Jpn. J. Trop. Agr. 38(4): 281—285, 1994

Studies on Sugarcane Cultivation

1. Effects of the mixture of charcoal with pyroligneous acid on cane and sugar yield of spring and ratoon crops of sugarcane (*Saccharum officinarum* L.).

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Abstract By the application of a mixture of charcoal with pyroligneous acid (charcoal 4: pyroligneous acid 1; Sannekka E, Miyazaki Midori PHARMS....IMC), the stalk number and length surpassed those of the control plots in both spring and ratoon crops, and the total dry matter weight and cane yields at the final farvest were significantly higher in the ratoon crops. The sugar content and yield of the Sannekka E (SE) treated crops were much higher than those of the control crops in both cropping types. CGR and LAI showed significant changes throughout the growth stages by SE application. The highest stalk and sugar yields were obtained by the application of SE of 400 kg/10a in both cropping types. Therefore, it is suggested that SE application affects significantly cane and sugar yields.
Key words Charcoal, Growth analysis, Pyroligneous acid, Sannekka E, Sugarcane

サトウキビの栽培に関する研究　第1報　木酢液・木炭混合物が春植及び株出サトウキビの乾物生産，原料茎及び蔗糖収量に及ぼす影響　ウディン S.M.・モスレム・村山盛一*・石嶺行男*・統栄治**　鹿児島大学大学院連合農学研究科　〒890 鹿児島市郡元1-21-24　*琉球大学農学部　〒903-01 沖縄県西原町千原1　**宮崎大学農学部　〒889-21 宮崎市学園木花台西1-1-1

要　約　本実験は木酢液と木炭の混合物（木酢液1：木炭4，以下，サンネッカEと略称）が春植及び株出サトウキビの乾物生産，原料茎及び蔗糖収量に及ぼす影響を明らかにすることを目的とした．実験はサンネッカE施用量の異なる4水準，すなわち，0(対照区)，200，400及び800Kg/10a施用区を設けて，4反復の乱塊法で実施した．供試品種には，沖縄県の代表的奨励品種であるNCo310を用いた．結果は以下の通りである．　1．春植及び株出サトウキビとも茎数，茎長は対照区よりサンネッカE施用区で大きい値を示した．また，収穫時の全乾物重では株出で対照区に比較して施用区の値が有意に高い値を示した．　2．原料茎収量，蔗糖収量ともサンネッカE施用区が対照区に比較して高い値を示し，春植の蔗糖収量，株出の原料茎収量及び蔗糖収量では有意であった．　3．株出区を対象に実施した生長解析の結果，CGR，NAR，LAIのいずれにおいてもサンネッカE施用区が対照区より高い値を示した．　4．以上の事から，木酢液と木炭の混合物であるサンネッカEはサトウキビの原料茎及び蔗糖収量の両者を向上させる効果があると考えられた。
キーワード　サトウキビ，サンネッカE，生長解析，木酢液

Introduction

The effects of the application of Sannekka E (a mixture of charcoal with pyroligneous acid; charcoal 4: pyroligneous acid 1) on the growth of rice plants was studied by TSUZUKI et al.[10]. Recently, the same author has reported that the sugar content of melon plants increased by the application of Sannekka E (SE)[11]. It has been reported that pyroligneous acid (PA) played a role as a soil disinfectant[2]. In some cases, when rice seedlings were treated with PA, a growth response was noticed[3]. Fungicidal effect of PA was studied by other workers with some positive responses[6,9]. SHIRAKAWA et al.[8] reported significant effects of PA application on physiological activities in rice plants. Although the effects of SE on growth, yield and quality of many crops were studied, no investigation had been made on the growth of sugarcane plants and ratoon crops. Therefore, the present investigation was carried out to study the effects of SE on cane and sugar yields of spring planting and ratoon crops of sugarcane.

Received November 11, 1993

Materials and methods

The experiments were carried out at the experimental farm of the College of Agriculture, University of the Ryukyus from March, 1990 to March, 1992. Popular variety NCo 310 was used in this study. The SE, manufactured by Miyazaki Midori PHARMS...IMC, 945 Tobieda, Akae, Miyazaki, Japan was used in this study. Pyroligneous acid, a component of SE is extracted by cooling of smoke derived from the slowly burnt bark of the broad leaved wood plants[4,5]. The experiments included four treatments; no application of SE (control), SE application of 200, 400 and 800 kg/10a. On March 5, 1990 (spring planting) after treatment with Benlate T, two-eyed cuttings were planted in 7×6 m^2 plots at a 30 cm distance along the furrows on gray upland soils (Jahgaru) which are distributed in the central part of Okinawa main Island. The experiment was carried out using a randomized block design with four replications. The missing hills were replanted with seedlings of one-eyed cuttings. Row spacing was maintained at 1.5 m. For spring crops, SE was applied into the trench and mixed with soil before cutting placement and for the ratoon crops, it was applied in the basal part of the hills during ploughing between two rows after the spring crops had been harvested. Compound fertilizers ($N : P_2O_5 : K_2O = 22 : 11 : 11$) at the rate of 44 kg/10a were applied according to the recommendations for sugarcane cultivation in the Okinawa area[1].

The spring crops were harvested on March 5, 1991, 360 days after planting. After ratooning, the succeeding crops were also harvested on March 5, 1992. The stalk number and length, dry matter weight and sugar content in stalks were recorded throughout the growth stages. Cane and sugar yields were estimated from their components at the final harvest. Dry matter weight of each plant part was measured for the growth analysis. Plant samples were taken from a 1 m^2 area. Each stalk was cut at the level of the fifth leaf from the flag leaf. A small representative sample of plant parts was dried at 85℃ for seven days using an electric oven to determine the dry matter content. Leaf area was measured using an Area Meter (LI-3100, LI. Cor. Inc. Lincoln, Nebraska, USA). Crop Growth Rate (CGR), Net Assimilation Rate (NAR) and Leaf Area Index (LAI) were determined using the data of dry weight and leaf area at each growth stage. Sugar content in juice was determined by liquid chromatography (SHIMADZU LC 5A).

Results

The number and length of stalks for the spring and ratoon crops are given in Table 1. In both cropping types, the plot with SE application at the rate of 400 kg/10a showed the largest number of stalks, followed by those with SE applications at 200 kg/10a in spring and 800 kg/10a in ratoon crops. The stalk of the SE treated crops was longer than that of the control crops in the spring and ratoon crops.

Table 1. Effect of Sannekka E (SE) application on stalk number and length in spring and ratoon crops at the final harvest.

Application of SE (kg/10a)	Spring crop		Ratoon crop	
	Stalk number (No./10a)	Stalk length (cm)	Stalk number (No./10a)	Stalk length (cm)
Control	7,444	153	7,489	182
200	7,558**	162	7,781**	202**
400	7,892**	172	8,405**	203**
800	7,447	164	8,134**	202**

Note: ** indicates significant differences from the control plot at P=0.01.

Table 2. Effect of Sannekka E (SE) application on total dry matter weight in spring and ratoon crops at the final harvest.

Application of SE (kg/10a)	Spring crop		Ratoon crop	
	Total dry (t/10a)	Index (%)	Total dry weight (t/10a)	Index (%)
Control	2.07	100	1.84	100
200	2.16	105	2.59**	141
400	2.27	110	2.69**	146
800	2.08	101	2.54**	138

Note: ** indicates significant differences from the control plot at P=0.01.

Total dry matter weight in the SE treated crops increased compared with the control (Table 2). In the SE treated ratoon crops the dry matter weight was significantly higher, surpassing that in the control by 38-46%. The changes in the CGR, NAR and LAI in ratoon crops are shown in Fig. 1. The CGRs increased markedly in the SE treated crops compared with the control crops throughout the growth stages. The maximum CGR value of 16 g/m²/day was obtained by SE application at the 400 kg/10a during 120-180 days after planting (Fig. 1, A).

The NAR increased up to 120 days after planting, then decreased gradually with the progression of growth in all the experimental plots including the control (Fig. 1, B). The LAI in all the treatments steadily increased up to 180 days and then decreased gradually (Fig. 1, C). Throughout the growth period, the LAI of the SE treated crops was higher than that of the control.

Sugar content, cane and sugar yield of both cropping types at the final harvest are shown in Table 3. High cane yields in both the spring and ratoon crops were obtained by SE application. In the SE treated spring crops, the yield exceeded that of the control by 2-16%. On the other hand, the cane yield in the SE treated ratoon crops was significantly higher than that of the control by 23-36%. The highest yield was obtained by SE application at 400 kg/10a, followed by 200 kg/10a. Sugar contents in both SE treated crops were significantly higher than those of the control crops in the spring and ratoon crops.

Discussion

The results of the present study showed that SE application exerted significant effects on sugar yield and yield components of sugarcane. High cane yield can be achieved through the improvement of major yield components; stalk number per unit area, stalk length, stalk diameter and individual stalk weight[7]. In this study, a large number of long stalks were produced by SE application, especially in the ratoon crops. As a result, the total dry matter weight was significantly large through the increase of the stalk number and length in the SE application to ratoon crops.

A significantly high sugar content was observed in the SE treated crops. These results were in agreement with the findings of TSUZUKI et al. who observed high sugar content in SE treated melon plants[11]. Therefore, the results of the present study suggest that

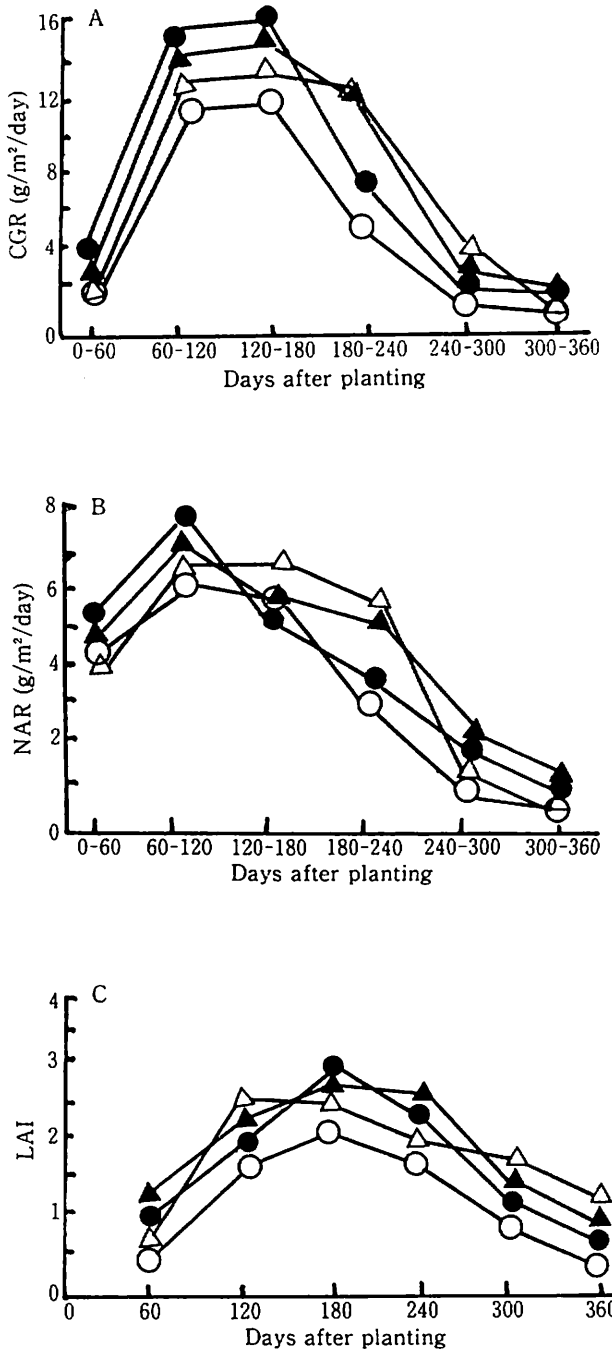

Fig. 1. Effects of Sannekka E application on CGR (A), NAR (B) and LAI (C) of ratoon crops. ○ (Cont.), △ 200, ▲ 400, ● 800 (kg/10a Sannekka E)

Table 3. Effects of Sannekka E (SE) application on the sugar content, cane and sugar yield of spring and ratoon crops.

Application of SE (kg/10a)	Spring crop			Ratoon crop		
	Stalk yield (t/10a)	Sugar content (%)	Sugar yield (t/10a)	Stalk yield (t/10a)	Sugar content (%)	Sugar yield (t/10a)
Control	4.9	14.3	0.70	6.2	17.0	1.05
	(100)	(100)	(100)	(100)	(100)	(100)
200	5.4	14.8**	0.80**	8.1**	18.2**	1.47**
	(110)	(104)	(114)	(131)	(107)	(140)
400	5.7	15.0**	0.85**	8.4**	18.0**	1.51**
	(116)	(105)	(121)	(136)	(106)	(144)
800	5.0	14.7	0.73	7.6**	17.3	1.31**
	(102)	(104)	(104)	(123)	(102)	(125)

Notes: ** indicates significant differences from the control plot at P=0.01. Figures in parentheses indicate percentage to the control.

sugar formation and storage in cane stalk are enhanced by SE application.

In summary, in this study the significant effects of SE application on cane and sugar yields were revealed. Although the dry matter and cane yields in the spring crops were not significantly increased, the values obtained from the ratoon crops were significantly higher than those in the control crops. On the other hand, the sugar content and yield of the SE treated crops in both cropping types were significantly higher than those of the control. Significant increases in dry matter weight, cane and sugar yields in ratoon crops were associated with the high CGR throughout the growth stages, particularly during the late stages. The high CGR recorded through SE application was caused not only by the high LAI value, but also by the high NAR, reflected by the photosynthetic activities of leaves. From the above results, it can be considered that the beneficial effect of SE application to sugarcane is related to the higher dry matter content, cane yield and high sugar content, especially in the ratoon crops. Furthermore, it is suggested that the increase of cane yield by the SE application is due to the improvement of the soil environment for root growth, nutrient uptake, etc. Further physiological studies on root growth and sugar accumulation should be conducted in relation to SE application.

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