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Performance of sugarcane cultivated with contour-zonary techniques

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ABSTRACT

Objective: The objective is to compare the sugarcane performance under contour -zonary cultivation techniques with the one under traditional cultivation techniques. Method: Sugarcanes of both Qiantang 4 and Qiantang 5 were planted with different techniques. When they reached technical maturity, the samples of their roots, leaves, stems, number of ratoon cane buds etc. were collected, measured and compared to find out the differences of the yield and quality of the sugarcanes cultivated with different techniques. Result: It is found that sugarcanes under the cultivation with contour -zonary techniques had following characters that were fresh root weight increasing by 92.81-117.57%, functional leaf number increasing by 10.11-14.68%, cane stem production increasing by 16.65-17.57%, cane sucrose contents increasing by 4.05-4.07% and ratoon number increasing by 62.81-65.10%. Conclusion: Sugarcanes cultivated with contour -zonary cultivation techniques perform better than the ones cultivated with traditional cultivation techniques in both their yield and their qualities.

Introduction

Research Significance Sugarcane is one of the main sugar crop in China (Zhang et al, 2003). With the national agricultural restructuring, the main sugarcane production regions are being shifted from the coastal southeast into the inland southwest. Guizhou located in the inland southwest is therefore planning to expand its sugarcane's area from current 66, 000 acres to 180, 000 acres in the future. The problem is that sugarcanes' unit production in Guizhou is still low, though the sugarcanes' planting area will be increasing. In order to make Guizhou one of the main sugarcane production areas, it is necessary to explore the new way to increase sugarcanes' unit production. Previous Research For solving the problem of low unit production in Guizhou, many experts put forward many strategies including breeding and cultivation improvement (Liu, 1997; Gong, 1998, 2004; Zhou, 2006). In breeding aspect, some experts brought in new varieties of sugarcanes, such as Qiantang 4 bred by Yi Daiyong et al (2002), and ROC22, ROC26, Baxi 45, etc. introduced by Zhou et al (2005). These excellent varieties plus other improved varieties, which have increased yearly sugarcane production from 2.5 t/666.7m^2 in 1998(Zhou et al, 1998) to 3.5 t/666.7m^2 at present (QXN, 2010), have covered more than 80% of the total area in Guizhou (Zhou et al, 2005,2010). In cultivation aspect, some experts like Li et al (2004) think that sugarcanes should be planted deeply in soil. Other experts like Li et al (2009) point out sugarcanes planted in grooves and holes are helpful for the promotion of their unit output and quality. Still other experts like Wei et al (2011) suggest sugarcanes should be cultivated in smash-ridging areas. Finally, some experts like Huang et al (2010) point out that the application of dripping irrigation techniques will increase sugarcanes' output. But the above strategies do not completely conform to the situation in Guizhou, because on the one hand Guizhou is a mountainous province and most of sugarcane fields are located on dry land slopes where water sources are scarce(Zhou, 2006), so dripping irrigation techniques are difficult to be applied; on the other hand the land slopes in Guizhou are usually steep, so application of large scale agricultural machines is restricted and thus the labor extensive smash-ridging cultivation is not easy to be practiced. In accordance with the geographic characteristics of Guizhou combined with working experience summarized through observation by authors of the article (Chen et al, 2001), contour -zonary cultivation is put forward. Research Objective This study aims at exploring the feasibility of contour -zonary cultivation and investigating the effect of contour-zonary cultivation on sugarcanes' yield and qualities.

Material and Method

Experiment design

Experiments of sugarcanes' contour-zonary cultivation were carried out at Ceheng county and Wangmo county in Guizhou province from 2010 to 2011. The sugarcane varieties chosen for the experiment were Qiantang 4 and Qiantang 5. The sugarcanes were randomly planted 3 times in test lands located along contour-zonary areas. Each of the test lands occupied 60 m^2, which was 10 m in length and 6 m in width. The experiment includes two treatments: contour-zonary cultivation and traditional cultivation (CK). Under the contour-zonary cultivation, the sugarcanes were planted in contour-zonary test lands in which ditches excavated as 0.4 m deep, 0.25 m wide at bottom, 0.6 m wide on surface, and the distance between ditches were 1.2 m. Under traditional cultivation (CK), the sugarcanes were planted in non contour-zonary test lands, in which the earth was ploughed 0.3 m deep, and then ditches were excavated every 1.2 m away. On March 17, 2010, sugarcanes of Qiantang 4 were planted at density of 6000 buds/666.7 m^2 in both contour-zonary test lands and non contour-zonary test lands. On March 18, 2010, sugarcanes of Qiantang 5 were planted at density of 6000 buds/666.7 m^2 in both contour-zonary test lands

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and non contour-zonary test lands. They were harvested and observed on January 9, 2011 and January 10, 2011 respectively.

Indicators for measurement

Millable canes per unit area: all the canes higher than 1 m being counted every 666.7m^2; plant high: the height from earth ground to leaf ring; stem diameter: including stem diameters measured by vernier caliper around the stem head, stem body and stem foot; green leaf number: the number of green folded and unfolded leaves in sugarcanes; green leaf weight: green leaf total weigh measured by balance scale; single stem weight: the single stem weight being the weight of all millable canes within 5m^2 divided by the stem number; root and ratoon number: the number of roots and ratoon being dug and cut within an area of 3 m^2 randomly from every test land; yield: the amount of sugarcanes per unit area harvested according to the market standard; qualities: the results of analysis on five normal sugarcanes picked up from each treatment in laboratory by the standard of DB45/T 450-2007.

Data analysis

The data collected were analyzed with EXCEL for descriptive results, and analyzed with DPS for significance check.

Results

Sugarcane roots in later period of contour-zonary cultivation

Table 1 shows that in contrast to CK: Qiantang 4 fresh root weight increases by 117.57%, and Qiantang 4 dry root weight increases by 99.58%; Qiantang 5 fresh root weight increases by 92.81%, and Qiantang 5 dry root weight increases by 80.66%. The root weights of the two varieties of sugarcanes under the treatment of contour-zonary techniques are both obviously higher than those of the two varieties of sugarcanes under the treatment of CK. Moreover, it is found that roots of the sugarcanes cultivated with contour-zonary techniques are denser, longer and deeper in soil.

Sugarcane leaf and ratoon number in later period of contour-zonary cultivation

Table 2 shows that though in the later period completely unfolded green leaves (functional leaves) numbers of Qiantang 4 and Qiantang 5 increase by 0.46 and 0.59 or 10.11%-14.68%, green leaf weights of Qiantang 4 and Qiantang 5 increase by 16.92% and 15.38%, and incompletely unfolded green leaf weights of Qiantang 4 and Qiantang 5 increase to some extent per plant respectively in contrast to CK, the differences are not significant in statistics.

The ratoon number of sugarcanes cultivated with contour-zonary techniques

The amount of millable sugarcanes is determined by and proportional to the number of ratoons. The more the ratoon number is, the more the amount of millable sugarcanes will be next year. Table 2 shows in contrast to CK, the ratoon numbers of Qiantang 4 and Qiantang 5 cultivated with contour -zonary techniques increase by 65.10% and 62.81% respectively, both of which increases are significant.

Sugarcane stem traits and yield of contour-zonary cultivation

Table 3 shows the stem height, diameter, weight, stems and yield are all superior to CK. Especially, contour-zonary sugarcane yield is greatly higher than CK sugarcane yield.

Specifically, in terms of Qiantang 4, the stem is 6.2 cm higher, the diameters increase by 0.08cm, 0.02cm and 0.06cm from the upper to the bottom, the single stem increases by 0.05kg or 3.45% and the yield increases by 894 kg/666.7m^2 or 17.57%; in terms of Qiantang 5, the stem is 9.29 cm higher, the diameters increase by 0.02cm, 0.10cm and 0.01cm from the upper to the bottom, the single stem increases by 0.12kg or 8.96% and the yield increases by 788 kg/666.7m^2 or 16.65%.

Sugarcane quality of contour-zonary cultivation

Table 4 shows the sugarcanes cultivated with contour-zonary techniques are superior in sucrose content, fiber content, brix degree, moisture content and purity degree than sugarcanes of CK. To be specific, in terms of Qiantang 4, the sucrose content increases by 4.07%, fiber content increases by 0.30%, brix degree increases by 1.62%, moisture content increases by 0.89%, purity increases by 1.81%; in terms of Qiantang 5, the sucrose content increases by 4.05%, fiber content increases by 0.09%, brix degree increases by 3.12%, moisture content increases by 2.23%, purity increases by 2.59%.

Discussion

Characteristics of soil in which sugarcanes cultivated with contour-zonary techniques

Sugarcanes cultivated with contour-zonary techniques in comparison with sugarcanes cultivated with traditional techniques have following advantages: 1) ditches are excavated along the contour of dry slope, thus the rainfall is detained becoming a natural reservoir for sugarcanes; 2) ditches are excavated along the contour-zonary area, thus and soil and fertilizers loss with radial water flow is reduced; 3) ditches separated with 1.2 m distance in between them and excavated along different altitudes are helpful to ventilation and photosynthesis (Yi et al, 2009); 4) ditches dug 40 cm deep are helpful for sugarcanes' roots to stand firmly; 5) the soil between ditches being kept untouched is lying fallow, which thus protects the soil (Wei et al, 2011). The main differences between the contour-zonary cultivation and smash ridging cultivation are that the former does not need agricultural machines and suitable to bumping areas with precipitous slopes like in Guizhou; the latter needs special machinery to smash the soil clots, thus fit to relative flat terrains (Wei, 2010; Wei et al, 2011).

Comprehensive effects of sugarcanes cultivated with contour-zonary techniques

Drought is frequently occurred in spring, fall and winter in Guizhou where sugarcanes' growth, yield and sucrose accumulation are put on trial (Luo et al, 2005; Inman et al, 2005; Robert, 2000; Singels et al, 2010). To deal with the situation, on the one hand, smash ridging cultivation techniques are introduced into the practice in which the soil for planting is loosened and sugarcanes are planted deeply. Experiments in corn, peanut, soy bean and mulberry tree demonstrate that smash ridging cultivation is indeed effective to develop plants' root system stand the test of drought. On the other hand, this study shows even though without mechanical soil smashing process, the contour-zonary cultivation promotes sugarcanes' root system development. Through experiments it is found roots of sugarcanes cultivated with contour-zonary techniques are longer, weightier and denser. The result of the study shows roots of sugarcanes cultivated with contour-zonary techniques increase by 92.81- 117.57%. Moreover, as known to all, the developed root system improves the resistance to plant diseases and falling down.

During the experiment period 2010–2011, in spite of dry weather causing overall green leaf reduction and growth stagnation (Chen and Li, 2011), functional green leaves of sugarcanes cultivated with contour-zonary techniques surpass ones of sugarcanes cultivated with traditional techniques by

10.11-14.68%. It demonstrates in contrast to CK, that contour-zonary cultivation is more helpful to photosynthesis increasing sugarcanes' diameters by 0.2-0.8mm, sucrose contents by 4.05-4.07% and yield by 16.65-17.57%.

In short, the advantages of roots and leaves brought by contour-zonary cultivation can be found in the indicators of millable sugarcane number, single sugarcane weight, sugarcane stem weight and sugarcane, combining of which explains why the sugarcane yield under contour-zonary cultivation is bigger than the one under CK. In addition, the advantages of roots and leaves brought by contour- zonary cultivation can be found in the indicators of sucrose content, fiber content, brix degree, moisture degree and purity degree, combining of which explains why the sugarcane qualities under contour- zonary cultivation is better than the ones under CK.

Table 1 Sugarcane roots in later period of contour-zonary cultivation

Breed	Treatments	Fresh root weight (g/3m^2)	Dry root weight (g/3m^2)
Qiantang 4	Contour-zonary	198.45aA	100.25 aA
	CK	91.21bB	50.23 bB
	Contour-zonary increase over CK percentage (%)	117.57	99.58
Qiantang 5	Contour-zonary	211.67 aA	101.37 aA
	CK	109.78 bB	56.11 bB
	Contour-zonary increase over CK percentage (%)	92.81	80.66
Different capital and small letters mean significance at 0.01 levels and 0.05 levels, respectively. They are the same as below			

Table 2 Sugarcane leaf and ratoon number in later period of contour-zonary cultivation

Breed	Treatments	Green leaves per plant		Leaf weight per plant (kg)	Ratoon cane buds number per plant
		Complete leaf	Incomplete leaf		
Qiantang 4	Contour-zonary	5.01aA	4.00 aA	0.235 aA	4.21 aA
	CK	4.55 aA	3.76 aA	0.201 aA	2.55 bB
	Contour-zonary increase over CK percentage(%)	10.11	6.38	16.92	65.10
Qiantang 5	Contour-zonary	4.61 aA	3.52 aA	0.210 aA	4.64 aA
	CK	4.02 aA	3.20 aA	0.182 aA	2.85 bB
	Contour-zonary increase over CK percentage(%)	14.68	10.00	15.38	62.81

Table 3 Sugarcane cane stem traits and yield of contour-zonary cultivation

Breed	Treatments	Plant height (cm)	Stem diameter (cm)			Single stem weight (kg)	Millable stems number (plant/666.7m2)	Cane yield (kg/666.7m2)
			Head	Body	Foot			
Qiantang 4	Contour-zonary	265.30aA	2.98aA	3.02aA	2.90aA	1.50aA	4860aA	5980.00aA
	CK	259.10aA	2.90aA	3.00aA	2.84aA	1.45aA	4656aA	5086.00bA
	Contour-zonary increase over CK percentage(%)	2.39	2.76	0.66	2.11	3.45	4.38	17.57
Qiantang 5	Contour-zonary	261.40aA	3.00aA	3.35aA	3.01aA	1.46aA	4626aA	5521.00aA
	CK	252.11aA	2.98aA	3.25aA	3.00aA	1.34aA	4411aA	4733.00bA
	Contour-zonary increase over CK percentage (%)	18.82	0.67	3.08	0.33	8.96	4.87	16.65

Table 4 Sugarcane quality of contour-zonary cultivation

Breed	Treatments	Sucrose content (%)	Fiber content (%)	Brix degree (°BX)	Moisture content (%)	Degree of purity (%)
Qiantang 4	Contour-zonary	15.34	10.03	16.27	73.70	79.52
	CK	14.74	10.00	16.01	73.05	78.11
	Contour-zonary increase over CK percentage(%)	4.07	0.30	1.62	0.89	1.81
Qiantang 5	Contour-zonary	13.11	11.01	15.21	70.61	80.12
	CK	12.60	11.00	14.75	69.00	78.10
	Contour-zonary increase over CK percentage (%)	4.05	0.09	3.12	2.33	2.59

Conclusions

The contour-zonary cultivation is a new technology suitable to sugarcanes planted in Guizhou. It helps improve sugarcanes' performance both in quantity and quality in contrast to traditional cultivation. It saves the cost of mechanical operation in comparison with smash ridging cultivation. It is hoped by the authors that further studies should be done to compare the functional variation of the two cultivation techniques in planting diseases resistance and photosynthesis.

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