major sugarcane research institutes are the Sugarcane Synthetic Institute of Fujian Agriculture and Forestry University, Guangzhou Sugarcane Industry Research Institute, Guangxi Sugarcane Institute and the Sugarcane Institute of Yunnan Academy of Agricultural Science.

The institute of Fujian Agriculture and Forestry University has undertaken sugarcane research and development for 54 years. It established the first Sugarcane Branch of the National Sugar Crop Improvement Centre and managed a number of research laboratories and organisations; notably, the Key Laboratory of Sugarcane Genetics and Improvement of the Ministry of Agriculture, Cane Sugar Inspection Centre of the Ministry of Agriculture, Sugarcane Society of the Chinese Crop Society and National Sugarcane Variety Accreditation Committee. The Institute had the authority to award masters and PhD degrees and also hosted post-doctoral workers.

Professor Chen Rukai, the discipline leader, is a member of the Science and Technology Commission of the Ministry of Agriculture, and a chief scientist in sugarcane. In his institute, there are 6 professors who are national-level scientists in sugarcane research and 13 associate professors. The Institute has 30 staff and 30 to 40 graduates, and it is engaged in sugarcane research and development including genetics and improvement for sugar and energy sugarcane, nutrition management, pest control, agricultural mechanisation and industrial economy.

Guangzhou Sugarcane Industry Research Institute has undertaken sugarcane research and development for 50 years. It was under the former Ministry of Light Industry, and now it is the National Centre for Sugar Quality Inspection, Guangdong Branch of National Sugarcane Improvement Centre, and National Sugarcane Hybridisation Station in Hainan.

Table 2—Major technological indices of China's sugarcane growing areas in recent years.

		01/02	02/03	03/04	04/05	05/06	06/07	07/08	07/08	
									Proportion of total of China/%	Increment compared to 2001/2002 (%)
Average	Area million ha	1.029	1.092	1.174	1.205	1.214	1.318	1.522	100.00	47.87
	Total yield (Mt)	63.934	72.365	77.470	80.535	79.848	89.910	114.787	100.00	79.54
	Cane yield (t/ha)	62.10	66.30	66.00	66.90	65.70	68.25	75.30	100.00	21.26
	Total sugar yield/%	7.470	9.396	9.436	8.571	8.008	10.745	13.670	100.00	83.12
Guangxi	Area(ha)	508 000	573 333	684 000	684 000	766 667	814 000	966 667	63.57	90.41
	Total cane yield (Mt)	32.299	39.266	46.931	47.294	52.862	57.524	76.510	66.65	136.88
	Cane yield (t/ha)	63.60	68.55	68.55	69.15	69.00	70.65	79.05	104.98	24.29
	Total sugar yield %	4.430	5.610	5.880	5.320	5.377	7.086	9.372	68.51	111.56
Yunnan	Area (ha)	266 667	273 333	260 000	286 667	244 860	285 627	313 333	20.59	17.50
	Total cane yield (Mt)	14.683	15.942	15.087	17.256	13.592	16.695	17.960	15.65	22.32
	Cane yield (t/ha)	55.05	58.35	58.05	60.15	55.50	58.50	57.30	76.10	4.09
	Total sugar yield %	1.4350	1.8900	1.9501	1.5920	1.4130	1.8315	2.1625	15.81	50.70
Guangdong	Area (ha)	149 333	142 667	126 667	135 333	126 367	138 000	166 667	9.20	11.61
	Total cane yield (Mt)	11.079	10.9367	9.203	9.932	9.546	10.907	14.490	12.62	30.79
	Cane yield (t/ha)	74.25	76.65	72.60	73.35	75.60	79.05	87.00	137.45	39.39
	Total sugar yield %	1.044	1.165	0.985	1.121	0.922	1.279	1.453	10.63	39.20
Hainan	Area (ha)	60 000	60 000	63 333	70 000	60 000	60 667	80 000	5.26	33.33
	Total cane yield (Mt)	3.166	3.460	3.685	4.185	2.789	3.517	4.400	3.83	38.99
	Cane yield (t/ha)	52.80	57.60	58.20	59.85	46.50	58.05	55.05	73.11	4.26
	Total sugar yield %	0.3040	0.420	0.408	0.385	0.178	0.375	0.517	3.78	69.90

Source : Chinese Sugar Industry Association

Director Li Qiwei is engaged in sugarcane breeding and cultivation and is responsible for the Guangdong Sugarcane Society. He is also the executive member of China's Sugarcane Special Committee.

The institute has 4 national-level scientists, 30 researchers and associate researchers, and a staff of 120 members who work in sugarcane genetics and breeding, cultivation, plant protection, sucrose and ethanol processing, and sugar quality inspection. It is an assistant institute for the national projects undertaken by Fujian Agriculture and Forestry University.

Guangxi Sugarcane Institute is the Sugarcane Research Centre of the Chinese Academy of Agricultural Sciences, Sugarcane Variety Inspection Centre of Ministry of Agriculture, and Guangxi Branch of National Sugar Improvement Centre. It has 3 national-level experts, 20 researchers and associate researchers, and a staff of 160 members engaged in sugarcane breeding, cultivation and pest control. It is also in charge of two prepared projects for the National Science and Technology support plan, as an assistant institute for national projects undertaken by Fujian Agriculture and Forestry University.

The Institute of Yunnan Academy of Agricultural Sciences is the Yunnan Branch of National Sugar Crop Improvement Centre, and National Sugarcane Germplasm Resources Base is an assistant institute for national projects undertaken by Fujian Agriculture and Forestry University. Director Zhang Yuebin is engaged in sugarcane cultivation research. The institute has 3 national-level experts, 20 researchers and associate researchers, and a staff of 60 members.

Table 3—Technological indices of China's sugar processing industry in recent years.

Index	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07
Cane processed (Mt)	66.499	83.071	76.552	69.369	66.169	87.713
Sucrose content of cane %	13.56	13.25	14.30	14.28	13.95	14.56
Sugar output (Mt)	7.613	9.449	9.450	8.573	8.022	10.745
Recovery in refining %	88.66	88.92	89.61	89.48	88.18	88.96
Overall recovery/%	85.48	85.30	85.90	85.80	85.09	85.38
Percentage of sugar output /%	11.68	10.95	12.34	12.36	12.13	12.23
Energy consumption as t coal equivalent per 100 t cane	6.43	6.25	5.81	6.00	6.23	4.97

To centralise the management of scientific research and prevent repetition at a low level, the Ministry of Agriculture and Ministry of Finance has appointed a number of scientists nationwide to build a national sugarcane industrial technology system under the guarantee of retaining the current administrative relationship.

The system is divided into two layers, including one national sugarcane industrial technology research and development centre and 15 extension stations. Based on the Fujian Agriculture and Forestry University, the research and development centre consists of 5 programs.

They are: sugarcane genetics and improvement with 6 scientists, nutrition and cultivation with 4 scientists, plant protection with 5, facilities and equipments with 3, and the processing and industrial economy with 2. Major participants are the Fujian Agriculture and Forestry University, Guangzhou Sugarcane and Sugar Industry Institute, Guangxi Sugarcane Institute, Yunnan Sugarcane Research Institute and South China Agricultural University.

Professor Chen Rukai has been appointed as the chief scientist. Lin Yanquan, Li Qiwei, Huang Chenghua, Ou Yinggang and Zheng Chuanfang have been appointed as program leaders. Meanwhile, 15 extension stations have been established based on provincial and district level that are based on Nanning, Chongzuo, Laibin, Liuzhou, Bose, Beihai, Nongken of Guangxi; Suixi, Zhanjiang of Guangdong; Kaiyuan, Lincang, Baoshan of Yunnan; Zhangzhou of Fujian; Nankang of Jiangxi; Zhanzhou of Hainan.

Fifteen directors have been appointed for the stations for a 5-year term with funds from government. In the current administration system, the projects are structured in a vertical fashion. The cooperation among different sectors of the industry, regions and disciplines should accelerate sugarcane industrial technology progress.

Prospects for future: further expansion

From 1996 to 2007, China's sugar consumption increased from 7.8 million to 13.4 million tonnes, with an annual increase of 0.46 million tonnes. Based on this rate, the domestic sugar demand will reach 17 million tonnes by 2015, of which 13 million tonnes will come from cane sugar, 2.5 from corn, and 1.5 from sugar beet. This requires an extra 2 million tonnes of cane sugar based on the 10.75 million tonnes of cane sugar production in 2007. It is predicted that by 2015 total sugarcane area would be around 1.6 million hectares, cane yield 75 tonnes per hectare and total cane yield 12 million tonnes. With this prediction, the targeted sugar production could be met.

In China, the 'Renewable Energy Law' has come into effect, and the standards of 'Denaturalised Fuel Ethanol' and 'Gasoline Alcohol' have been established. The 863 Nation High Technology Project on energy sugarcane and sugarcane ethanol has started and is making progress. The concept of diversified ethanol materials has been extremely popular. The cost of ethanol is \$0.25/L in Brazil, \$0.50/L in USA, also \$0.50 /L in China. Ethanol at \$0.50/L is more cost-effective than gasoline at \$70 per barrel in the market. In South China, sugarcane does not compete with grain crops for land and water. In Yunnan, Guangxi, Guangdong, Fujian and Hainan, there are still about

0.67 million ha of land that can be used to grow energy sugarcane, and it could produce 5.88 million tonnes of sucrose or 3.84 million tonnes of ethanol. It is beneficial to the environment because it will reduce pollution caused by automobiles. The development of the sugarcane ethanol industry will optimise the production structure of the sugarcane industry, stabilise the sugarcane growing areas, and increase farmers' job opportunities and incomes.

The Chinese sugar industry produces 4.40 million t molasses annually, which can be used to produce 800 000 tonnes of fuel ethanol. It also produces 26.57 million tonnes of bagasse with 50% water content. Bagasse can be used to produce 8 million tonnes of paper pulp or a 1600 MW power plant to produce 11.2 billion kWh of green power per year. The cellulose and hemicellulose of bagasse are high quality raw materials for future industrial use to produce fuel ethanol.

In the coming 5 years, the major tasks in China sugarcane research and development will be as follows:

- Selection of new sugarcane varieties with high yield, optimal quality, resistance to diseases and pests, strong ratooning ability for the dominant sugarcane growing areas; this is necessary in order to solve present problems in production such as few varieties, same maturity periods, low sugar yield, deficiencies in rural labour forces, lack of machinery, severe diseases and pests, effects of toxic pesticides on environment, high production costs.
- A system of production technologies including mechanisation, water-fertiliser management, intercropping, diseases and pest control, along with more varieties with a wide range of maturing periods. Production trials and demonstrations in large areas of these technologies should be conducted in different ecological regions, from which to form a practical production system with high efficiency and low cost.
- Development and demonstration of techniques on water use efficiency, intercropping systems (sugarcane and leguminous), harvest machinery systems, and the integration of cultivation and varieties
- Research from the viewpoint of the sugarcane industry facing the challenge of growing population, resource and environmental pressures.

RECHERCHE ET PRODUCTION DE LA CANNE A SUCRE EN CHINE

Par

CHEN RUKAI et ZHAONIAN YUAN

Laboratoire de l'Amélioration Génétique de la canne à Sucre,

Ministère de l'Agriculture, Fuzhou 350002

yzn05@sina.com

Mots Clés: Industrie, Histoire, Chine, Recherche, Production.

Résumé

Cet article décrit l'état d'avancement de l'industrie de la canne à sucre en Chine, les principales caractéristiques des systèmes de production, ainsi que la Recherche et le Développement. Au cours des 8 dernières années la superficie de production s'est étendue par 47.87 %, la production totale de la canne à sucre a augmenté de 79.54 %, le rendement de canne à l'hectare de 21.26 % et la production de sucre annuelle de 83.12 %. La consommation de sucre en Chine a également connu une croissance constante. La canne à sucre a été principalement cultivée au Centre-Sud Guangxi, au Sud-Ouest de Yunnan, à l'Ouest de Guangdong et au Nord de Hainan. Pour la production d'énergie à partir de la canne à sucre, les projets nationaux de recherche ont été effectués. Une étude pilote a montré que le coût de production de l'éthanol à partir de la canne à sucre pourrait être réduit à 0,50 \$ US/L, qui était plus économique que l'essence à US\$ 70 le baril. Les problèmes auxquels fait face l'industrie et les solutions possibles sont également abordées.

PRODUCCION E INVESTIGACIÓN DE CAÑA DE AZÚCAR EN CHINA

Por

CHEN RUKAI y ZHAONIAN YUAN

Key Lab of Genetic Improvement for Sugarcane, Ministry of Agriculture, Fuzhou 350002

yzn05@sina.com

PALABRAS CLAVE: Industria, Historia, China, Investigación, Producción.

Resumen

Este trabajo describe el progreso de la industria azucarera en China, así como las principales características de los sistemas de producción y de investigación y desarrollo (R&D en inglés). Durante los últimos 8 años, el área total de producción se expandió en 47.87%, la producción total de azúcar se incrementó en 79.54%, el rendimiento de caña por hectárea mejoró en un 21.26% y la producción anual de azúcar en 83.12%. El consumo de azúcar en China también ha tenido un crecimiento estable. Los cultivos de caña de azúcar estaban principalmente en la Región Centro-Sur de Guangxi, al suroeste de Yunnan, al Oeste de Guangdong y el norte de Hainan. Se han realizado proyectos de investigación a nivel nacional para la producción de energía proveniente de la caña. Un estudio piloto demostró que el costo de la producción de etanol de caña podía reducirse a USD 0.50/L, lo que es más económico que el precio de la gasolina a USD 70 por barril. Los problemas que enfrenta la industria y sus posibles soluciones también son discutidos.