CANE AND SUGAR PRODUCTION OF THE VARIETY ECU-01 WITH N, P, K, S AND MICRONUTRIENT APPLICATION IN PLANT CANE.

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KEYWORDS: Sugarcane fertilization, micronutrient applications, ECU-01 variety

Abstract

In 2007, the Sugar Cane Research Centre of Ecuador (CINCAE) released their first variety, ECU-01, which has recorded good production throughout locations and ratoons. ECU-01 was grown commercially on 4000 ha in 2009. There is a need to study nutrient management of this variety by determining the effect of N, P, K, S and a mixture of micronutrients (Zn, Cu, Fe, Mn and B) to assess cane and sugar production. The experiment was established in Fluventic Haplustept, Vertic Ustropepts and Typic Haplustert soil types, which represent 59, 45 and 12% of the sugarcane area of Valdez, ECUDOS and San Carlos mills, respectively. Results showed that the highest cane yield (132 TCH) was produced at Valdez Mill, followed by ECUDOS Mill (108 TCH) and San Carlos Mill (84 TCH). The ECU-01 variety exhibited a significant response to 141 kg/ha N with an increase of 15, 40 and 30% tonne of cane/ha (TCH) and 21, 57 and 37% tonne of sugar/ha (TSH) compared to the control treatment (zero fertiliser) in ECUDOS, San Carlos and Valdez mills, respectively. On the other hand, in ECUDOS and Valdez mills, the dosage of 30 kg/ha of P_2O_5 recorded the greatest production with 120-140 TCH and 15-17 TSH. The rate of 100 kg/ha of K_2O increased TCH and TSH by 20% in ECUDOS mill and by 8% in San Carlos mill. In Valdez mill, K affected only the sugar concentration. There was no response to S application on TCH and TSH. Only in Valdez Mill, the addition of the micronutrient mixture produced an increase of 2.1 TSH and 11.0 TCH compared with the treatment without micronutrients. Our results have demonstrated that N is the most limiting nutrient in plant cane in all three locations. However, new data will be collected and analysed in first and second ratoon to determine fertilisation strategies for ECU-01 in the ratoon crops.

PRODUCCIÓN DE CAÑA Y AZÚCAR DE LA VARIEDAD ECU-01 CON LA APLICACIÓN DE N, P, K, S Y UNA MEZCLA DE MICROELEMENTOS EN CAÑA PLANTA

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Palabras claves: Fertilización de caña de azúcar, aplicación de micronutrientes, variedad ECU-01

Abstract

En el 2007, el Centro de Investigación de Caña de Azúcar del Ecuador (CINCAE) liberó la primera variedad llamada ECU-01, la cual ha presentado buena producción en diferentes localidades y socas. Desde su lanzamiento el área comercial se han incrementado hasta llegar a 4000 ha^{-1} en el 2009. Hay una necesidad para estudiar el manejo de nutrientes determinando el efecto de N, P (as P_2O_5), K (as K_2O), S y una mezcla de micronutrientes (Zn, Cu, Fe, Mn y B) en la producción de caña y azúcar. El experimento fue establecido en suelos del tipo Fluventic Haplustept, Vertic Ustropepts y Typic Haplustert, los cuales representan 59, 45 y 12% del total del área cañera de los ingenios Valdez, ECUDOS y San Carlos, respectivamente. El mayor tonelaje de caña por hectárea (TCH) presentó el ingenio Valdez (132 TCH), seguido por ECUDOS (108 TCH) y San Carlos con 84 TCH. La variedad ECU-01 presentó una respuesta significativa a la aplicación de 141 kg/ha de N con un incremento de 15, 40 y 30 % de TCH y 21, 57 y 37 % de TAH comparado con el tratamiento control (cero fertilización) en ECUDOS, San Carlos y Valdez, respectivamente. En los ingenios ECUDOS y Valdez, la dosis de 30 kg/ha de P_2O_5 tuvo la más alta producción de caña y azúcar (120-140 TCH y 15-17 TAH). La aplicación de 100 kg/ha de K2O incremento 20% del tonelaje de cana y azúcar en el ingenio ECUDOS y 8 % en el Ingenio San Carlos. En Valdez el K afectó solamente a la concentración de azúcar. No hubo respuesta a la aplicación de S en el tonelaje de caña y azúcar por hectárea. Únicamente, en el ingenio Valdez, el uso de la mezcla de microelementos produjo un amento de 2.1 TAH y 11 TCH comparado con el tratamiento sin la aplicación de microelementos. Los resultados demostraron que el N es el nutriente más limitante en la producción de caña planta en las tres localidades. Sin embargo, nueva información será colectada y analizada en la primera y segunda soca para determinar estrategias de fertilización en las socas.

Introduction

As a result of 10 years of selection, the Sugarcane Research Center of Ecuador (CINCAE) released its first Ecuadorian variety, ECU-01, in July 2007. Sugarcane mills planted at least 600 ha of ECU-01 in 2008 (CINCAE, 2008) and established increase seed plots. In 2009, an increase to approximately 4000 ha was observed. Field trials of ECU-01 documented better response to fertilization than variety Ragnar in a wide range of soil types and texture (CINCAE, 2004; CINCAE, 2005). Cane production ranged between 90 to 110 tonnes of cane/ha (TCH), and 7.5 to 10.7 tonnes of sugar/ha (TSH) on plant cane using 80 N, 60 P_2O_5 and 80 kg/ha of K_2O. Whereas two ratoons recorded yields of 60 to 140 TCH and 6.0 to 12.5 TSH using 120 N, 100 P_2O_5; and 140 kg/ha of K_2O, under traditional fertilization rates used by sugarcane mills (CINCAE, 2008).

Studies on fertilization with N, P and K have shown that nutrient recommendations depend on soil type, sugarcane variety and the number of ratoons (Quintero, 1995). Commercial production of variety Ragnar has been managed with applications of 120 and 150 kg N/ha in plant cane and first ratoon, respectively (CINCAE, 2004). Preliminary observations with variety ECU-01 in trials at Valdez and San Carlos mills showed acceptable cane yields with low levels of N (40 and 80 kg/ha in plant cane and first ratoon, respectively) (CINCAE, 2007a). However, the sites did not represent soil types commonly used for sugarcane cultivation.

Soil maps drawn by three Ecuadorean sugarcane mills allowed us to choose representative zones to establish an experiment to study the effects of N, P (as P_2O_5), K (as K_2O), S and a micronutrient mixture on cane and sugar production in plant cane of variety ECU-01. This experiment would also allow the calculation of a statistical function which may identify the relationship between soil nutrients and sugar production in Ecuador.

Materials and methods

The experiment was planted at 3 locations: 1) on a Fluventic Haplustept (Valdez mill), 2) Vertic Ustropept (ECUDOS mill) and 3) Typic Haplustert (San Carlos mill) soil, representing 59, 46 and 12% of the total sugarcane cultivation area. The treatment set up is shown in Table 1.

Applications of P, K, S and the micronutrient mixture were performed at the base of the row before planting the cane stools. All plots received 35 kg N/ha at sowing to adjust concentrations with the P sources (DAP). The remaining N was applied after 45 and 90 days. Micronutrients were combined in a mixture of 10, 10, 10, and 5 kg/ha of Zn, Mn, B and Cu, respectively. A randomised complete-block design with three replications was used for the experiment at each location; each experimental unit was formed by 6 rows, 10 m long, with 1.5 m between rows. Analysis of variance and linear or quadratic regressions for the rates of the nutrients were calculated with the INFOSTAT program (INFOSTAT, 2009).

Table 1. Treatment lay out in each location

	TREATMENTS				
	N	P_2O_5	K_2O	S	Microelement mixture
Nº	kg ha $^{-1}$				
1	**35**	90	200	60	NO
2	**88**	90	200	60	NO
3	**141**	90	200	60	NO
4	**194**	90	200	60	NO
5	120	**0**	200	60	NO
6	120	**30**	200	60	NO
7	120	**60**	200	60	NO
8*	120	**90**	200	60	**NO**
9	120	90	**0**	60	NO
10	120	90	**50**	60	NO
11	120	90	**100**	60	NO
12	120	90	**150**	60	NO
13	120	90	200	**0**	NO
14	120	90	200	**30**	NO
15	120	90	200	60	**SI**
16	0	0	0	0	NO

* This treatment is used to complete the high levels of K_2O and S in the analysis of K and S effect; also, to compare with the level with microelement mixture

Soil samples were taken at 30 cm depth before planting and fertilisation, and immediately after harvest. Soil P concentration, assimilate cations (K^+, Ca^{++}, Mg^{++}) and micronutrients (Zn, Mn, Fe, Cu) was determined by a modified Olsen extraction. Leaf samples were taken at three and six months after sowing to determine N, P, K, Ca, and Mg concentrations using a mixture of sulfuric acid with selenium. Micronutrients (Zn, Mn, Cu and Fe) were determined by nitric and perchloric acid digestions. A nitric-perchloric acid and chlorhidric acid method was used for extracting sulfur. Boron was extracted by diluted sulfuric acid (CINCAE, 2007a).

The soil at the three locations was slightly acid (pH: 6.3-6.7), and Mn was between 10 and 20 ppm. Organic matter (OM) was < 1% in ECUDOS mill, while in San Carlos and Valdez mills OM was between 1.64 and 2.23%. The ECUDOS mill location had the lowest Ca (11-18 meq/100 g soil), Mg (4-13 meq/100 g soil) and Cu (4-8 ppm), but had high Zn and Fe content (3.8-6.3 ppm and 57-65 ppm, respectively). The San Carlos location had lower B concentration (1.0-1.3 ppm) than ECUDOS and Valdez mills (2.1-2.7 ppm). Soil P (10-12 ppm), K (0.09-0.18 meq/100) and S (11-16 ppm) concentrations were similar at the three sites.

Results and discussion

Soil response to the application of P_2O_5, K_2O and S fertiliser

A relationship between the fertiliser applied and the soil mineral content was significant in the ECUDOS trial but not at the other locations (Figure 1). However, changes in P availability were found when P_2O_5 was applied to the soil. A similar trend was observed with applications of K_2O and S fertilisers.

Application of P_2O_5 and S increased soil mineral content by 0.085 and 0.041 ppm, respectively in ECUDOS. Therefore, a dosage of 11.8 kg/ha of P_2O_5 and 24.4 kg/ha of S increased soil mineral content one ppm each. However, in a previous study in a Vertic Tropaquept soil (sandy loam) from ECUDOS with variety Ragnar a dosage of 30 kg/ha of P_2O_5 led to 1 ppm of P increase (Salazar *et al.*, 2008).

Increasing K into the soil solution was small in ECUDOS and San Carlos mills; however, a linear effect was shown for meq of K/100 g in the soil with a significant correlation (R^2=0.70). Similar effect was observed for S in ECUDOS Mill (Figure 1).

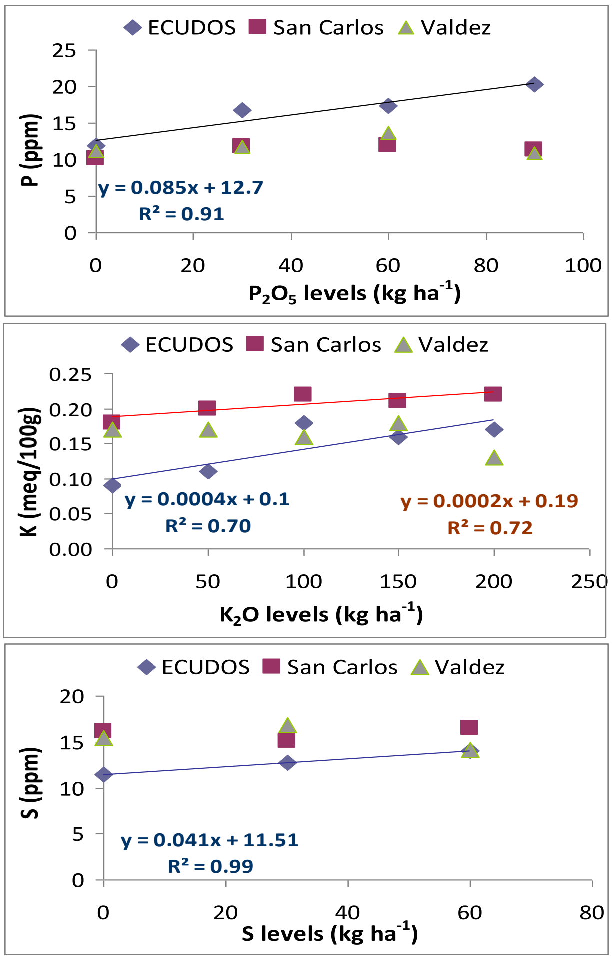

Fig. 1. Relationship between P_2O_5, K_2O and S application and soil contents of P (ppm), K(meq/100 g soil) and S (ppm) evaluated in three locations. 2008

This small response of the soil to applications of these nutrients might have been due to the type of colloidal material present in the soil;

probably, there was loss of K because it has less bonding strength to the cation exchange sites than Ca and Mg, or in the case of P maybe there is a fixation of fertiliser phosphate by soil due to precipitation of phosphate compounds such as calcium phosphate (McLaren and Cameron, 1996).

Cane and sugar production response to the application of nitrogen (N)

At the three locations, applications of 141 kg/ha of N recorded the highest sugar yields (TSH) (Figure 2). At this rate, in San Carlos and ECUDOS mills, TCH was low (89 and 101 TCH) whereas sugar production was high (11 and 13 TSH, respectively), due to higher sugar concentrations (12.1 and 12.9% pol, in that order). At the Valdez Mill location, yields of 20 TSH were obtained from the highest tonnage of cane (154 TCH) (Figure 2). However, another study (CINCAE, 2007b) showed that ECU-01 can have good yields with only 40 kg/ha of N applied. Nevertheless, that study was conducted in soils with high organic matter (SOM) concentration (2.7%); whereas, in the present study, SOM was only 0.7 to 0.9%. Some studies carried out by Quintero (1995) and Cassman *et al*. (2002) determined that sugarcane N needs depended on soil type, number of ratoons, and variety; with SOM concentration a key factor affecting the response to N application.

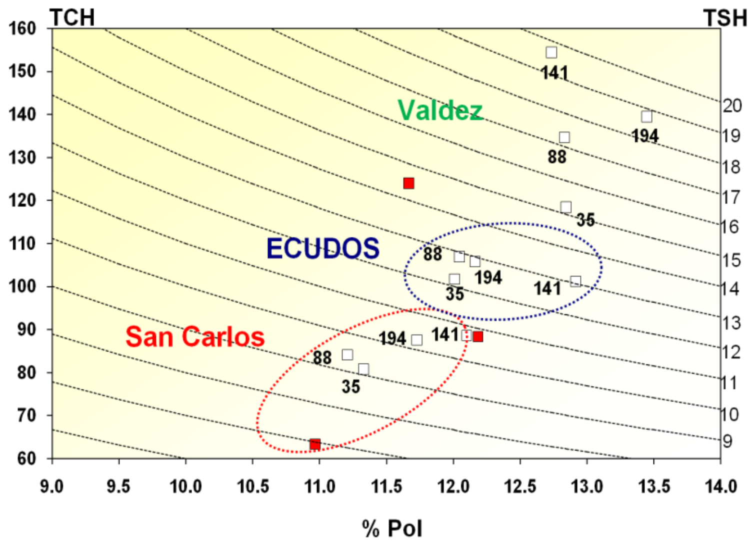

Fig. 2. Isoproductive lines of tonnage of cane/ha (TCH), tonnage of sugar/ha (TSH) and sugar concentration (% Pol) of variety ECU-01 in plant cane at four N levels (35, 88, 141 and 194 kg/ha) and 0 N control treatment (■**)**. Data are from three locations in Ecuador.

Cane and sugar production response to the application of P_2O_5, K_2O and S

The effect of P, K and S application was different at each location. In ECUDOS and Valdez mills, the application of 30 kg/ha of P_2O_5 increased 7 and 4 TCH and 1.5 and 0.8 TSH compared to 0 application of P (control). A study carried out by CINCAE on Inceptisol and Vertisol soils (sandy loam) showed that 30 or 60 kg/ha of P_2O_5 were enough to achieve maximum sugar yields (Salazar *et al*., 2008). There was no effect of P in San Carlos mill.

Application of 100 kg/ha of K_2O increased from 100 TCH in the 0 K control treatment to 120 TCH in ECUDOS mill; while, in San Carlos mill, the increase was from 81 to 88 TCH. At this rate, the boost of TSH was higher (20%) in ECUDOS mill than in San Carlos mill (8%).

Only, in Valdez mill, the use of K_2O affected sugar concentration from 11.6% pol in the 0 K control treatment to 12.7 and 13.5% pol in the rates of 50 and 100 kg/ha, respectively.

Application of S did not lead to significant differences in cane production at the three locations. This could be due to the high S concentration in the soil (ECUDOS mill, 26-47.3 ppm, San Carlos and Valdez Mills, 11–20 ppm). However, at Valdez Mill, 30 kg/ha of S increased sugar content from 12.3% pol in the 0 S treatment to 13.5% pol. Similar results were observed by Quintero (1995) on Vertisol, Mollisol and Inceptisol soils where no response to S application was found, but a slight increase of sugar content in the juice was observed.

The micronutrient mixture increased yields by 15 TCH and 2 TSH at the Valdez Mill. However, leaf tissue concentrations and plant removal of Zn, Cu, Fe, Mn and B from the soil were not different in the micronutrient mixture treatment compared to zero application of microelement mixture (data not shown), suggesting that there was sufficient micronutrient concentration for sugarcane growth in the soil solution. Therefore, ranges for soil concentration were established at the three locations for Cu (3.0– 8.0 ppm), B (1.0-2.8ppm), Fe (14-65 ppm), Mn (4.0-13.0 ppm) and Zn (0.3-0.5)

Conclusions

Cane and sugar production of variety ECU-01 depended on the soil type and crop management in the three locations. The highest cane yields were recorded with the application of 141, 30, 100 and 30 kg/ha of N, P_2O_5, K_2O and S respectively. Nitrogen applications increased both cane and sugar production at the three sites, while responses of tonnage of cane, sugar and % pol to P, K and S were different at each site.

This study has confirmed that N was the most limiting nutrient for plant cane at three mills in Ecuador. Data will be analysed for the first and second ratoon to determine cane yield response to nutrient application in the ratoon crops.

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