SILICON AMENDMENT IN THE PRODUCTIVITY OF FOUR SUGARCANE VARIETIES IN BRAZIL

By

F.L.F. DIAS[1], R. ROSSETTO[1],
M.G.A LANDELL[1] and A. MENDES[2]
[1]*IAC/APTA – Instituto Agronômico de Campinas,*
C.P. 206 – CEP: 14001–970 – Ribeirão Preto, SP – Brazil
[2]*EXCELL – Fertilizers and Mineral, MG – Brazil*
dias@iac.sp.gov.br

KEYWORDS: Silicon, Sugarcane Productivity, Economy, Variety.

Abstract

SILICON is a beneficial element for some crops. The low rates of available silicon in tropical soils, together with the large amount of silicon extracted by sugarcane, emphasises the importance of this work which reports on the responses of four sugarcane varieties to excoriates of metallurgy applied as a silicon source. The soil in the experiment was an Oxisol, medium texture, previously cultivated with pasture and it has a low level of soluble silicon (less than 3 ug/cm^3). A split plot trial comprised four sugarcane varieties as the main plots: RB867515—high productivity; SP81-3250—rich and high productivity; RB72454 and SP83-2847—wide adaptability varieties. The sub plots were two treatments comprising a control (no silicon) and a plot receiving 940 kg/ha of Agrosilício containing 23% SiO_2. The fertilisers were applied at the bottom of the furrows at planting. The measured parameters were fibre, purity, Pol, reducing sugars (AR) and total recoverable sugars (ATR), and cane yield (t/ha). The economic analysis was conducted on plant cane. We observed different productivity for varieties due to silicon application in the first harvest. The varieties RB72454 and SP83-2847 were more responsive, and there were economic gains from silicon application. The economical gains in the second period of harvest were lower, with no statistical differences between treatments.

Introduction

In the past 10 years, Brazil has become the world's leading exporter of sugar, accounting for 30% of world exports of the product. Brazilian ethanol produced from sugarcane is both more economical and more efficient in terms of carbon dioxide balance (GHG emissions) than gasoline.

This aspect is reflected in the fact that Brazil is now responsible for half of world exports of the product.

There has been major expansion of sugarcane planted areas in the west of São Paulo, Minas Gerais, Mato Grosso, Mato Grosso do Sul and Goias states. Many of those areas, for example the west of São Paulo and Goias states, are usually deficient in Si with marginal soils that are sandy and with low fertility.

Although silicon is not considered an essential element for plant nutrition, scientific research has showed its involvement in structural, physiologic and biochemical aspects.

Some benefits have been ascribed to silicon application, such as: more tolerance to water stress, resistance to lodging in rice and cane, productivity increase and improvement in the product quality. Lima Filho *et al*. (1999) emphasised the need for silicon in tropical and subtropical soils. In general, tropical soils have lost available silicon by intensive leaching due to climatic conditions and some agricultural practices like intensive cultivation and continuous monoculture.

There is a lack of information in the literature concerning differences between sugarcane varieties in response to silicon application.

Sugarcane uptakes more silicon than potassium and nitrogen. Therefore, the low rate of available silicon in verified (or controlled) plants in Oxisols, plus the great silicon extraction accumulated by sugarcane biomass, emphasise the objectives of this paper.

Our main objective was to verify the response of four different sugarcane varieties in productivity, Pol, purity, reducing sugars (AR) and total recoverable sugars (ATR).

Material and methods

Field trials were initiated in May, 2007 at Moema sugar-mill production area, in the district of Orindiuva, São Paulo, Brazil, on an Oxisol of medium texture, 3 mmolc/dm^3 of soluble silicon to study the productivity of sugarcane varieties following the application of silicon fertiliser in two planting seasons namely July and November 2008.

The experiment used a split plot design with four main treatments, namely sugarcane varieties RB867515, RB72454, SP81-3250 and SP83-2847.

The sub-plot treatment comprised the control (without silicon) and the treated plot receiving 940 kg/ha of 'Agrosilício' that is a silicon fertiliser produced by EXCELL company containing 23% of total silicon and 43% of soluble silicon.

Silicon fertiliser was applied in the planting furrow. In each plot, 500 kg/ha of 13-20-25 (N-P_2O_5-K_2O) was applied in the furrow.

The plots were replicated four times in a randomised block design. Each sub plot consisted of 10 cane rows 8 m long and spaced at 1.40 m.

The plots were weighed with a dynamometer to determine cane yield (t/ha). Pol, fibre, purity, reducing sugars (AR) and total recoverable sugars (ATR) were determined in ten stalks collected in each plot according to CONSECANA, (1999).

We also calculated the economic revenue (mean ATR/ha) = mean productivity of the varieties-treatment with silicon – mean productivity of the varieties-treatment without silicon; productivity (%) = (mean productivity of the varieties-treatment with silicon/mean productivity of the varieties-treatment without silicon * 100; Relative revenue for the productivity earnings = productivity * ATR (month reference August of 2008 = U$0.0999 and month reference November of 2008 = U$0.1206); cost fertilisers = function of the applied dose and adopted product. Liquidate relative = relative revenue – cost of the fertilisers (U$40.00/ha).

Statistical analyses of variance were performed using SAS software, and means were compared with Tukey's test with P = 0.05%. The graphs were produced with the Office/Excel software.

Results and discussion

In Table 1 we show the results of the first evaluation time. The varieties showed differences such as: Pol cane, purity, reducing sugars (AR) and total recoverable sugars (ATR).

The varieties RB72454 and SP83-2847 are considered varieties with wide adaptability to low soil fertility and restrictive conditions of climate. RB867515 and SP81-3250 require more nutrients; however, there was no statistical difference in yield between varieties. Silicon promoted just a few changes in Pol% and ATR. Silicon application promoted increments in stalk productivity near 5 t/ha (132.61-127.36).

In the second harvest period (Table 2), which differed from the first period because there were no constraints in water and thermal climate parameters, there was no response for silicon application in stalk yield.

Increases in productivity were observed for variety RB867515 in the second harvest, but variety SP81-3250 maintained the same productivity in both harvests.

These varieties should be harvested in the second harvest period. However, the varieties RB72454 and SP83-2847 should be harvested in the middle of the harvest period.

There was no interaction between variety and silicon.

Table 1—Variance analysis and comparison among averages for Pol, fibre, purity, reducing sugars (AR), total recoverable sugars (ATR), and stalks productivity harvested on July 2008.

Treatments	Fibre	Purity	Pol cane	AR	ATR	TCH
	%	%	%		kg/t cane	t/ha
Variety (V)						
RB867515	12.29 a	15.85 b	90.39 a	0.54 b	155.47 ab	132.73 a
RB72454	10.32 a	16.47 a	89.93 ab	0.56 ab	161.35 a	128.92 a
SP81-3250	12.73 a	16.03 ab	88.47 b	0.61 a	157.29 ab	129.78 a
SP83-2847	12.25 a	15.45 b	88.87 ab	0.59 ab	151.71 b	128.92 a
Silicon (S)						
(-Si) without silicon	11.84 a	15.72 b	89.02 a	0.59 a	154.29 b	127.36 b
(+Si) with silicon	11.95 a	16.20 a	89.77 a	0.56 a	158.62 a	132.61 a
V X S						
RB867515 (–Si)	12.55	15.71	90.08	0.55	153.88	128.62
RB867515 (+Si	12.03	1606	90.52	0.54	157.07	136.84
RB72454 (–Si)	9.47	16.46	89.77	0.56	161.32	124.92
RB72454 (+Si)	11.16	16.48	90.08	0.55	161.34	132.18
SP81-3250 (–Si)	12.97	15.65	87.62	0.64	153.81	127.72
SP81-3250 (+Si)	12.50	16.42	89.34	0.58	160.76	131.84
SP83-2847 (–Si)	12.37	15.06	88.61	0.60	148.11	128.17
SP83-2847 (+Si)	12.13	15.84	89.14	0.58	155.31	129.67
F value						
Variety (V)	2.50 ns	3.79 *	3.84*	3.77*	3.95*	1.26 ns
Silicon (S)	0.03 ns	4.85*	2.93*	2.85 ns	4.62*	9.64**
V vs S	0.60 ns	0.70 ns	0.56 ns	0.50 ns	0.72 ns	0.81 ns
Blocks (B)	0.72 ns	1.72 ns	1.26 ns	1.36 ns	2.00 ns	1.71 ns
CV (%)	16.19	3.85	1.39	7.47	3.64	3.68
MSE (%)	1.93	0.61	1.24	0.04	5.70	4.79
General mean (T)	11.90	15.97	89.39	0.58	156.45	129.99
msd (V)	2.69	0.86	1.23	0.06	7.94	6.67
msd (S)	1.42	0.45	0.91	0.03	4.19	3.52

AR: reducing sugar. ATR: recovered total sugar; TCH: stalks tonnes per hectare. Averages following by different letters differ are significantly different by Tukey's test. * and **: significant for p = 5 and 1%, respectively. Ns: not significant.

Table 2—Variance analysis and comparison among averages for Pol, fibre, purity, reducing sugars (AR), total recoverable sugars (ATR), and stalks productivity harvested on November 2008.

Treatments	Fibre	Purity	Pol cane	AR	ATR	TCH
	%	%	%	%	kg/t cane	t/ha
Variety (V)						
RB867515	11.57 a	16.10 a	89.64 a	0.57 b	157.76 a	134.17 a
RB72454	11.52 a	16.04 a	90.26 a	0.55 b	157.05 a	125.56 b
SP81-3250	12.65 a	15.19 a	88.85 a	0.59 b	149.16 a	129.55 ab
SP83-2847	11.77 a	13.45 b	863.10 b	0.79 a	134.27 b	124.05 b
Silicon (S)						
(–Si) without silicon	11.78 a	15.12 a	87.76 a	0.63 a	148.89 a	127.06 a
(+Si) with silicon	11.86 a	15.27 a	88.17 a	0.62 a	150.23 a	129.65 a
V X S						
RB867515 (–Si)	11.28	16.25	89.23	0.58	159.30	132.67
RB867515 (+Si	11.85	15.95	90.04	0.55	156.22	135.67
RB72454 (–Si)	11.53	15.67	89.40	0.58	153.67	124.61
RB72454 (+Si)	11.51	16.42	91.13	0.52	160.43	126.72
SP81-3250 (–Si)	12.61	15.26	89.53	0.57	149.67	127.80
SP81-3250 (+Si)	12.70	15.12	88.17	0.62	148.70	131.31
SP83-2847 (–Si)	11.71	13.31	82.86	0.80	132.97	123.18
SP83-2847 (+Si)	11.42	13.60	83.34	0.78	135.57	124.93
F value						
Variety (V)	2.88 ns	23.28 **	18.09**	17.91**	21.24**	5.25**
Silicon (S)	0.07 ns	0.35 ns	0.28 ns	0.29 ns	0.58 ns	0.20 ns
V vs S	0.30 ns	0.85 ns	0.70 ns	0.68 ns	0.49 ns	0.99 ns
Blocos (B)	2.43 ns	3.52*	2.40 ns	2.36 ns	0.04 ns	0.87 ns
CV (%)	7.80	4.76	2.48	12.08	4.48	4.33
MSE (%)	0.92	0.72	2.19	0.08	6.70	5.52
General mean (T)	11.82	15.20	87.96	0.62	149.56	128.36
msd (V)	1.29	1.01	3.05	0.11	9.33	7.76
msd (S)	0.68	0.53	1.61	0.05	4.92	4.09

AR: reducing sugar; ATR: recovered total sugar; TCH: stalks tonnes per hectare. Averages following by different letters are significantly different by Tukey's test. * and **: significant for p= 5 and 1%, respectively. ns: not significant

Table 3 shows the calculations of economical income concerning the use of silicon. The largest incomes as well as the relative balances were positive for silicon application in the first period of harvest. However, in the second harvest period, the incomes were not so impressive, resulting in little economical return per hectare. As an example, the agricultural area in a sugar mill is around 20 000 hectares.

In this case, it is possible with use of silicon to obtain profits of US$548 400.00 (20 000 hectares multiplied by US$27.42 with silicon, Table 3).

Table 3—Absolute contributions and relative balances obtained for varieties vs silicon and silicon in the experiment harvested in August (Time 1) and November (Time 2).

Treatments	Productivity Average ATR/ha	Productivity ATR/ha	Productivity (%)	Balance relative US$/ha
	Time 1			
RB867515 (–Si)	19 789	–	–	–
RB867515 (+Si)	21 452	1663	8.40	126.17
RB72454 (–Si)	20 156	–	–	–
RB72454 (+Si)	21 328	1172	5.81	98.89
SP81-3250 (–Si)	19 646	–	–	–
SP81-3250 (+Si)	21 205	1559	7.94	144.72
SP83-2847 (–Si)	19 007	–	–	–
SP83-2847(+Si)	20 134	1127	5.93	90.76
Silicon (average)				
(–Si) – without silicon	19 649	–	–	–
(+Si) – with silicon	21 030	1381	7.03	97.99
	Time 2			
RB867515 (–Si)	21 130	–	–	–
RB867515 (+Si)	21 212	82	0.39	– 30.11
RB72454 (–Si)	19 162	–	–	–
RB72454 (+Si)	20 327	1165	6.08	100.50
SP81-3250 (–Si)	19 115	–	–	–
SP81-3250 (+Si)	19 529	414	2.17	9.93
SP83-2847 (–Si)	16 401	–	–	–
SP83-2847(+Si)	16 981	580	3.54	29.95
Silicon (average)				
(–Si) – without silicon	18 953	–	–	–
(+Si) – with silicon	19 512	559	2.95	27.42

(–Si) and (+Si): without silicon and with silicon, respectively.

Silicon use provided gains in productivity for all varieties in this experiment. The increase was around 7% in the first period of harvest and of 3% in the second time. The varieties RB867515 and SP81-3250 were more responsive in the first evaluation time, showing 8.40 and 7.90% respectively in ATR gains.

For the second period of harvest, the varieties RB72454 and SP83-2847 were more responsive showing 6.08 and 3.54% respectively in ATR gains.

REFERENCES

CONSECANA (1999). Manual da Consecana. In: Chapter I: Quality of Sugar Cane, São Paulo, 1999.

Lima Filho, O.F. de, Lima, M.T.G. de and Tsai, S.M.O. (1999). Silício na agricultura. Informações Agronômicas, Piracicaba, 87: 1–7.

EFFET D'UN AMENDEMENT A BASE DE SILICIUM SUR LA PRODUCTIVITE DE QUATRE VARIETES DE CANNE A SUCRE AU BRESIL

By

F.L.F. DIAS[1], R. ROSSETTO[1],
M.G.A LANDELL[1] et A. MENDES[2]
[1]*IAC/APTA – Instituto Agronômico de Campinas,*
C.P. 206 – CEP: 14001–970 – Ribeirão Preto, SP – Brazil
[2]*EXCELL – Fertilizers and Mineral, MG – Brazil*
dias@iac.sp.gov.br

MOTS CLES: Silicium, productivité de la canne à sucre, économie, variété

Résumé

LE SILICIUM est un élément bénéfique pour de nombreuses cultures. Les faibles teneurs en Silicium disponible dans les sols tropicaux associées aux grandes quantités de Silicium mobilisées par la canne à sucre, accentuent l'importance de cette étude qui relate la réponse de quatre variétés de canne à sucre à des scories de métallurgie appliquées comme source de silicium. Le sol de l'essai était un Oxisol de texture moyenne, avec un précédent pâturage et ayant une faible teneur en silicium soluble (moins de 3 µg/cm3). Un essai en split plot comprenait quatre variétés de canne à sucre comme parcelles principales, RB867515, productivité élevée; SP81-3250 – riche et productivité élevée; RB72454 – large adaptabilité; et SP83-2847 – rustique. Les sous parcelles comprenaient un témoin sans silicium et un traitement recevant 940 kg/ha d'Agrosilício contenant 23% de SiO_2. Les engrais ont été épandus au fond du sillon à la plantation. Les paramètres mesurés furent la fibre, la pureté, le Pol, les sucres réducteurs (AR), les sucres totaux extractibles (ATR) et le rendement (t/ha). L'analyse économique fut réalisée sur la canne plantée. Selon les doses de silicium, différentes productivités ont été observées pour les variétés de canne. Les variétés RB72454 et SP83-2847 ont montré les réponses les plus élevées avec des gains économiques dus à l'application de silicium. Les gains économiques sur la seconde récolte furent plus faibles avec aucune différence statistique entre traitements.

ENMIENDA DE SILICIO EN LA PRODUCTIVIDAD DE CUATRO VARIEDADES DE CANA DE AZUCAR EN BRASIL

Por

F.L.F. DIAS[1], R. ROSSETTO[1],
M.G.A LANDELL[1] y A. MENDES[2]
[1]IAC/APTA – Instituto Agronômico de Campinas,
C.P. 206 – CEP: 14001–970 – Ribeirão Preto, SP – Brazil
[2]EXCELL – Fertilizers and Mineral, MG – Brazil
dias@iac.sp.gov.br

PALABRAS CLAVE: Silicio, Productividad de Cana de Azúcar, Economía, Variedad.

Resumen

EL SILICIO es un elemento benéfico para algunos cultivos. El bajo contenido de silicio en los suelos tropicales, aunado a la gran cantidad de silicio que la caña de azúcar extrae, enfatiza la importancia de este trabajo, que reporta las respuestas de cuatro variedades de caña de azúcar a la aplicación de residuos de metalurgia como fuente de silicio. El suelo en que se planto el experimento era un Oxisol, de textura media, previamente cultivado con pasto y con bajo nivel de silicio (menos de 3 ug/cm^3). Se utilizo un diseño de parcelas divididas con las variedades de cana como parcela grande- RB867515 – productividad alta; SP81-3250 – productividad alta y rica; RB72454 – amplia adaptabilidad y SP83-2847 – una variedad rustica. Las parcelas pequeñas fueron dos tratamientos: un testigo (sin silicio) y una parcela donde se aplico 940 kg/ha de Agrosilicio que contiene 23% SiO_2. Los fertilizantes se aplicaron en el fondo del surco en el momento de la siembra. Los parámetros evaluados fueron fibra, pureza, Pol, azúcares reductores (AR) y total de azúcar recuperable (ATR) y rendimiento de cana (ton/ha). Se realizo un análisis económico en soca. Se observo diferencia en la productividad de las variedades debidas a la aplicación de silicio en la primera cosecha. Las variedades RB72-2454 y SP83-2847 tuvieron mejor respuesta y presentaron ganancias económicas con la aplicación de silicio. Las ganancias económicas en la segunda cosecha fueron menores, sin diferencia estadística entre tratamientos.