

# Sugarcane Agriculture and Sugar Industry in China

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**Abstract** China is the world's third largest sugar producing country after Brazil and India. During milling years 2004/2005 and 2013/2014, the average yearly sugar production in China was 11.64 MT, 49.86 % more than in the previous decade. However, the major increase came from Guangxi province, which produced 7.21 MT sugar per annum in average in recent decade, increased by 104.25 % compared to the production of 3.53 MT sugar per annum in average during 1994/1994 and 2003/2004. Sugarcane contributed more than 90 % of the total sugar production in recent decade. Chinese sugar industry encompasses 270 operating sugar mills, 233 sugarcane, and 37 sugar beet. In the milling year 2007/2008, the total sugar production in China reached 14.83 MT, which was 24.04 % higher than that in previous milling year; and cane sugar production reached 13.67 MT, which occupied 92.18 % of the total. However, the severe low temperature and drought occurred almost every year since 2008, which caused continuous in cane and sugar productivity in the subsequent years. The sugar production began recovering since 2011/2012, and

reached 13.32 MT sugar in 2013/2014, still 10.18 % lower than that in 2007/2008. Guangxi is the largest sugarcane and sugar producer in China, 9.41 MT sugar in 2007/2008, and 8.56 MT sugar in 2013/2014. Besides, many products, such as pulp, paper, alcohol, yeast, xylitol, chemicals, cane juice, bio-manure, feed, and electricity are also produced from sugarcane. The sugar industry is also the major contributor to the socio-economic development of the major cane producing areas especially Guangxi, Yunnan and western Guangdong.

**Keywords** Sugarcane · Sugar beet · Sugar · Alcohol · Limitation

## Introduction

China is the world's third largest sugar producing country after Brazil and India. Recently, this industry produces about 13 MT sugar and many other products such as pulp, paper, alcohol, yeast, xylitol, chemicals, drinking cane juice, bio-manure, feed, and electricity. During the past decade, more than 90 % of the sugar production was contributed by sugarcane. Sugarcane is a major crop in southern China, especially in Guangxi, Yunnan and western Guangdong. Guangxi is the dominant sugarcane and sugar producer in China. It is the contribution of Guangxi making China the third biggest sugar producer in the world. In fact, the sugar production in Guangxi has taken a decisive position in the sugar production and safety in the country (Li 2004a, b, 2005a, b, 2006; Li and Wei 2006; Li and Yang 2008, 2009; Li 2010; Wei and Li 2006). In 2013/2014 milling season, the total sugar production in China was 13.32 million tons of sugar, and 12.57 million tons were from sugarcane.

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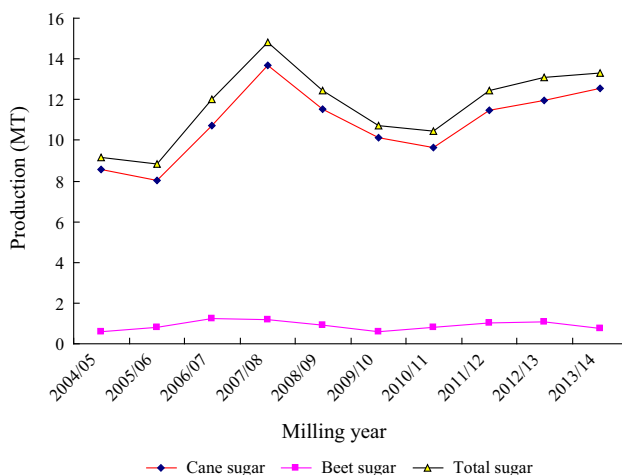
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## General Information

The sugar production in China is in parallel with the cane sugar production because 90 % or more of the sugar was produced from sugarcane, and it attained a boost during milling years 2006/2007 and 2007/2008 from 2005/2006 (Fig. 1). China produced 11.99 tons of sugar in the milling year 2006/2007, which was 36.06 % higher than that in 2005/2006 and; 14.87 million tons in 2007/2008, which was 24.04 % higher than that in 2006–2007. The cane sugar production reached 10.75 tons in 2006/2007, which occupied 89.66 % of the total sugar production and; 13.67 million tons in the milling year 2007/2008, which occupied 92.2 % of the total sugar production. However, the severe low temperature and drought have occurred almost every year since 2008, which caused continuous decreasing in cane and sugar productivity in the subsequent time in Guangxi and Yunnan, and the decreasing trend reached the bottom in the milling year 2010/2011. The sugar production began recovering since 2011/2012, and reached 13.32 MT sugar in 2013/2014, but 10.18 % lower than that in 2007/2008. Guangxi is the largest sugarcane and sugar producer in China, and it produced 9.41 MT sugar in 2007/2008, and 8.56 MT sugar in 2013/2014. Figure 1 also showed that sugar beet and sugarcane contributed about 6–10 and 90–94 %, respectively to the total sugar output in China.

Chinese sugar industry encompasses 270 operating sugar mills, among them, 233 for sugarcane, and 37 for sugar beet, and they belong to 48 sugar groups. Besides, there are 11 sugar refinery factories. Many products, such as pulp, paper, alcohol, yeast, rum, xylitol, chemicals, cane juice, bio-manure, feed, and electricity are also produced from sugarcane and sugar beet. The Chinese sugar industry contributes about GDP 6–8 billion RMB Yuan (1



**Fig. 1** Sugar production from milling years 2004/2005–2013/2014 in China

USD = 6.15 RMB Yuan approx.), about 0.1 % of the total GDP in China, but it is important for ensuring the basic sugar supply in China because the sugar consumption has been increasing very fast in recent years, and it is necessary to ensure at least 70 % of sugar consumption by domestic production. Based on the statistical information, the sugar consumption was 13.50 MT in 2011/2012 and 13.90 MT in 2012/2013. The sugar production could not meet the demand of domestic market. In fact, sugar import has been increasing year by year in China, which was 292 MT in 2011, 375 MT in 2012, and 4.45 MT in 2013. In fact, the sugar import is stimulated by the big difference of sugar price between domestic and international markets although it may have been too much for the domestic market in the recent 2 years. For example, the average sugar price was 5653 RMB Yuan per ton in China while the international sugar price dropped down from US 22–16 cents per pound (2983–2169 RMB Yuan per ton) in 2012/2013; and the average sugar price was 4550–4600 RMB Yuan per ton in China while the international sugar price dropped down to 15 cents per pound (2034 RMB Yuan per ton) in 2013/2014. Besides, China produced 9.5 MT starch sugar and 3,000 tons of saccharin in 2013. The comprehensive factors have been making a very difficult time for Chinese sugar industry.

However, sugar industry is the major contributor to the socio-economic development of the major sugarcane producing areas especially for Guangxi, Yunnan and western Guangdong areas. In Guangxi, for example, the GDP of sugar industry was 43.58 billion RMB Yuan, contributing to 3.33 % of the total GDP in Guangxi, and farmers' income from sugarcane reached 32.26 billion RMB Yuan in 2012/2013. There are more than 20 million populations in the sugarcane producing area of this province, and sugar industry also provides many opportunities for other industries such as transportation, marketing and employment.

The major cane sugar producing provinces in China are Guangxi, Yunnan, Guangdong and Hainan, and the major beet sugar producing provinces are Xinjiang, Heilongjiang and Inner Mongolia, and the other sugar producers contributed very little (Table 1). In fact, over 60 % of the total sugar in China has been produced by Guangxi since 2007/2008, and its contribution is getting more and more important. In 2013/2014, Guangxi produced 8.56 million tons of sugar, that is, 64.3 % of the total sugar and 68.1 % of the cane sugar in the country.

The dramatic expansion of sugarcane growing area in China in recent years (Table 2) is mostly due to the stimulation of the good sugar price in both international and domestic markets before 2013/2014, so the sugar mills increased the price of millable canes. The yearly average millable cane price was 230 (27.8), 280 (35.9), 267 (36.5),

**Table 1** The sugar production (million ton) in the major provinces in China since 2004/2005

| Year      | Total | Guangxi | Yunnan | Guangdong | Hainan | Xinjiang | Heilongjiang | Inner Mongolia | Others |
|-----------|-------|---------|--------|-----------|--------|----------|--------------|----------------|--------|
| 2004/2005 | 9.17  | 5.32    | 1.59   | 0.90      | 0.39   | 0.35     | 0.13         | 0.07           | 0.42   |
| 2005/2006 | 8.82  | 5.38    | 1.41   | 0.92      | 0.19   | 0.44     | 0.18         | 0.13           | 0.17   |
| 2006/2007 | 11.99 | 7.09    | 1.83   | 1.28      | 0.38   | 0.71     | 0.24         | 0.20           | 0.26   |
| 2007/2008 | 14.84 | 9.41    | 2.16   | 1.45      | 0.52   | 0.61     | 0.31         | 0.18           | 0.20   |
| 2008/2009 | 12.43 | 7.63    | 2.24   | 1.06      | 0.46   | 0.41     | 0.29         | 0.16           | 0.18   |
| 2009/2010 | 10.74 | 7.12    | 1.77   | 0.86      | 0.32   | 0.38     | 0.09         | 0.07           | 0.13   |
| 2010/2011 | 10.45 | 6.75    | 1.76   | 0.87      | 0.23   | 0.43     | 0.18         | 0.11           | 0.15   |
| 2011/2012 | 11.52 | 6.94    | 2.01   | 1.15      | 0.31   | 0.47     | 0.28         | 0.14           | 0.22   |
| 2012/2013 | 13.07 | 7.92    | 2.24   | 1.21      | 0.50   | 0.55     | 0.24         | 0.16           | 0.25   |
| 2013/2014 | 13.32 | 8.56    | 2.31   | 1.19      | 0.42   | 0.45     | 0.03         | 0.17           | 0.19   |

270 (39.7), 263 (39.8), 344 (52.9), 476 (74.4), 493 (79.5), 469 (76.9) and 431 (70.1) RMB Yuan/t (US dollar/t) in 2004/2005, 2005/2006, 2006/2007, 2007/2008, 2008/2009, 2009/2010, 2010/2011, 2011/2012, 2012/2013 and 2013/2014, respectively. But at present, both sugar factories and farmers are having a difficult time as sugar and sugarcane prices have dropped down to a low level. The data in Table 2 also suggested that sugar crop productivity (yield) showed a continuous 3-year decreasing since 2007/2008 milling years, and this is mainly due to the severe extreme cold and rainy weather occurred in early 2008 which affected the ratoon crops dramatically, especially in Guangxi. The decreasing trend in sugar recovery since 2010/2011 was caused mainly by degradation of the main sugarcane variety ROC22 and frequent extreme bad weathers, such as frost and long duration of rain and weak sunlight during milling season in the main sugarcane producing areas.

As the largest sugar producing Province in China, there are 104 sugar mills in Guangxi belonged to 30 sugar groups or companies Ltd. with average daily milling ability of 6,652 tons of millable cane. Among 104 mills, 20 belong to 5 state owned or state-controlled enterprises, that is, Nanning Sugar (4), Guangxi State Farms Sugar Group Ltd. (9),

Guangxi Shang Shang Sugar Company Ltd. (1), and Cofco Tunhe (3), holding total daily milling ability of 1,36,300 tons; 14 belong to 3 foreign or foreign capital-controlled enterprises, that is, East Asia Sugar Group (6), Associated British Sugar (5), and Yongkai Sugar and Paper Group (3), holding total daily milling ability of 1,52,000 tons; and 70 belong to private or private-capital controlled enterprises, that is, Fengtang Group (10), Guitang Joint-stock (Group) Company Ltd. (1), Guangxi Nanhua Sugar (15), Dongtang Group (10), Yongxin Huatang Group (5), Ganhua Joint-stock Company Ltd. (3), Ouya Sugar (4), Xianggui Sugar Group (3), Shiji Feilong Sugar (3), Fenghao Sugar (2), Weiheng Sugar (2), Hengfu Sugar (2), Heshan Xiangxing Sugar Company Ltd. (1), Huanjiang Fengyuan Company Ltd. (1), Guigang Jintian Sugar Company Ltd. (1), Pubei Anzhai Sugar Company Ltd. (1), Jinxiu Dongda Sugar Company Ltd. (1), Qinzhou Huayu Sugar Company Ltd. (1), Guilin Yongfu Sugar Company Ltd. (1), Mengsh Yong'an Sugar Company Ltd. (1), Debao Huahong Sugar Company Ltd. (1) and Tianlin Fumin Sugar Company Ltd. (1), holding total daily milling ability of 39,6,900 tons.

Guangxi basically showed an increasing trend in sugarcane growing area (Table 3). By comparing the data in Tables 2 and 3, it is clear that the sugarcane growing area,

**Table 2** Planting area, yield, sucrose content and sugar recovery for sugarcane and sugar beet in China during 2004/2005 and 2012/2013

| Year      | Area (million ha) |      | Yield (t/ha) |      | Sucrose content (%) |       | Sugar recovery (%) |       |
|-----------|-------------------|------|--------------|------|---------------------|-------|--------------------|-------|
|           | Cane              | Beet | Cane         | Beet | Cane                | Beet  | Cane               | Beet  |
| 2004/2005 | 1.20              | 0.16 | 64.5         | 34.1 | 14.24               | 16.05 | 12.19              | 13.80 |
| 2005/2006 | 1.21              | 0.19 | 54.0         | 33.6 | 13.95               | 14.35 | 12.15              | 12.57 |
| 2006/2007 | 1.32              | 0.26 | 66.8         | 37.5 | 13.96               | 14.61 | 12.70              | 13.00 |
| 2007/2008 | 1.53              | 0.16 | 66.8         | 37.5 | 13.96               | 14.61 | 12.17              | 13.00 |
| 2008/2009 | 1.56              | 0.22 | 60.3         | 33.5 | 14.15               | 15.00 | 12.31              | 12.20 |
| 2009/2010 | 1.47              | 0.14 | 57.0         | 41.7 | 14.38               | 15.50 | 12.54              | 12.10 |
| 2010/2011 | 1.49              | 0.19 | 55.5         | 39.0 | 13.78               | 14.65 | 11.99              | 11.14 |
| 2011/2012 | 1.56              | 0.22 | 59.4         | 43.5 | 13.71               | 14.88 | 11.89              | 11.37 |
| 2012/2013 | 1.63              | 0.22 | 63.8         | 46.1 | 13.43               | 14.23 | 11.19              | 10.96 |

**Table 3** General information of the sugar production in Guangxi from 2004/2005 to 2013/2014

| Year      | Area (Mha) | Cane production (MT) | Sugar production (Mha) | Cane yield (t/ha) | Sucrose content (%) | Sugar recovery (%) | Farmers' income (RMB ¥ BY) |
|-----------|------------|----------------------|------------------------|-------------------|---------------------|--------------------|----------------------------|
| 2004/2005 | 0.63       | 41.85                | 5.32                   | 66.75             | 14.64               | 12.72              | 8.6                        |
| 2005/2006 | 0.72       | 43.53                | 5.39                   | 60.15             | 14.22               | 12.42              | 12.9                       |
| 2006/2007 | 0.81       | 55.91                | 7.09                   | 68.70             | 14.59               | 12.69              | 16.4                       |
| 2007/2008 | 0.92       | 77.10                | 9.41                   | 83.80             | 14.42               | 12.19              | 21.1                       |
| 2008/2009 | 1.01       | 61.30                | 7.64                   | 60.30             | 14.30               | 12.47              | 16.8                       |
| 2009/2010 | 0.96       | 55.69                | 7.12                   | 57.75             | 14.63               | 12.80              | 19.9                       |
| 2010/11   | 0.99       | 55.69                | 6.75                   | 56.25             | 13.93               | 12.12              | 27.6                       |
| 2011/2012 | 1.04       | 57.69                | 6.94                   | 55.50             | 13.85               | 12.04              | 29.0                       |
| 2012/2013 | 1.06       | 67.50                | 7.95                   | 63.90             | 13.58               | 11.78              | 32.3                       |
| 2013/2014 | 1.10       | 70.74                | 8.56                   | 64.31             | 14.10               | 12.10              | 31.0                       |

sugarcane and sugar productivity, sucrose content and sugar recovery in Guangxi were all higher than those of the national average. Although the sugar production was affected severely by two extreme low temperature attacks and one extreme severe drought suffering since 2008, the proportion of its sugar production to the total national production kept increasing. The millable cane productivity in Guangxi reached 83.58 t/ha in the year 2007/2008, but kept decreasing later. The reason for the considerable increase in the cane productivity during 2007/2008 was mainly due to the good rainfall distribution during the whole crop growth. There was no obvious autumn and winter drought, and the crop was flourished by heavy rains (about 25–50 mm in most areas) in December in the major sugarcane growing areas. A long duration of extreme low temperature and rainy weather occurred in Guangxi from January 12 to February 20, 2008 and most sugarcane was seriously damaged (Fig. 2), a frost occurred in December 2009 and another severe low temperature attack occurred again in December 2010, and serious drought also occurred from January to June 2010, which decreased the cane and sugar productivity considerably as compared with the normal conditions (Table 2). During the milling seasons of 2011/2012 and 2012/2013, extreme long durations of low temperature and rainy weathers in Guangxi resulted in the records of low sucrose content and low sugar productivity. According to the weather reports, there were more than 30 days of continuous rain, low temperature with frosts in Guangxi sugarcane growing areas. Even worse situation occurred in 2012/2013, the bad weather controlled almost whole milling season, and it recorded the worst weather with least sunlight in history. The bad weather also made sugarcane harvest and transportation very difficult.

## New Challenges for Chinese Sugar Industry

### Drought

Drought is the most important constraint for sugarcane and sugar productivity in China because more than 80 % of sugarcane is grown in the upland areas where irrigation is not available (Li 2004b, 2005a, 2006; Li and Yang 2008, 2009). Drought occurs very often in the major sugarcane growing areas, especially in the spring and autumn, which affects cane productivity severely.

### Natural Disasters

Recently, natural disasters occurred frequently in China, which have imposed serious loss to China sugar production since 2008/2009. The long duration of severe low temperature, frosts, floods, and rainy and cloudy days occurred in the major sugarcane growing areas Guangxi and Yunnan.

### Insect Pests and Diseases

The most important insect pests in China are borer, thrips, aphid etc. that was reported previously (Li 2004a), and longhorn beetles are getting more and more serious in recent years (Li and Yang 2008). Because of serious singleness of sugarcane variety in the main sugarcane growing areas, that is the variety ROC22 occupies almost 70 % of the total sugarcane area for more than 10 years already, and this variety is susceptible to smut and borer, which has caused the prevailing of smut and borer in recent years, resulting in considerable loss in sugarcane and sugar pro-

**Fig. 2** Serious damage caused by the long duration of low temperature and rainy weather from 12 January to 20 February 2008 in Guangxi



ductivity. Other important diseases include ratoon stunting disease, mosaic, rust, etc.

#### Cost Escalation

The cost for planting sugarcane has been increased fast in China in recent years. Labor cost is a necessary expense for field management and harvest. At present, mechanization is accounting for about 40–50 % field operations in sugarcane production but almost 100 % manual operation for cane harvest which cost 140–150 Yuan (22.8–24.4 USD) per ton millable cane in 2013/2004, and increased by 20 % as compared in 2012/2013. Fertilizers and chemical are in big inflation in recent years.

#### Over-Fertilization

In China, farmers usually apply 400–800 kg N, 150–300 kg P<sub>2</sub>O<sub>5</sub> and 250–500 K<sub>2</sub>O per hectare in sugarcane production, much higher than in other countries, especially the nitrogen application may be 3–10 times of that in Brazil. The over-fertilization not only increases the unnecessary production cost and wastes resources, but also causes serious environmental pollution in the agro-ecological system.

#### Short Ratoon Duration and Low Productivity in Ratoon Crops

The sugarcane production cycle is usually 3 years, that is, 1 plant crop and 2 ratoon crops. The main sugarcane variety ROC22 has poor ratoon ability, and cane productivity decreased rapidly in ratoon crops, and the cane yield may decrease by 50 % or more in the second ratoon crop. Short

production cycle also resulted in more farming operations and higher production cost.

### Technologies for Improving Sugar Productivity and Efficient Sugar Production in China

#### Variety Selection and Diversification

The heavy loss due to long duration of low temperature and rainy weather in recent years could be attributed to the result of singleness of sugarcane variety, as the variety ROC22 occupied over 65 % of the total sugarcane growing areas in China. This variety is cold sensitive, and almost 100 % of its crop suffered from the cold stress and faced more rapid decrease in sucrose content and worse ratoon performance, and this variety is also susceptible to smut and borer. In recent years, a group of new elite GT varieties have been released, and the varieties GT21, GT29, GT31, GT32, GT40, GT42 and GT43 have performed well in different areas. Compared with ROC22, they show higher productivity and stronger ratoon ability. We strongly recommend use multiple sugarcane varieties for each sugar mill, at least 8–10 varieties in 30:50:20 % for early: intermediate: late maturing varieties. Cold resistant varieties such as GT21, GT29, GT32 and GT40 should be selected in the northern areas such as Hechi, Laibin and Liuzhou areas in Guangxi.

#### Farming Technologies

In recent years, combined with new sugarcane variety breeding and popularization, we have exploited a series of

advanced appropriate farming technologies in commercial sugarcane production. These technologies include deep plough and fine preparation of soil, plastic film mulching, intellectual fertilization system, trash addition to field, water saving irrigation, pathogen free healthy seedcane, rational application of vinasse as a liquid fertilizer, chemical control, machine operation for sugarcane management, and comprehensive control of diseases, pests, weeds and rats, etc.

#### Deep Plough and Fine Preparation of Soil

Experiments (Ye et al. 1995; Liao et al. 2010) showed deep plough to 45–60 cm and fine preparation of soil increased soil moisture, which is good for germination and emergence, rooting, tillering and fast growing, and finally more millable stalks, thicker and longer stalk, and also good for improving the lodging resistance and sugar accumulation in stalk so resulting in 20 % or more increase in cane and sugar productivity of sugarcane in rain-fed upland field.

#### Plastic Film Mulching

Plastic film mulching is favorable to keep soil moisture and nutrients, and increased the soil temperature when seedcane were planted in winter and spring, so resulted in 10–20 days of earlier germination and emergence, improved emergence rate by 15.3–26.1 % and increased 15000–30000 plants/ha. Enough strong and uniform plants increased cane productivity by 14.96 %, and improved sucrose content by 0.53 % (Li 2010).

#### Intellectual Fertilization System

An intellectual fertilization system has been established for sugarcane based on years of related data. After application this system, farmers have decreased fertilizer application rate and production cost, improved cane productivity by 10–25 %, sucrose content by 0.4–0.8 %, and fertilizer use efficiency by 4.5–8.2 % (Li 2010).

#### Trash Retention in Field

Experiments from 1987 to 2010 showed that trash retention in field has improved soil structure and physico-chemical properties. As a result, soil organic matter level was increased from 1.79 to 2.60 %, total nitrogen from 0.09 to 0.14 %, available phosphorus from 13.37 to 43.25 mg/kg, available potassium from 79.63 to 233.33 mg/kg, and the average cane productivity was improved by 7.7 %. Trash addition to field significantly increased the microbe populations, and numbers of bacteria, fungi and actinomycetes were 2.38, 1.80 and 2.74 times as many as the conventional

control (Liao et al. 2013). Besides, trash addition to field is also good to keep soil moisture and control weeds (Li 2010).

#### Water Saving Irrigation

Water saving irrigation include spray and drip irrigation, which has been developing fast in China in recent years. Application of spray and drip irrigation (fertigation) saves water, fertilizer and labor. Experiments showed that fertigation application improved cane productivity by 19.2–56.4 %, realizing high productivity of 150–195 t/ha, improved fertilizer use efficiency by 90 %, and saved water by 30–60 % (Li 2010; Xu et al. 2010, 2011; Chen et al. 2012).

#### Healthy Seedcane

Pathogen free healthy seedcane technology has been applied for years in China. Experimental results proved that application of pathogen free healthy seedcane improved cane productivity by 15.1–52.1 % and sucrose content by 0.12–1.71 % because of removing various diseases such as ratoon stunting disease, mosaic viruses, yellow leaf disease, etc. in the seedcane (Li 2010). Using temporary immersion bioreactor system (TIBs) further increased the propagation rate up to 40 times compared with traditional tissue culture method (Yang et al. 2011a, b). However, in many places of Guangxi, the results were not good for application of the pathogen free healthy seedcane of ROC22, because long duration monoculture of ROC22 in large scale had already accumulated substantial pathogen of smut and pests that are keen to this variety in the environment. So the application of pathogen free healthy seedcane technology should be combined with propagation of newly released elite sugarcane varieties to speed up the extension of the new varieties.

#### Vinasse as a Liquid Fertilizer

Vinasse from sugarcane mills has been a very good liquid fertilizer for sugarcane, and a technological system has been developed for application in both plant and ratoon crops of sugarcane in China (Li 2010; Li et al. 2007, 2008; Zhu et al. 2009; Jiang et al. 2012; Su et al. 2012; Yang et al. 2012, 2013). Experiments proved that spraying 75 t/ha vinasse of Brix 6–8 in plant cane, and 105 t/ha vinasse of Brix 8–9, covered with plastic film, could ensure well growth of sugarcane plants without additional application of any chemical fertilizer, and improving cane productivity 10–30 %, and sucrose content 0.2–1.0 % compared with traditional fertilization control. Spraying vinasse with high

pressure spray gun could make very good soil coverage on the newly planted seedcanes.

### Chemical Regulation

Chemical regulation is very effective for promoting plant growth and improving sugar productivity in sugarcane production. Different concentrations of ethephon shows different physiological regulation effects on sugarcane, including promoting plant growth, improving drought and cold resistance, and improving cane and sugarcane productivities, so ethephon is a versatile growth regulator for sugar cane industry (Jian et al. 2012; Li, 2006, 2010; Li and Solomon 2003, 2004, 2006). Chemical ripening with glyphosate-borate complex and high concentration of ethephon are very effective to promote sugar accumulation in sugarcane and improve sugar productivity (Li 2004c; Li et al. 2004, 2010).

### Mechanization of Sugarcane Production

With the urbanization in China, farming labors are getting less, and labor cost is growing fast, which promote the developments of mechanization of sugarcane production. Machines have been applied in almost 100 % soil preparation and common in most field operations such as planting, fertilizing, soil and plastic film coverage, weed and pest controls, but very little in harvest (Li 2010; Li et al. 2008, 2011). The major difficulties are the farm condition limits and the quality requirement of millable cane controlled by sugar mills. For common machine harvest operation, it is necessary to combine small farms into big farms, and enlarge the field sizes. Obviously, it still needs some more time, but is promising.

### Control of Diseases, Pests, Weeds and Rats

Comprehensive controls of diseases, pests, weeds and rats included selecting resistant sugarcane varieties, using pest and pathogen free healthy seedcanes, sterilization of seedcanes, removing resources of diseases, pests and rats, control of infectious resources, farming control, biological control of borers using pheromone, trichogramma and Cuban flies; underground insect control with *Metarhizium*, light trapping of borer, longhorn beetle and scarab, weed control before and after emergence with herbicide, rat control in large scale, and so on.

### Prospect of Chinese Sugar Industry

Based on the reality of high production cost and great pressure of international competition, mechanization for whole sugarcane production is urgent for China, farm

merging, farmland consolidation, sugarcane varieties and farming arrangements good for machine operation, and new requirement of millable canes are most important for the development of mechanization.

The biological nitrogen fixation characteristic of sugarcane and the ability of nitrogen fixation, releasing phosphorus and potassium, and growth promotion of soil microbes should be utilized to decrease chemical fertilization in sugarcane production, decrease production cost and improve fertilizer use efficiency while assuring high cane and sugar productivities.

The application of pathogen free healthy seedcane should be combined with propagation of new elite sugarcane varieties to accelerate the extension of new sugarcane varieties and improve the seedcane quality for commercial production. Deep plough and fine preparation of soil are important, and large tractors should be extended to plough soil deep to 50–70 cm. This is the important foundation for high and stable productivity and strong lodging resistance in rain-fed upland sugarcane growing areas.

Extension of sugarcane varieties with strong resistance and ratoon ability such as GT29, GT32, GT40 and related farming technologies should further stressed to prolong the production cycle from 3 to 5 years or longer, to decrease the production cost and improve the production efficiency of Chinese sugar industry.

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