

Damage in Sugarcane Production Caused by Long Duration of Chilling and Frost in Guangxi, China

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Abstract: A comprehensive survey was carried out to investigate the adverse effects of the severe frost and long duration of chilling stress, occurred in central and northwestern Guangxi (China) from 16 December 2010 to 9 January 2011, on sugarcane production. Analysis reports from sugar mills were collected and field surveys were conducted in 11 sugarcane growing areas covering Laibin, Liuzhou and Hechi Cities of Guangxi. About 203.3 thousand hectares (kha) of sugarcane crops were found injured or damaged. Of which 96.1 kha (70.2%) areas were seriously damaged, accounting 33.6% of the total sugarcane growing area (289.7 kha). The effects were more pronounced in sugarcane varieties ROC22 and Taiyou, especially in Liucheng, Rong'an, Rongshui, Loucheng, Wuxuan and Xiangzhou counties, and Xingbin district. The plants affected by chilling temperatures showed drying and curling of leaves and destruction of growing points and buds. The longitudinal section of the cane showed tissue spoiling and found to smell alcohol. However, the sugarcane varieties GT21, GT28 (GTCP00-122), GT29, GF98-296, GT97-69, GT32, GT35, GT02-467 and GT02-1156 were found to be less affected by the low temperatures and indicated stronger cold tolerance. The replacement of cold sensitive varieties ROC 22 and Taiyou by these varieties have been recommended for central and northwestern Guangxi sugarcane growing areas to reduce the losses. Further, the comprehensive control measures such as plastic film covering, trash covering, application of organic manures, vinasse and filter mud have been suggested. Priority harvesting of damaged cane crops and milling the canes as quickly as possible is strongly recommended to improve the sugarcane productivity under chilling damage conditions.

Keywords: Sugarcane, Frost, Chilling, Cold Resistance, Control Measures

1. INTRODUCTION

Low temperature is a widely occurring problem in many sugarcane growing countries. Besides affecting growth and development of sugarcane, it also affects cane quality and its processing. During recent years, vagaries of weathers were more frequent in the form of very low temperature and frosts and adverse affected the sugarcane production in Guangxi, China [1] [2]. In 2008, during spring season, many areas in Guangxi suffered from the longest duration of low temperature and rains in the history. This resulted in severe losses, especially in form of sugarcane sucrose content and the juice purity, difficulty in seed cane supply and ratoon sprouting [3] [4]. In January 2009, the frost damaged 68.03% area of main

sugarcane crop variety ROC 22 in central Guangxi [5]. Under these conditions, therefore, the necessity was realized to develop proper control measures for reducing the losses caused by low temperature stress. Surveys were conducted in low temperature affected sugarcane fields during the milling seasons 2007-08 and 2008-09, and mechanisms related to damages caused by low temperature have been worked out [3] [4] [5] [6] [7]. Several cold resistant sugarcane varieties have been evaluated and screened under natural conditions of severely frost affected areas [4] [8] [9]. The differences in cellular, morpho-physiological and biochemical characteristics amongst sugarcane varieties, possessing various degrees of cold resistance, were also investigated [10] [11] [12]. Many workers suggested different control measures to deal with different types of low temperature attacks [3] [4] [5] [6] [7] [13]. The sugarcane crops in central and northwest Guangxi were attacked by frosts from 16-17 December 2010, and again from long duration of low temperature (0 – 3 °C) for several times and sometimes combined with rains, resulted in large scale severe crop damages. The present survey was conducted to investigate the effects of the frosts, and long duration of chilling combined with rains, on the sugarcane production in these areas, and to provide the references for developing proper control measures to reduce losses.

2. MATERIALS AND METHODS

A. Survey Time and Areas

The survey was conducted from 7-9 January 2011 in 11 counties/district of central and northwest Guangxi, viz., Xingbin District and Wuxuan, Xiangzhou, Xincheng counties in Laibin City, Jinchengjiang District, Luocheng, Huanjiang counties and Yizhou City in Hechi City, and Liucheng, Rong'an and Rongshui Counties in Liuzhou City.

B. Survey Parameters and Methodology

The studies were conducted by surveying the affected areas, reviewing crop records and reports given by the officers of different administrative areas, field investigations and on-site collection of data. During the survey, information on total sugarcane growing area, sugarcane varieties, harvested area, low temperature damaged area, and the juice quality performances in different sugar mill areas, before and after occurrence of

low temperatures, was recorded. During field investigations, the affected sugarcane was graded according to the severity of symptoms, and samples were taken for analyzing cane tissue damage and juice quality parameters such as brix, sucrose percent cane, juice purity, etc.

3. RESULTS

A. The Affected Area and Degree Damages to Sugarcane Crop

The results of the survey showed that the severe frost followed by the long spell of chilling and rainy weather caused considerable damages to sugarcane production in the investigated areas. The survey was conducted in total 289.65 kha sugarcane growing area spread in 11 different counties/districts. Of which, 53.7% (155.53 kha) area was occupied by the sugarcane variety ROC22. Another variety Taiyou occupied 27.8% (80.55 kha) of the total sugarcane growing area. Of the total sugarcane plantation

area, 70.2% (203.25 kha) was found to be affected by the frost and low temperatures, while the sugarcane crop grown in 33.6% (96.08 kha) area was found severely damaged by the vagaries of weather (Table 1). The damage was more serious in Liucheng, Rong'an, Rongshui, Luocheng, Xingbin, Wuxuan, Xiangzhou and Xincheng compared to other areas. The crops grown in higher terrains showed lesser damages as indicated by less or no symptoms, while the damage was considerably higher in the lower terrain areas (Fig. 1). The sugarcane varieties ROC22 and Taiyou grown in 76.5-96.9% area were found to be damaged severely in Liucheng, Rong'an, Luocheng, Xingbin, Wuxuan, Xiangzhou and Xincheng, while the GT varieties, covering about 17.2 - 39.5 % of sugarcane area in Rongshui, Yizhou, Huanjiang and Jinchengjiang, showed less damages. In Rongshui County, out of the two varieties, GT21 and Taiyou, the former was slightly affected while the latter one was found severely affected with frost and chilling conditions.

Table 1 The area and degree of damages caused to sugarcane crops by frost and chilling weather at 11 locations

Location	Total sugarcane area (kha)	Total affected area		Severely damaged area		Sugarcane varieties
		Area (kha)	Area (%)	Area (kha)	Area (%)	
Liucheng County	43.40	37.40	86.2	29.33	67.6	ROC22, Taiyou, GT21, GT28, GF98-296, YL6, LC03-182, etc. ROC22 and Taiyou. ROC22 occupied 50.4 and 22.3% area, respectively.
Rong'an County	6.40	6.20	96.9	2.07	32.3	Taiyou, GT21, ROC22, YT93-159, GT35, GT28, GT29, etc. Taiyou occupying 66.7% area.
Rongshui County	8.67	7.45	86.0	78.0	60.0	GT21, Taiyou, ROC22, YT00-236, GT28, etc. GT21 and Taiyou occupied 34.1 and 20.5% area, respectively.
Jincheng-Jiang District	8.55	2.13	24.9	1.00	11.7	Taiyou, GT21, ROC22, YT93-159, YT00-236, GT16, GT28, GT29, GT30, etc. Taiyou occupied 59.5% area.
Huanjiang County	11.47	4.53	39.5	2.00	17.4	Taiyou, F172, YT00-236, GT21, GT28, GT29, etc. Taiyou occupied 65.1% area.
Luocheng County	11.00	8.73	79.4	4.67	42.4	Taiyou, ROC22, GT21, GT32, GT02-467, GT35, GT28, GT29, etc. Taiyou occupied 75.2% area.
Yizhou City	39.50	6.80	17.2	3.33	8.4	Taiyou, GT21, ROC22, YT00-236, GT28, GT29, GT02-1156, etc. Taiyou and GT21 occupied 54.2 and 24.3% area, respectively.
Xingbin District	100.00	80.00	80.0	32.00	32.0	ROC22, ROC16, YT93-159, GT35, ROC96-2817, GT21, GT02-467, GT02-1156, etc. ROC22 occupied 80% area.
Wuxuan County	26.00	20.67	79.5	9.33	35.9	ROC22, YT93-159, YT00-236, GT21, GT16, GZ18, etc. ROC22 occupied 80% area.
Xiangzhou County	23.33	20.67	88.6	7.33	31.4	ROC22, Taiyou, ROC16, GF98-296, GT28, FN22, YL6, ROC88-99. ROC22 occupied 70% area.
Xincheng County	11.33	8.67	76.5	1.17	10.3	ROC22, Taiyou, YT00-236, GT12, YT94-128. ROC22 occupied 70% area.
Total	289.65	203.25	70.2	97.43	33.6	ROC22 and Taiyou occupied 53.7 and 27.8% area, respectively.



Fig.1(A)



Fig.1(B)

Fig.1. The damages caused by the frost and low temperatures on sugarcane crops grown in different terrains; Liuling Village, Liucheng County (A), Suburbs of Rong'an County (B).

B. Crop Damage for Different Sugarcane Varieties

The genetic variability has been observed amongst different varieties in terms of their responses to chilling temperatures (Table 2, Figs. 2 - 5). The sugarcane variety

ROC22, grown in the largest area, was found to be affected most by the chilling temperatures. 22.3% plantation area (44.07 kha) of this variety was suffered due to chilling and the degree of damages ranged grades 3 - 4. The damaged area of sugarcane variety ROC16 plantations reached 143 kha (4.7% of the total damage area), while it was 5.7% (172.7 kha of the total damaged area) in case of the variety Taiyou. The sugarcane variety GT21 tried to resist the chilling temperatures and showed lesser damages compared to other varieties. However, it was also found to be suffered greatly at the temperatures equal or below - 3°C. The heavily damaged area of this variety occupied 1.9% (57.1 kha) of the total damaged area. Generally, most of the affected area was planted with the varieties ROC22 and Taiyou which were found to have very weak cold resistance, therefore highly affected by the chilling temperatures and resulted in heavy loses. On the contrary, fields cultivated with multiple varieties and having large proportion of variety GT 21 affected the least. The survey results clearly showed that the sugarcane varieties of GT or GF series such as GT21, GT28 (GTCP00-122), GT29, GT30, GF98-286, GT97-69, GT35, GT32 and GT02-467 showed stronger cold resistance and suffered least.

At all the 11 areas (counties/district/city), the damaged plants of sugarcane varieties ROC22, Taiyou and ROC16 showed drying and curling of leaves and dead growing point of cane. Especially in the lower terrain fields, 100% of the growing point of canes, more than 60% of the buds in aboveground part and some buds in underground part were found dead, and the sectioned parts of cane looked waterlogged with alcoholic smell, and most cane tissues were destroyed. However, the buds were still found in good condition in sugarcane variety GT21 at the same location, though the degree of damage ranged 3 - 4 with completely drying leaf symptoms (Fig. 5).

Table 2. Area of the damaged sugarcane varieties and the grades of damages caused by frost and long duration of chilling temperatures (1: least damaged; 4: severely damaged)

Location	Damaged area and grade	Sugarcane variety										
		ROC22	ROC16	Taiyou	GT21	GT28	GT29	GT35				
Xingbin District	Area (kha)	38.4	7.2		Few	Few	Few	Few				
	Grade	4	4		1	1	1	1				
Wuxuan County	Area (kha)	11.2			Few							
	Grade	4			2							
Xiangzhou County	Area (kha)	7.7	1.4	1.4								
	Grade	4	4	4								
Xincheng County	Area (kha)	1.2		0.26								
	Grade	4		4								
Rong'an County	Area (kha)	0.45	0.35	1.00	2.00	2.33	1.80	0.55	0.42	Few	Few	Few
	Grade	3	4	3	4	3	4	3	3	1	1	1
Rongshui County	Area (kha)	0.33	0.03		0.64	0.06	1.05	0.10		Few		
	Grade	3	4		3	4	3	4	1			
Liucheng County	Area (kha)	4.04	2.07		1.79	0.92	0.9	0.46		Few		
	Grade	3	4		3	4	3	3	1		1	
Jincheng-Jiang District	Area (kha)	0.17			0.86			0.40		Few	Few	
	Grade	4			4			2		0	0	
Huanjiang County	Area (kha)	0.57			1.95					Few	Few	
	Grade	4			4					1	1	
Luocheng County	Area (kha)	1.09			5.26			0.62		Few	Few	Few
	Grade	4			4			4		1	1	1
Yizhou City	Area (kha)	0.51		2.7				1.21		Few	Few	
	Grade	4		4				3		1	1	



Fig.2 (A)

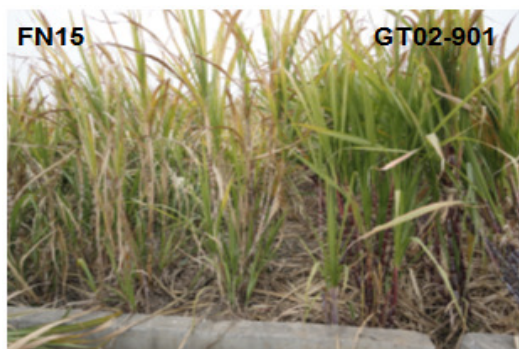


Fig.2 (B)

Fig.2. Performance of some sugarcane varieties under frost and long duration of chilling temperatures at Ertang Township (North altitude 23°40', east longitude 109°41', and elevation 70 m), Wuxuan County (Photograph taken on 8th January, 2011).



Fig.3 (A)



Fig.3 (B)



Fig.3 (C)

Fig.3. Performance of some sugarcane varieties under frost and long duration of chilling temperatures at Siding Village, Siding Township (North altitude 25°01', east longitude 109°31', and elevation 355 m), Rong'an County (Photograph taken on 8th January, 2011).

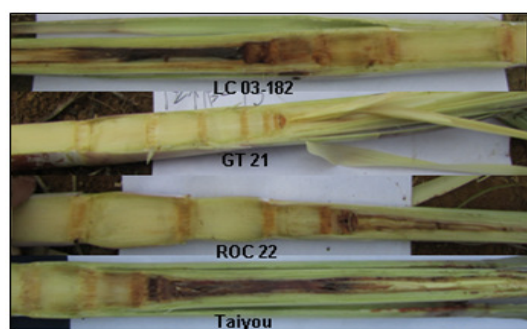


Fig.4. Performance of some sugarcane varieties under frost and long duration of chilling temperatures at Liuling Village, Zhailong Township (North altitude 24°38', east longitude 109°07', and elevation 252 m), Liucheng County (Photograph taken on 8th January, 2011).



Fig.5. The cane pieces showing buds (upper) and longitudinal section of the cane tissue of 5 sugarcane varieties (lower) grown at Xinyin Village, Siba Township (North altitude 24°45', east longitude 108°51', and elevation 562 m), Liucheng County (Photograph taken on 9th January, 2011).

B. Effect of Frost and Chilling Damage on Cane Brix in Field

The field observations showed significant adverse effects of frost and chilling on cane brix in the samples taken during the time of the survey. Twelve samples (63.2%) of variety ROC22 showed 4th degree of damage and the average brix was 19.9 with minimum 16.9 while the rests showed 3rd degree of damage and the total average brix was 21.0 The variety ROC16 at 4 locations

(2 with 4th degree of damage) showed 21.6 in average brix. The variety GT21 sampled at 9 spots showed 20.3 average brix value at 9 locations (with 3rd degree of damages) while at 1 spot with 4th degree of damage it was 18.3. The data showed that severely affected variety showed lower brix compared to less affected same variety. In ROC22, the brix of 4th degree damage cane was 1.1% (absolute value) lower than that of the 3rd degree damaged cane. The cold resistant varieties showed higher brix compared to the susceptible varieties at the same locations.

C. Effect of Frosts and Chilling Tress on Sucrose % Cane in Mill

The records of sucrose % cane from December to early January for the years 2009/2010 and 2010/2011 were provided by Rong'an Sugar Company Ltd., Guangxi, and are shown in Fig. 6. Compared to the year 2009-2010, the sucrose % cane was decreased significantly due to frost and long duration of chilling stress in the year 2010-2011. During 2009-2010, from 16-17 December 2009 to 6 January 2000, it increased from 13.67 to 15.49%, showed 1.82% rise in absolute value; but during the year 2010-11, from 16-17 December 2010 to 6 January 2011, it increased from 12.93 to 13.00%, showed only 0.07% rise in absolute value due to frost and long duration of chilling stress.

4. DISCUSSION

A. Application of Cold Resistant Sugarcane Varieties

Frosts and chilling stresses were most frequent during the recent years in many parts of China, especially in central and northwest regions of Guangxi and resulted in severe losses in sugarcane production. The most important reason of losses was domination of weak cold resistant varieties ROC22 and Taiyou in these areas [3] [5] [6] [7]. Some cold resistant elite sugarcane varieties such as GT21, GT28, GT29, GF98-296, GT97-69, GT35, GT32, and GT40 (GT02-1156) have been screened out under the support of the National R & D Program project [3] [8] [9] [12]. The result of present surveys showed that these cold resistant sugarcane varieties had high germination rate even after the death of spindle leaves and slight browning in parts of buds. Therefore, these cold resistant elite sugarcane varieties should be extended for cultivation in central and northwest areas of Guangxi, instead of the varieties ROC22 and Taiyou. It has been suggested that government and sugar mills should offer subsidies to sugarcane farmers for planting new elite sugarcane varieties and use of healthy seed canes, propagations through tissue culture rapid multiplication technique.

B. Comprehensive Extension of Cold Resistant Techniques

The effective farming measures such as deep furrow preparation with tractors, plastic film covering, trash covering, application of vinasse, filter mud and other organic warming manures, chemical control and rational irrigation, etc, should be applied to improve the soil temperature and keep soil moisture available to promote early germination and rapid plant growth. In Guangxi

sugarcane growing areas, the sugar corporations produce high quantity of vinasse which has not only a warming effect, but also rich organic matter and complete nutrients, its appropriate application can save production cost and improve sugarcane productivity [16] [17].

C. Rescheduling Cane Harvest Plan

The cane harvest schedules should be rearranged, and severely damage sugarcane crops (grades 3 and 4) should

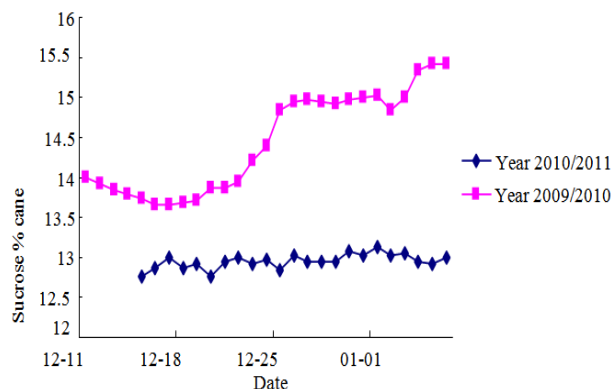


Fig. 6. A comparison of changes in sucrose % cane in early milling season in Rongan Sugar Company Ltd., Guangxi, during 2009-2010 and 2010-2011.

be harvested in priority and milled as quickly as possible to reduce the losses of both sugar mills and farmers.

D. Seed Cane Selection

The seed canes should be selected from the areas and fields which have not been affected by the chilling stress. If the crops has slight injury symptom, the seed canes should be harvested after 20 or more days of growth for recovering from the chilling stress.

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