Mechanisation of sugarcane production in China: Experience with Sugarcane Machinery on Guang Qian State Farm

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Abstract

Sugarcane is an important industrial crop in South China, mainly grown in Guangdong, Guangxi, Yuennan and Fujian Provinces. State farms are important cane producers. They produce about one-tenth of the nation's total cane. These sugar companies are integrated enterprises including farm and milling activities but, due to declining sugar prices, they are not particularly profitable.

Under the "Responsibility system" which is now used on state farms, a large number of small canegrowers are allocated land (average area 1.6 hectares) on which to grow cane which they harvest and transport to a collection area for transport to the mill. Because of their small area and low work efficiency, these canegrowers' average incomes are very low.

Besides the economic problems flowing from lower sugar prices, the state farms are also suffering from labour shortages and many temporary workers have to be employed. The managers of some of the state farm companies believe that the solution to their problems lies in mechanization of canegrowing and harvesting operations. A large investment in Austrlian sugarcane machinery was made by the Guang Qian Sugar Farm in Zhangjiang, Guandong Province, south China in 1997. This paper reports some experiences with the machinery in actual farm production and addresses some of the economic considerations involved in the mechanisation of sugarcane production in China.

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INTRODUCTION

China produces both sugarcane and sugarbeets although sugarcane accounts for over 80 percent of total sugar production.

Sugarcane is an important industrial crop in South China, mainly grown in Guangdong, Guangxi, Yunnan and Fujian Provinces. Sugarcane production is however shifting from Guandong and Fujian provinces to more marginal land in Guangxi and Yunnan. Cane production statistics for the past three years for the main growing areas in China are reproduced in Table 1. Sugarbeet is mainly produced in northern regions of China. The leading provinces include Heilongjang, Inner Mongolia, Xinjiang, and Gansu which account for over 77 percent of production.

Table 1: Cane sugar production in China, 1996/7 to 1998/9 ('000 hectares and '000 tonnes)

	1996/97		1997/98		1998/99	
	Area	Production	Area	Production	Area	Production
Guangxi	508	28 305	549	32 424	551	32 509
Guandong	220	13 920	241	17 643	239	17 686
Yunnan	202	11 431	249	14 349	257	15 137
Hainan	74	3 293	77	3 775	80	4 000
Fujian	38	2 539	37	2 499	37	2 543
Jiangxi	37	1 858	42	2 206	42	1 790
Sichuan	34	1 724	31	1 577	33	1 683
Huan	28	1 292	30	1 745	32	1 308
Hubei	17	856	18	1 009	19	710
Other	33	1 658	39	1 690	66	2 584
Total	**1 189**	**66 876**	**1 313**	**78 897**	**1 356**	**79 950**

Source: China and Sugar, October 1998

China is expected to be producing 8.5 to 10 million tonnes sugar by 2000 which will still be less than requirements for the domestic market.

State farms are important cane producers currently producing one-tenth of the nation's total cane. Guang Qian Company is an integrated state sugar enterprise, located at Zhangjiang in south-west Guangdong province. Its farm was established in 1952 for rubber production but sugarcane was introduced in 1962. It is in the centre of an important sugar producing area. Guandong produced 17 million tonnes cane last year, 11 million tonnes of it in Zhanjiang county.

Company structure

The Guang Qian Sugar Company is an integrated farming operation which produced over 481 000 tonnes cane in 1995. They manufactured 57 200 tonnes white sugar as well as 5 235 tonnes of alcohol, 1 104 tonnes of paper, and 2 499 tonnes of fibreboard. In addition, 454 tonnes of rubber were produced but the area is marginal for rubber production and the former rubber plantation is being replanted to sugarcane.

The farm structure involves six sub-farms with more than 10 production teams working on each. As well as its own farm, the company had 3 864 individual canegrowers operating in 1996 under the "responsibility system" that is now used on state farms using an area of 6 365 hectares. These independent canegrowers are each allocated a small area to grow cane which they harvest and transport to the collection area for subsequent transport to the mill. Because of difficulties in obtaining sufficient local growers, a large number of temporary workers from other provinces (1 169 in 1996) are now growing cane on Guang Qian farm.

Each small canegrower manages 25 mu, about 1.6 hectares of land. The average yield of cane is 90 tonnes per hectare. Only one ratoon crop is grown because yield falls to less than 75 tonnes per hectare by the second ratoon crop. The farm transports cane produced by individual canegrowers to the mill and has 80 km of road system. The major roads are well maintained and some have been concreted, but the in-field roads are narrow and often in a poor state. Small individual canegrowers pay rent for the use of the land (usually 2 tonnes cane per mu, equivalent to about 30t cane per ha) and a small management fee (1 t cane on 2.5 mu) as well as for tillage services, fertilizer, seed, sprays etc. Due to their low work efficiency, canegrower's average incomes are very low.

The sugar mill is capable of crushing 5 000 tonnes per day but the mill is barely profitable. With a declining sugar price, the regulated price of cane paid to the independent canegrowers leaves the company with very little profit so the question of how to make both canegrowing and the company more profitable is an important issue. The farm is also suffering from labour shortages as mentioned previously and many temporary workers have to be employed. The managers of the company believe that the solution lies in mechanization of canegrowing and harvesting operations.

MACHINERY EVALUATION

In order to evaluate a fully mechanized system, a set of sugarcane machines, mainly made by Case-Austoft and P&H-Bonel Australia, were imported and tested on Guang Qian Company farm. The machines included a nine tined ripper, 4-furrow swing plough, rotary tiller, tandem disc harrows, billet planter, inter-row cultivator, trash incorporator, fertilizer applicator, trailed sprayer, chopper harvester and self-unloading transporter. Four Massey Ferguson tractors with different power ratings (255, 165, 110 and 90 hp respectively) were used with the various machines.

Six sections of land (numbered as No.1 to No.6) with a total area of 200 hectares were initially allocated to be mechanized. Among this area were existing sugarcane fields (70 ha), reclaimed rubber plantation (100 ha), and other areas comprising small trees and shrubs (30 ha).

All land had to be pre-treated to remove stumps and stones before land preparation began. All of these operations were under the control of technical experts from Australia. Ten young Chinese drivers were trained under the supervision of the foreign technicians to operate the machines. South China Agricultural University staff were invited to conduct surveys and tests, and give comments on the performance of machines and on the whole system. These three parties worked together as a team to conduct several experiments with

the machinery which were reported at the 1998 International Conference in Engineering in Agriculture (Ou *et al*. 1998).

Soil preparation, planting and cultivating machines were tested during the period from January to July 1998 and the harvester was used to harvest the machine-planted cane in March 1998

During the first phase of the experiment, only 50 hectares of land (17 ha in No.1 block and 33 ha in No.6) were mechanized due to delays with the delivery of machinery and the unexpected amount of work required for land clearing. Cutter-bars pulled by crawler tractors were required to clear the land of tree roots and stumps. This was a once-only cost which can be spread over a very long period, possibly 100 years, but was an essential step for the use of modern machinery. As a result, the parties realised that changing to mechanization requires many changes in the way that the farmwork is done.

During the land prepartion, the ripper was used twice, a heavy duty disc harrow was used to harrow and level the field and some blocks were ploughed and treated by rotary tiller. A self-made marker was used to mark the field for planting.

The performance of the billet planter created most interest. Between 14 February and 18 March, the Bonel billet planter was tested and planted 50 hectares. Because it was too late in the season to continue planting, it was decided to stop planting at that time. Working efficiency of the planter was tested and some failures were recorded. The seed cane could not be harvested by harvester and put into the planter by self-unloading trailer so additional workers were used to help in planting. About 2 510 days of casual labour were required for chopping seed-cane billets and another 1 020 casual labour days for loading seed-cane billets into the bin of the planter. The pure working efficiency of the billet planter was approximately 1 ha/hr which was considered a reasonable result but too much time was consumed in loading and extra-ordinary time was involved when, for example, the machine hit a stump. The practical work efficiency was only 0.4 ha/hr and better organization is required to achieve better performance. Some mechanical failures were noted during the planting period. For example, the bearings on the rear wheel shaft on the planter broke several times because it did not seem strong enough although the road conditions on the farm were not good and put extra strain on the components.

The harvester was used to harvest Block No. 6, with an area of 33ha, in March 1998 but the driver needed to adjust the harvester during this three-day period and no special measurements were taken. The working speed of the harvester was about 12 km/hr and general comments on its performance were very good. Trash content, however, was an important issue. The trash content for manually cut cane accepted by the mill is 0.5-0.8%. The trash in the cane cut by the harvester was 8-10% so there is need for some compromise between the farm and mill in respect to trash content in harvested cane. However, research currently being carried out into the modification of cleaning systems on sugarcane harvesters at the University of Southern Queensland may reduce the trash level in harvested cane quite significantly without causing losses of clean billets (Harris, pers. comm., October 1998). Due to some cane being taken before harvest to be used as seed cane by the local canegrowers, it was only possible to estimate the yield from the mechanized planting using the data from an investigation conducted before harvesting. An average of three samplings gave an estimate of 65.7 tonnes cane from the mechanically planted and harvested area compared to 75.1 tonnes from the manually planted cane.

Estimates for both systems were highly variable but there is general consensus that the yield of mechanically planted and harvested cane was significantly below that of the manual system. There was no significant difference in weight between each single stalk of cane from the mechanised and manual fields but there were differences in the number of stallks per hectare. The mechanized cane had about 35 000 to 55 000 stalks per hectare while, in the manually planted fields, this number is usually 80 000 to 90 000. Although the number of cane stalks in the mechanically planted blocks was much lower than the manually planted cane, it was expected the cane could be much bigger when the row spacing was wider and more sunshine could be absorbed. However, with the cloudy climate in China, not as many tillers were present as expected in Australia and the advantages of wider row spacing under the mechanised system were not realised.

More gaps occurred in the rows of cane planted mechanically in the 1997 season than were expected so some attention was paid to find out the reason when, during the next season, another 150 ha were planted. Some new cultivation machines arrived and were tested during this time. The total mechanized area for 1998 was 185 hectares including 152 ha of plant cane and 33 ha of ratoon cane.

The results of experiments conducted in 1998 showed that the total number of missing stools was about 12% (Ou *et al*. 1998). Some areas that were not planted by the machine were subsequently planted by hand and germinated well. This suggested that some seed cane was damaged by the planter during planting. The reason for this could be the size of the seed cane which was small and so some got jammed in the conveyor of the planter. Even if this damage is not considered, the 8.3% of missing stools with no seed cane is still too high and more investigation is needed on this

The cultivators caused some damage to the cane because the operation was conducted too late and the cane was too high. This damage to the cane was not the fault of the machine but it was obvious that much skill was needed to operate the three-row cultivator and it was better for the young Chinese operators to use the single row cultivator.

ECONOMIC EVALUATON

The equipment imported in the first year for the project included:

MF9240/4 240 DIN hp tractor
MF8140/4 160 DIN hp tractor
MF3655/4 155 DIN hp tractor (second hand)
MF399/4 104 DIN hp tractor
MF 229 40 disk (3.05m) offset cultivator
Howard Type SP4-5 square plough (Swing plough)
Dowdeswell Model 130 rotavator
Bonel B37-109 7 tine ripper
Bonel B58-900 stool splitter fertiliser applicator
Bonel B58-702 trash incorporating fertiliser applicator
Bonel B59-311 cutaway cultivator
2 B110-810 billet planters
Demco HP500 (seral 96080) sprayer
Doyle Type PT-10000, Model G-W-5 lime spreader
Austoft 7000 cane harvester

Austoft Powerhaul 9 tonne sidetipping cane transporter
2 Austoft 600S 6 tonne sidetipping hauled transporters

The total payment for this package was about $US 1.160 and further equipment including more of tractors and additional cane transporters, additional fertiliser applicators, and other equipment was to be delivered in later years. The prices paid for some individual pieces of machinery, particularly tractors, were about double Australian prices in 1998 so that about 60 percent of the investment package was represented by machinery with the remaining 40 percent of the cost attributed to "technology". This was the expert help supposedly available to the Chinese to help in setting up the machinery and teaching the Chinese operators how to use it.

Before and after comparisons of the cost of producing cane by individual canegrowers and for the whole farm have been attempted.

An estimate of individual canegrower's income and costs under the existing system is presented below. Each family farm was allocated 25 mu of land (1.6 ha) from which an average yield of 6.5 t cane /mu was achieved.

Total income: from 25 mu, 6.5t/mu, 250 RMB per tonne = 40 625 RMB

Production costs:

land rental to company: 2 tonnes cane/mu on 85% of land allocated to sugarcane (ie. 22.5 mu)	= 11 250 RMB
management fee paid to sub-farm: 1 t cane/mu for 2.5 mu	= 625 RMB
government tax: 5 RMB/ t cane	= 812.5 RMB
seed cane: 0.5 t/mu, 250 RMB per t	= 3 125 RMB
Fertiliser	= 5 525 RMB
Plastic film, weedicides, rat baits, etc	= 1 125 RMB
Mechanised operations (ploughing and land preparation provided by farm	= 1 500 RMB
Total	= 22 837 RMB
Margin over production costs	= 16 662 RMB
Profit per mu	= 666 RMB

In the early 1990s, the sugar industry in China moved from a planned economic system to a market system. However, sugarcane growing was still kept under the planned economic system to the extent that farmers are restricted to grow sugarcane and the price of cane is still set by the government. Some recent research showed that profit from growing cassava could be as much as 300 RMB per mu better than sugarcane and farmers who can grow vegetables to sell into north China can get as much as 3 500 RMB per mu, considerably more than sugarcane.

Sugar and cane prices have fallen in recent years, with cane prices dropping from 250 RMB per tonne in 1995 to 220 RMB for the 1997/98 season and possibly lower in future. Some researchers believe that the government has set the price for cane high in order to

encourage the farmers to grow it. Given that it takes about 10 t cane to produce one tonne white sugar, the direct costs of cane for sugar manufacture are about 2 200 RMB with about 600-700 RMB/t sugar as the estimate of the cost of processing. With current sugar prices quoted around 3 000 RMB or less, the sugar milling part of the operation, based on this payment to individual growers for cane, is only marginally profitable.

The other relevant comparison is how the estimate of 16 662 RMB from growing cane compares with the income that could be available from alternative sources, such as working on a building site or in a local factory. Because Guandong province has been experiencing rapid economic development, there has been a demand for labour in factories and on building sites and many former farm workers have chosen what they regard as an easier and more profitable life than farm work in these alternative industries.

Cost of cane supply for the mill

An attempt has been made to evaluate the cost of cane from manual production and compare it with mechanised production.

The total cost of cane supply before mechanination is based on estimates for 1997/98 crushing season when it was expected that 80 000 tonnes sugar would be made. At an average conversion of 9t cane per tonne sugar, (better than achieved previously) this would require a cane supply 720 000 tonnes cane. In the past, about one sixth of the cane crushed at the mill has been supplied by external growers. If this proportion is maintained, 120 000 tonnes will be supplied from that source. The mill ultimately has to pay for about 400 000 tonnes of cane supplied from its own growers while the balance (200 000 tonnes) does not cost the mill anything since it represents the rental on land used for growing cane. This means that the mill pays for about 520 000 tonnes out of a total cane supply of 720 000 tonnes. The cost of this cane at the factory gate is RMB255 per tonne (RMB235 per tonne at the delivery point +RMB20 per tonne transport cost to take the cane to the mill).

Therefore the total cost of cane supply under this system was estimated to be RMB132.6 m.

Cost of cane supply after mechanisation

The long-term plan for Guang Qian farm is to mechanise production on about half of the total area of the farm, ie 3 000 out of more than 6 000 hectares. The current set of equipment that has been delivered to the farm includes one harvester and is designed to handle up to 5 000 mu (or about 350 hectares). It could therefore replace about 200 individual canegrowers. The comparative costs of undertaking development to this stage have been estimated.

The extra annual costs of growing cane under mechanisation include

ownership costs for machinery: depreciation, interest on investment, shelter, etc, estimated as 15% of original cost (RMB83 m) = RMB12.5m

operating costs and repairs (except harvester): estimated at 5 percent of initial value = RMB4.15 m

fuel costs for cane harvester and haulouts: 2.5L per tonne cane, 2.5RMB/litre
= RMB 0.175 m

labour (including 10 drivers and 35 other people) =RMB 0.81 m

Canegrowing costs for 5 000 mu (formerly met by independent growers)
including seed cane, fertiliser, pesticides, and other costs, estimated at RMB700 per mu
=RMB3.5 m

The mill now pays growers for a reduced amount of cane. The 120 000 tonnes from outside canegrowers is still purchased but only 370 000 tonnes is supplied by the mill's own growers and is paid for. This reduces the total cane payment to RMB117.5m but the extra costs due to mechanised production raise the total cost of cane supply under this system to RMB127.7 m, which is slightly less than the cost estimate for the manual system.

The analysis assumed no change in other costs or income would be applicable.

DISCUSSION AND CONCLUSIONS

Twenty years ago, in December 1978 at a Central Committee meeting of the Chinese Communist Party in Beijing, Deng Xioping encouraged China to open its doors to the outside world. Deng pushed for the modernisation of agriculture, industry, defence, and science and technology (ideas that were first spelled out by former premier Zhou Enlai as early as 1954). These reforms were put aside during the cultural revolution from the mid-1960s to the mid-1970s but were revived by Deng "to turn China into a modern powerful socialist state by the end of this century". From the famous 1978 central committee meeting, a decision emerged to "resolutely and fully implement the policy of simultaneous development of farming, forestry, animal husbandry, side occupations and fisheries". Side operations apparently meant growing produce and livestock on a small private plots of land so that enforced collectivisation was re-assessed and then abandoned. A huge rise in rural output apparently resulted as farm output was re-organised along household lines.

Over the past 20-year period, agriculture's share of the Chinese economy has apparently fallen from 71 to 50 percent. It took the US 50 years and Japan 60 years to achieve similar levels of structural change (World Bank, *China 2020*). Private economic development has been proceeding rapidly but China's state enterprises have not fared so well. The proportion of China's 305 000 state enterprises making losses has apparently grown from 26 percent in 1992 to 50 percent in 1996 (Lardy 1996). About 10 percent of China's sugar production comes from state farms, and while there is no readily available data on their overall performance, it is assumed that the proportion of loss-making ventures among them is also rising.

It has been estimated that over the past 10 years, 10 percent of China's GDP has been absorbed by subsidising the growing losses of state-run businesses. These loss-making ventures have not been identified so far because industrial restructuring has been deferred and this has meant the build-up of huge financial liabilities by many Chinese firms because of preferential access to credit. In the case of Guang Qian Sugar Company, the company has been marginally profitable although its debt to capital ratio was nearly 64 per

cent. Out of a total income from all sources (sugar and by-products, alcohol, paper and fibreboard, rubber, electricity, animal products, and sales of fixed assets) of RMB394 m in 1995, the company recorded a profit of RMB35.8. Only about RMB5 m of this remained for discretionary spending and new investment after meeting costs for services provided by the company such as police, education, hospital and shops as well as support for retired workers.

While restructuring is occurring and a successful experiment in sugarcane mechanisation at Guang Qian will undoubtedly speed the process, it presents some serious political challenges. The closure of insolvent firms and the recapitalisation and associated restructuring of others is leading to a rate of unemployment not previously known in China. This has not been a serious problem for Guang Qian state farm so far since it has had trouble recruiting enough local canegrowers to supply its factory. Many local farm workers have found other employment opportunities on construction sites and in local factories in the rapidly expanding local economy. However, there must be concern about the general level of unemployment in China. Each year the workforce grows by an expected 3 million people while currently redundancies and layoffs are adding another 7 million per year to the pool of unemployed. Some commentators claim that the Chinese economy needs to grow by about 8 percent per year to absorb these 10 million extra workers. No developing country has previously faced dislocation on such a massive scale. When the massive migration out of agriculture occurred in countries like North America and Australia from the 1920s onwards, there was an opportunity to use displaced farm workers in relatively labour intensive manufacturing industries including automobiles, white goods and consumer products. Manufacturing plants (at least in the developed western hemisphere) now tend to be capital intensive operations that employ relatively few people and it is the service industries that provide most employment opportunities and these are not well developed in countries like China. The opportunity to absorb displaced farm labour in factories may not be available in China and other developing countries to the extent that it was in countries that made the transition from basically agricultural production to a more diversified economy in the middle years of the 20th century.

The tendency to allow temporary workers from other provinces to fill the employment gap may also lead to similar cases of exploitation and lack of integration that have been observed in earlier times in other countries. There are some signs that the temporary workers allowed into south China as a result of labour shortages in the area are treated differently to local inhabitants. There is a perception that they are responsible for increased crime in the area and a general feeling among local inhabitants that they would rather get by without this immigrant labour if they can do so. This leads to a potential argument that while mechanisation of farming operations could lead to negative employment effects from the national point of view, that is not a prime concern of administrators at the local and regional level.

China's policy on foreign economic trade was confirmed by a speech by the vice director of Bureau of Economic Trade Policy and Development and the Ministry of Foreign Trade and Economic Cooperation in November 1997 (Lu 1997). He reiterated that the Chinese government has adopted a trade policy of "active opening to the outside and the trade principle of approximate balance of import and export". He went on to point out that "political intervention in the regulation of foreign trade has been greatly weakened", and the system "of assuming sole responsibility for own profits and losses" has been put in place. Furthermore, the Chinese government has "greatly reduced the range of

commercial goods controlled by allocation licence issued by the state". There are only 16 categories of commodity (sugar not being one of them) where production and allocation is planned by the government. They are generally natural resource products (coal, tungsten, antimony, crude oil) or essential commodities that affect the national economy and peoples livelihoods (rice, soybean, corn, tea, cotton, worm silk, etc). Similar relaxation has been occurring in regard to imports with import controls abolished for all except 36 commodities and a greatly reduced tariff regime. As far as sugar is concerned, there is an import tariff and value added tax on sugar imported under quota for domestic consumption of 12 and 17 percent respectively (W. Males, Qld Sugar Corporation, *pers. comm.* (October 1998)). Thus the general policy towards new technology and foreign investment appears to be favourable and suggests that the project to test and implement mechanised sugarcane production is consistent with current policy.

The general conclusions from this phase of the machinery testing program have been that most of the imported sugarcane machines performed very well. Most of the equipment worked well when judged as individual machines but some problems became evident when the production of mechanised cane was judged as a whole system. Clearing the field of stumps and stones required much more time than expected due to lack of organization of the labour. The fertilizers and chemicals arrived late, the seed cane had to be chopped into billets and loaded into the planter by hand which took too much time and delayed the whole operation. Some problems arose with missing cane plants during planting and more investigation is required into the performance of the billet planter. The wider row spacing required for mechanical planting and cultivation should allow the available radiation to be absorbed by large individual stools of cane but the cloudy weather of southern China (and possibly the Chinese varieties selected for closer row spacing) negated this effect. Thus, the yield from the mechanised fields was not as good as expected and more seed cane needs to be planted.

The economic analysis showed that mechanised production will lead to cost reductions in the production of cane although these may not be as spectacular as some people might hope. Increasing yields from the mechanised system, keeping strict control over the cost of using machinery, and utilising it effectively will all contribute to achieving a better outcome.

This has been an interesting experiment in transforming a predominantly manual sugarcane production system to one that is partly mechanised. In doing that, the experience that producers in countries like Australia and US accumulated over the space of 40 or 50 years as they slowly adapted to increasing mechanisation has had to be compressed and transferred to Chinese farm labourers and managers with only a limited familiarity of mechanised operations. Initially, the foreign technical experts were not fully aware of these differences and needed time to become familiar with the farming conditions in China while both sides needed to learn about each other's way of working before they could cooperate well. All these problems showed that sugarcane mechanization is not only a question of machine performance but a lot of attention should be paid to management to get the whole system to work well.

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