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STUDY ON THE DEEP LOOSENING TECHNIQUE OF SUGARCANE

Xiwen Luo
South China Agricultural University
Guangzhou 510642, P.R.China

Haibo Wen
Hunan Provincial Agricultural Machinery Administration
Changsha 410008, P.R.China

Guofu Huang
Jinpen Farm, Hunan, P.R.China

ABSTRACT

Soil deep loosening technique can improve the soil structure and increase the air permeability and water permeability of soil. It can increase the yield of crops in a large scale, particularly the plants with deep root system.

This paper introduces the study on the deep loosening technique of sugarcane in Jinpen Farm where the soil is heavy clay with high ground water table. The implement and method of deep loosing, the experiments and results are include in this paper. The experimental results showed that the yield of sugarcane increased more than 20% after deep loosing.

Key word: Deep loosening, Soil management, Sugarcane.

INTRODUCTION

Soil deep loosening is a very important technique in soil management. It can improve soil structure and increase the air permeability and water permeability of soil. Because the deep tillage operations are carried out in subsoils and subsurface pans and don't turnover the soil, the subsoils are loosened, fissured and rearranged, the fertility of tilth top soil is kept. The application results of the deep loosening technique show that it can increase the yield of crops in a large scale, particularly the crops with deep root system.

Sugarcane is the crop with deep root system. The main factors affecting the yield of sugarcane are sunlight, heat, air, water and nutrient. The water, nutrient and part of heat are absorbed from the soil through the root system of sugarcane, therefore, the deep loosening technique is an important measure to increase the yield of sugarcane.

During 1984 and 1985, a range of experiments were carried out to investigate the effect of deep loosening technique in sugarcane fields by Agricultural Department of South China Agricultural University. The tests were carried out on lateritic soil in Zhanjiang, Guangdong Province. The conventional subsoilers were used and the tillage depths were 300-400 mm. The experimental results showed that the number of effective stems increased by 5-12.3%, the yield of sugarcane increased by 15.08% and sugar content increased by 15.3-20.4% after deep loosening.

The production of sugarcane is a main industry in Jinpen Farm. Jinpen Farm is near Lake Dongting, Hunan, China. The soil is heavy clay with high ground water table. Because most of the farmers use oxen to plough, the tilth top soil is only 100-120 mm, the subsoil is very hard and compact, the air permeability and water permeability are very poor. It is difficult for roots to absorb the water and nutrient from the soils in dry periods and it is difficult for water to drain from the soils in rain periods. Because the root system of sugarcane is difficult to develop into subsoil, the sugarcane will be lodging seriously in wind periods and the yield of sugarcane will decrease. To investigate the effect of the deep loosening technique on the production of sugarcane, a range of experiments were carried out in Jinpen Farm from 1991 to 1993. The experiments and results are described in this paper.

EXPERIMENT

Three years' experiments were carried out in Jinpen Farm. Jinpen Farm is near Lake Dongting. It belongs to alluvial soil. Table 1 is the particle size analysis. Fig.1 is the particle size distribution curve. From the Table 1 and Fig.1, the soil is heavy clay. Because it is near Lake Dongting, the ground water table is very high. It will be up to 120-150 mm below the soil surface in rain periods. The Cone Index (CI) in subsoil is high to 140 - 160 KPa at 300 - 350 mm depth. Fig.2 is the curve of Cone Index vs Depth before the deep loosening.

1991's experiments were carried out in rain periods, the moisture content of soil is very high. 1992 and 1993's tests were carried out in dry periods, the moisture content of soil is about 34%.

A track tractor with 75 HP was used in three year' experiments. The forward speed is 0.83 m/s during deep tillage operations in the field. The conventional subsoilers showed in Fig.3 were used in 1991's tests. The winged subsoilers showed in Fig.4 were used in 1992 and 1993's experiments.

Two winged subsoilers or conventional subsoilers were attached to the tractor. The subsoilers spacing was chosen as 900 mm according to Godwin's study (1984) and the grow request of sugarcane. One subsoiler run on one trace of track, another subsoiler run on the middle of tractor. Because the width of two tracks is 1800 mm, the compact soils by the tracks can be loosened by the subsoilers. In all tests, the loosening depth was 350 mm.

Every test plot was about 0.2-0.3 hectares. To eliminate the effect of the difference of test plots, every test plot was divided into two parts, one part was for test, another part was for contrast. On contrast plot, oxen were used to plough the soil, the depth is about 100-120 mm. There were four replications in 1991, six replications in 1992, eight replications in 1993.

To compare the yield of sugarcane in test plots and contrast plots, the management measures in all plots were the same, such as sowing at same time, covering with same plastic, applying same fertilizes and cultivating at same time.

EXPERIMENTAL RESULTS AND ANALYSIS

Tine performance was assessed in terms of the cross-sectional area of soil disturbed, the draught force and the draught/unit area of disturbance, termed the specific resistance.

A range of tests were carried out to investigate the performance of rigid deep loosening tines by Spoor and Godwin (1978). Table 2 is the results of subsoiler study by Spoor and Godwin.

In this study. We didn't measure the draught force and specific resistance. The soil disturbance was investigated.

Soil disturbance at depth was monitored by digging a trench across the disturbed area immediately after a run. The disturbed soil was removed by hand for a distance of 300~500 mm beyond the trench face and the undisturbed soil profile so exposed was measured. Surface disturbance was measured by surveying profile levels before and after the treatment. A subjective assessment of the degree of cold rearrangement was made by eye and by the relative ease with which the disturbed units could be removed.

Fig.5 shows the cross-sectional soil disturbance created by one winged subsoiler at 350 mm depth. The soil disturbance area is about 0.23 m^2. The soil is displaced forwards, sideways and upwards (crescent failure). The rupture planes radiate from the end of wing to the surface at angles of approximately 45° to the horizontal. This results is similar to Spoor's study.

Fig.6 shows the cross-sectional soil disturbance created by two winged subsoilers spacing 900 mm at 350 mm depth. It can be seen that the soil of the middle part between two winged subsoilers was loosened, therefore, the soil disturbance was increased. The soil disturbance area created by two winged subsoilers was larger than two times of the soil disturbance created by single winged subsoiler at same depth. The left rupture plane of left winged subsoiler and the right rupture plane of right winged subsoiler were similar to that of single winged subsoiler, radiated from the end of wing to the surface at angles of approximately 45° to the horizontal.

Table 3 shows the effective stems of sugarcane in test plot and contrast plot in 1991's experiment. Form Table 3, it can be seen that the increased ratio of the effective stems of sugarcane is high to 132.24% on April 29, but decreases to 18.56% on June 8.

Table 4 and Table 5 show the experimental results in 1992. Table 4 shows the comparison of the seedling rate, the height, diameter and weight of stem, the number of effective stems and the yield of sugarcane in test plat and contrast plot. Table 5 shows the sugar content analysis in test plot and contrast plot. From Table 4 and Table 5, it can be seen that the yield of sugarcane increased by 21.90% and the sugar content increased by 21.80% after deep loosening.

Table 6 to Table 9 show the comparison of the number of stems, the tillering ratio and tillering of single stem in test plot and contrast plot in four groups in 1993's experiments. Form Table 6 to Table 9, it can be seen that the number of stems, the tillering rate and the tillering number of single stem all increased in test plots in four groups.

From the experimental results in 1992, the yield of sugarcanes increased 1082 kg/0.0667 ha. (one Chinese mu). According to the purchasing price in 1992, the increased income was about 150 Chinese yuan for 0.0667 ha., the operation cost of deep loosening for 0.0667 ha. was about 15 Chinese yuan. The economic benefit was about 135 Chinese yuan for 0.0667 ha.. The ratio of cost/increased income was 1:10.

CONCLUSION

1. Soil deep loosening technique can improve the soil structure and increase the air permeability and water permeability of soil. It can increase the yield of crops in a large scale, particularly the plants with deep root system.

2. The experimental results show that the yield of sugarcane in heavy clay with high ground water table can increase by more than 20% after deep loosening. The ratio of cost/increased income is about 1:10. A high economic benefit can be gotten.

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TABLES

Table 1. Soil particle size distribution

Particle size (mm)	> 1	1-0.50	0.50 - 0.10	0.10 - 0.05	0.05 - 0.01	0.01 - 0.005	0.005 - 0.001	< 0.001
Percentage (%)	0.31	0.32	2.31	4.66	12.60	10.50	46.20	23.10

Table 2. Results of subsoiler study*

Implement	Mean draught force (kN)		Soil disturbance (m^2)		Mean specific resistance (kN/m^2)	
	Depth 0.35m	Depth 0.42m	Depth 0.35m	Depth 0.42m	Depth 0.35m	Depth 0.42m
Conventional subsoiler α_1=82°	20.43 a	39.96 a	0.098	0.087	208 a	459 a
Winged subsoiler w_3=0.42 m	28.65 b	42.36 ab	0.200	0.263	143 b	161 b
Winged subsoiler w_3=0.30 m	26.58 bc	43.66 b	0.184	0.250	144 b	175 b
Conventional subsoiler a_1=65°	19.01 a	---	0.116	---	164 b	---
Chisel tine w_2=75 mm, a_1=45/90°, a_2=20°	25.11 c	---	0.080	---	314 c	---
	Bayes l.s.d.=3.1kN		---		Bayes l.s.d. = 25kN/m^2	

* Copied from Spoor and Godwin (1978).

Table 3. The effective stems of sugarcane in test plot and contrast plot in 1991's experiment

Date	29/4	3/5	11/5	18/5	8/6
Test plot	425	1608	2234	3015	8003
Contrast plot	183	1039	1600	2253	6750
Increased ratio (%)	132.24	54.76	39.63	33.82	18.56

Table 4. The comparison of the sugarcane production in test plot and contrast plot in 1992's experiment

Item	Seedling rate (%)	Height of stem (mm)	Diameter of stem (mm)	Weight of stem (g)	Effective stems (0.0667ha.)	Yield (kg/ 0.0667 ha.)
Test plot	68.7	1910	22.1	755	7978	6023
Contrast plot	61.3	1850	20.7	640	7720	4941
Increased ratio (%)	12.07	3.24	6.76	17.97	3.34	21.90

Table 5. The comparison of the sugar content in test plot and contrast plot in 1992's experiment

Item	Fiber content	Cane-sugar content	Apparent purity	Brix	Reducing sugar	Sugar content(kg/ 0.0667 ha.)
Test plot	10.96	12.64	83.37	17.67	0.92	609
Contrast plot	11.36	12.65	83.32	17.87	0.77	500
Increased ratio (%)	-3.52	-0.70	0.60	-1.12	19.48	21.80

Table 6. The comparison of the sugarcane production in test plot and contrast plot in Group 1 in 1993's experiment

Item	The number of stems (in 0.0667 ha.)				Tillering rate (%)		Tilling number of single stem	
	26/4	3/5	11/5	24/5	11/5	24/5	11/5	24/5
Test plot	4602	4953	5460	6552	50	70	0.8	1.4
Contrast plot	4485	5070	5070	5850	0	0	0	0
Increased ratio (%)	2.61	-2.31	7.69	12.00				

Table 7. The comparison of the sugarcane production in test plot and contrast plot in Group 2 in 1993's experiment

Item	The number of stems (in 0.0667 ha.)				Tillering rate (%)		Tilling number of single stem	
	26/4	3/5	11/5	24/5	11/5	24/5	11/5	24/5
Test plot	3686	4066	4826	7677	20	70	0.3	0.9
Contrast plot	4484	4788	5054	7069	30	80	0.4	1.5
Increased ratio (%)	-17.8	-15.1	-4.5	8.6				

Table 8. The comparison of the sugarcane production in test plot and contrast plot in Group 3 in 1993's experiment

Item	The number of stems (in 0.0667 ha.)				Tillering rate (%)		Tilling number of single stem	
	26/4	3/5	11/5	24/5	11/5	24/5	11/5	24/5
Test plot	4127	5018	6285	8724	10	80	0.3	2.0
Contrast plot	4127	4690	5112	8630	20	80	0.2	1.7
Increased ratio (%)	0	6.99	22.95	1.09				

Table 9. The comparison of the sugarcane production in test plot and contrast plot in Group 4 in 1993's experiment

Item	The number of stems (in 0.0667 ha.)				Tillering rate (%)		Tilling number of single stem	
	26/4	3/5	11/5	24/5	11/5	24/5	11/5	24/5
Test plot	1504	2054	2091	3210	0	40	0	0.7
Contrast plot	1339	1467	1779	2072	0	0	0	0
Increased ratio (%)	12.32	40.01	17.54	54.92				

FIGURES

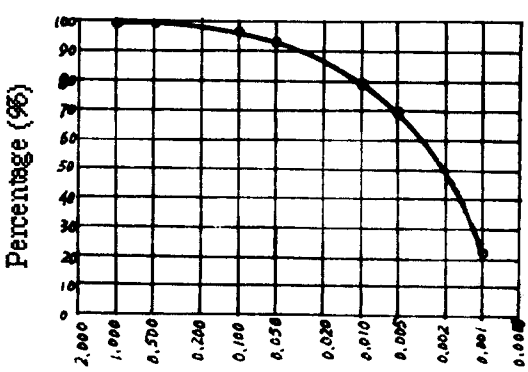

Fig. 1 Soil particle size distribution

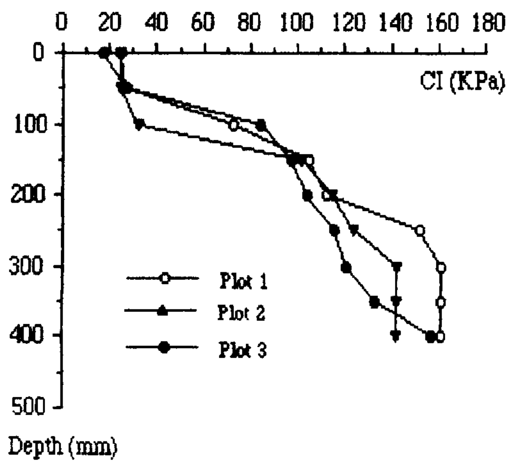

Fig. 2 Cone Index vs Depth (1993's Experiments)

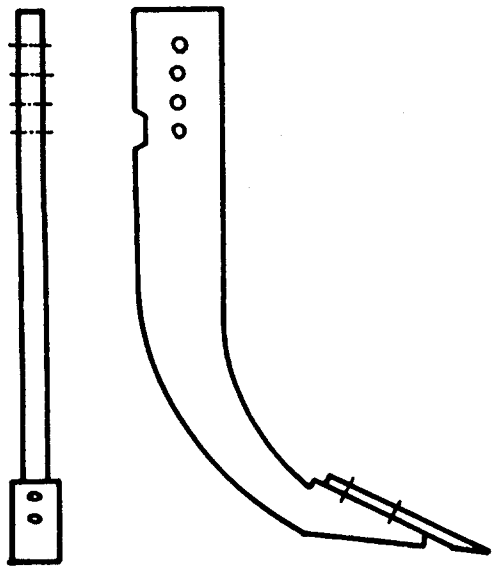

Fig. 3 Conventional subsoiler

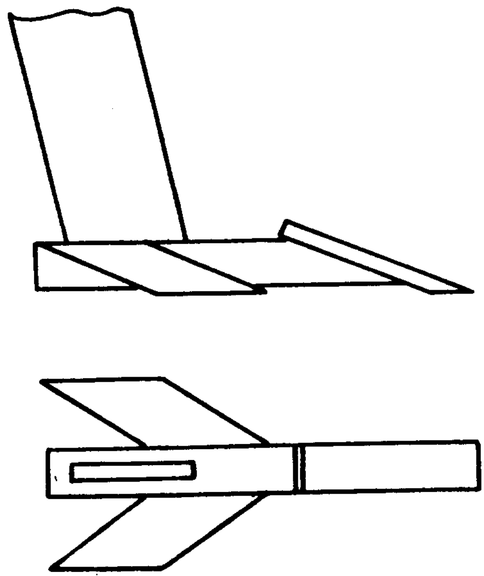

Fig. 4 Winged subsoiler

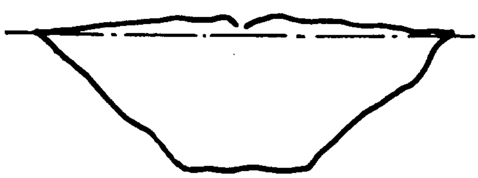

Fig. 5 Soil disturbance created by one winged subsoiler

Fig. 6 Soil disturbance created by two winged subsoilers