N AND K FERTILISATION OF SUGARCANE RATOONS HARVESTED WITHOUT BURNING

By

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KEYWORDS: **Green Cane,**
Sugarcane Nutrition, Potassium, Nitrogen.

Abstract

THE CURRENT production capacity of Brazilian sugarcane is mainly based in the State of São Paulo, which accounts for approximately 60% of national production. São Paulo state has environmental regulations prohibiting the burning of sugarcane before harvesting. The residue layer left on the soil surface can interfere with fertilisation, by recycling some nutrients and also making fertiliser incorporation more difficult. In order to verify if N and K rates recommended for the burnt cane ratoon system are different from green cane, in this paper we report the response of sugarcane ratoons to different nitrogen and potassium fertiliser application rates in green cane systems. Fifteen experiments were established in several regions of São Paulo State, Brazil. All the experiments had crop residue (trash) from plant cane remaining on the soil surface since sugarcane was mechanically harvested without burning. Fertilisers were applied over the trash at the rates of: 0, 60, 120 and 180 kg/ha of N and 0, 70, 140 and 210 kg/ha of K_2O. Each experiment was harvested after 12 months of growth. Our results showed significant responses to N application in 14 experiments, and significant responses to K fertilisation in 7 experiments. Nitrogen and K_2O application rates that produced optimum cane yields were: N = 148 kg/ha and K_2O = 125 kg/ha; however, economically profitable rates were N = 120 kg/ha and K_2O = 70 kg/ha. Productivity gains did not offset costs when rates were higher than 120 kg/ha of N and 70 kg/ha of K_2O. Sugarcane residues contributed mainly to sugarcane potassium nutrition.

Introduction

A great challenge facing the sugarcane industry in Brazil these days is to improve overall productivity, decrease production costs and improve sustainability. Sugarcane production systems in São Paulo State, Brazil, have experienced several modifications over time, especially due to new environmental regulations prohibiting crop burning. The sugarcane crop is now mechanically harvested without burning resulting in great amounts of residue on the soil surface. After several years of residue application, the trash layer can interfere with fertilisation, since residues make fertiliser incorporation more difficult. Our objective in this experiment was to update sugarcane fertilisation recommendations regarding N and K application in sugarcane ratoons harvested without burning. Fifteen experiments were established in the state of São Paulo, Brazil. Productivity responses were verified across differing rates of N and K application.

Material and methods

Fifteen experiments were carried out in diverse regions in São Paulo State, Brazil, including the main sugarcane production environments (named A, B, C, D and E). The production environments are defined by soil fertility status and the ability to store water for sugarcane crop. So, it is expected that sugarcane cultivation in environment A will achieve high productivity. In environment E, productivity is expected to be very low. In São Paulo state, sugarcane is grown mainly in environments B, C and D (Prado *et al*., 2008).

In addition, areas with different soil potassium levels were selected (Figure 1). The experiments were installed primarily in the first and second ratoon crops, with one of the trials implemented in third ratoon. All the experiments were established following mechanical harvest without burning. Table 1 presents the description of the 15 sites.

Table 1—Regions, soil types, environmental groups and varieties for each experiment.

Region	Soil Taxonomy	Environmental group	Variety	Ratoon
Andradina	Typic Hapludox	D	SP81-3250	1st.
Araçatuba	Arenic Hapludult	E	RB72454	2nd.
Araras	Rhodic Eutrudox	B	RB855453	2nd.
Guaira1	Rhodic Acrudox	D	SP80-1816	1st.
Guaira 2	Typic Hapludox	C	SP81-3250	2nd.
Iracemápolis	Rhodic Eutrudox	B	RB72454	1st.
Orindiuva	Arenic Hapludult	E	RB835054	2nd.
Piracicaba	Typic Hapludox	B	IAC89 3396	2nd.
Planalto	Xantic Hapludox	E	RB72454	3th.
Pradópolis	Typic Hapludox	D	RB867515	2nd.
Promissão	Xantic Hapludox	E	RB867515	2nd.
Ribeirão Preto	Typic Hapludox	C	RB867515	1st.
Santa Rita	Rhodic Eutrudox	B	RB72454	1st.
S. Joaquim Barra	Typic Hapludox	C	SP87-367	1st.
Sertãozinho	Typic Hapludox	B	RB855453	1st.

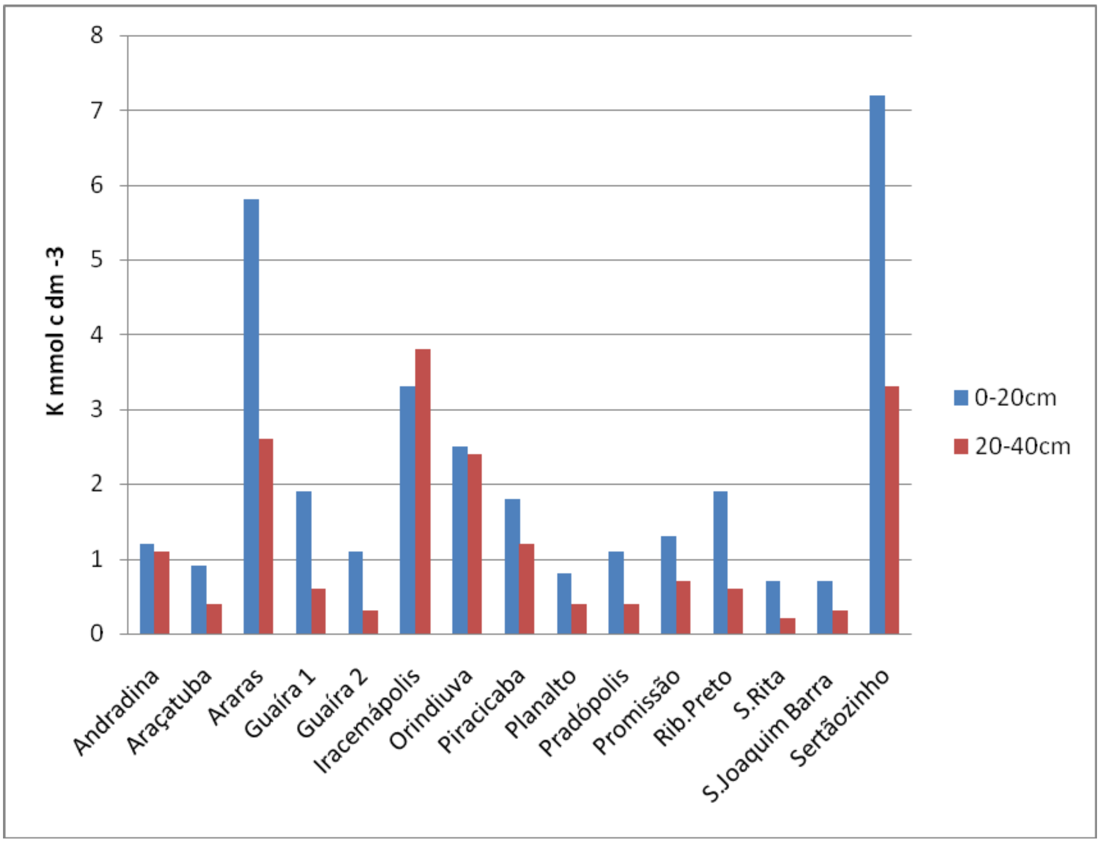

Fig. 1—Potassium (mmol c/dm^3) in soil samples for each experiment.

The experiments were planted in a factorial design with 16 treatments placed in randomised blocks with four replications. Plots consisted of 5 rows of sugarcane 10 metres long, with between-row spacing of 1.4 and 1.5 m. N and K fertility treatments were:

- Nitrogen – 4 rates (0, 60, 120 and 180 kg/ha of N);
- Potassium – 4 rates (0, 70, 140 and 210 kg/ha of K_2O).

The fertiliser sources were ammonium nitrate and potassium chloride. Each experiment was harvested following 12 months of growth. The plots were weighed with a dynamometer to determine cane yield (t/ha)

Statistical analyses of variance for a factorial design was performed using SAS, and Tukey means separations were calculated with P = 0.05. Productivity responses were also estimated by SAS.

Results and discussion

Cane yield results for each fertilisation treatment from all 15 sites are presented in Table 2. Results differed among locations; however, this was expected since different production environments, sugarcane varieties and crop longevity were studied. Higher cane yields were measured in experiments carried out in environments classified as B or C, as well as in the younger ratoons.

Based on the results, it can be established that soil classification and water storage capacity are very important to predict cane productivity Chalita (1991), determined that the soil level of potassium critical for cane growth in the State of São Paulo, Brazil, was 1.2 $mmol_c/dm^3$ for first ratoon cane. Our experiments show that lower cane productivities were obtained in soils when potassium levels were < 1 $mmol_c/dm^3$ of K. Average yields at each location can be observed in Figure 2. Higher productivity locations were: Araras, Iracemápolis, Guaira 2, Piracicaba, Ribeirão Preto, Sertãozinho and S. Rita.

Table 2—Sugarcane yield (t/ha) for each treatment and experiment.

Rates (kg/ha)		Andradina	Araçatuba	Araras	Guaira1	Guaíra 2	Iracema polis	Orindiuva	Planalto
N	K	$t.\ ha^{-1}$							
0	0	65.62	68.25	124.01	54.20	94.22	83.33	65.39	41.01
0	70	63.57	71.59	132.01	53.96	102.58	94.64	61.54	48.01
0	140	70.47	64.97	123.56	63.43	101.13	92.49	70.36	42.78
0	210	56.29	65.61	132.45	64.64	98.81	88.21	69.97	49.07
60	0	53.79	78.66	126.67	75.25	103.85	101.43	69.15	48.44
60	70	43.60	65.68	139.67	74.64	102.16	95.37	68.91	50.84
60	140	49.49	65.71	140.00	61.73	110.37	100.72	63.27	53.17
60	210	73.94	76.01	134.01	75.74	112.22	102.86	65.23	50.17
120	0	60.59	77.87	139.67	80.17	103.09	102.86	68.79	46.51
120	70	64.84	84.52	128.01	78.14	104.25	106.19	74.49	42.41
120	140	90.27	98.74	129.34	77.74	112.19	108.93	76.18	44.41
120	210	76.85	69.69	132.89	78.47	108.63	98.93	72.08	46.51
180	0	59.91	73.22	123.56	83.95	107.78	97.14	66.91	46.38
180	70	70.06	69.91	136.34	83.20	110.58	100.71	66.02	42.28
180	140	64.64	90.35	132.01	85.10	114.48	105.36	75.44	44.58
180	210	55.35	84.28	137.34	80.20	107.14	98.57	67.54	48.54
F value		12.75**	2.36**	3.51**	8.58**	3.15**	3.21**	2.30**	2.15**
CV%		9.17	15.78	4.55	9.30	5.54	7.10	9.52	10.02
msd (0.05)		4.87	9.91	5.01	5.67	4.90	5.08	5.45	3.12

** significant at p = 0.01; msd = minimum significant difference p=0.05

Table 2 (Cont.)—Sugarcane yield (t/ha) for each treatment and experiment.

Rates (kg/ha)		Pradópolis	Promissão	Rib.Preto	S.Rita	S.Joaquim Barra	Piracicaba	Sertãozinho	Media
N	K		t/ha						
0	0	71.75	77.18	91.04	80.36	78.00	94.22	85.89	78.30
0	70	72.03	88.00	109.47	98.93	89.25	102.58	97.56	85.71
0	140	74.58	92.57	96.14	85.71	84.25	101.13	85.91	83.30
0	210	78.77	92.91	102.81	74.64	83.50	98.81	92.52	83.27
60	0	77.40	81.40	95.11	87.86	103.25	103.85	102.06	87.21
60	70	73.25	97.33	99.92	90.00	105.75	102.16	105.49	87.65
60	140	79.63	95.24	90.87	84.76	106.00	110.37	110.99	88.15
60	210	81.48	93.25	90.98	94.29	104.50	112.22	86.95	90.26
120	0	69.73	91.53	96.24	98.22	113.75	103.09	106.63	90.58
120	70	77.83	90.39	92.80	92.86	115.50	104.25	93.11	89.97
120	140	80.70	98.65	111.70	95.37	108.50	112.19	87.88	95.52
120	210	79.15	89.68	92.45	100.00	117.50	108.63	98.68	91.34
180	0	76.20	93.95	97.11	98.22	113.00	107.78	100.43	89.70
180	70	88.95	92.57	90.76	98.86	110.00	110.58	91.25	90.80
180	140	78.00	89.57	109.07	92.86	121..25	114.48	77.25	90.94
180	210	85.95	94.40	99.87	102.38	111.25	107.14	83.87	90.92
F value		2.22**	1.71*	1.69*	3.93**	8.58**	2.31**	0.78	18.91**
CV%		8.73	8.36	10.90	7.71	7.91	8.35	17.38	3.06
msd (0.05)		5.67	6.58	8.90	5.90	6.86	5.35	9.30	1.49

** significant at *p* = 0.01; msd = minimum significant difference *p*=0.05

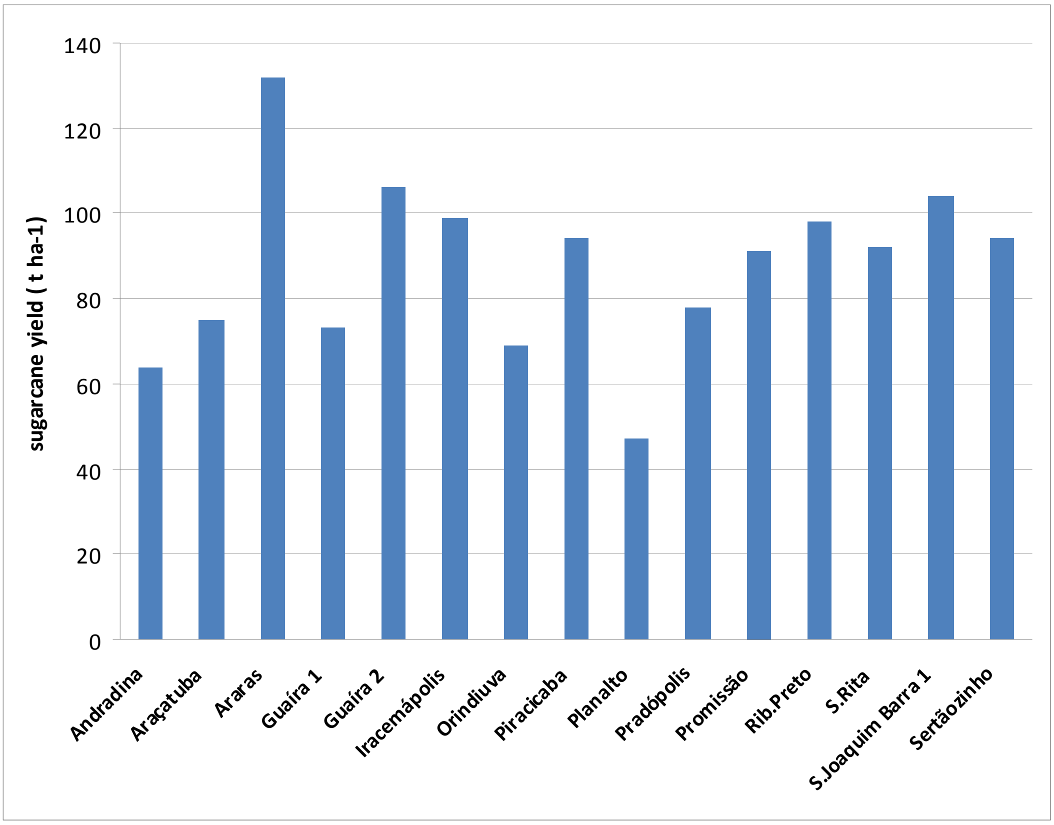

Fig. 2—Average cane yield at each location.

Statistical analyses of cane yield responses indicated that nitrogen significantly increased cane yield in 14 experiments and potassium increased cane yield in 7 trials. Thornburn *et al*. (2002) estimated that N application rates for sugarcane harvested without burning should be 60 kg per ha higher than burnt cane.

Higher N doses are required following green sugarcane harvest because the water storage capacity is higher and, consequently, the biomass accumulation can be increased. Also, there is a need to compensate for soil nitrogen immobilisation in the crop residue. These were the main reasons for cane yield responses to nitrogen in 14 of the 15 locations.

Sugarcane production systems with crop burning are considered highly responsive to potassium fertilisation in both the plant cane and ratoon crops (Rossetto *et al*. 2004). However, in green cane systems, the crop residues can add substantial amounts of K.

Oliveira *et al*. (2002) estimated that remaining trash can recycle approximately 65 kg/ha of K_2O. The potassium present in green cane residues can be rapidly transferred to the soil and supplied for the cane crop which means that sugarcane response to potassium fertilisers is reduced.

In fact, significant response to K fertilisation occurred only in 7 of the 15 locations even in soils with low potassium levels at Araçatuba, Guaira2, Planalto, Promissão, S. Rita and S. Joaquim da Barra.

Nitrogen and potassium rates for optimum cane yields were estimated. for the 15 locations as N = 148 kg/ha and K_2O = 125 kg/ha. Nevertheless, due to the high fertiliser costs, the economical rate of application was 120 kg/ha of N and 70 kg/ha of K_2O.

When higher rates were applied, the cane yield gain did not exceed 3 t/ha and therefore did not offset the increased fertiliser costs.

Sugarcane ratoon yield response curves to N and K fertilisation rates (average for 15 field experiments) can be observed in Figures 3 and 4.

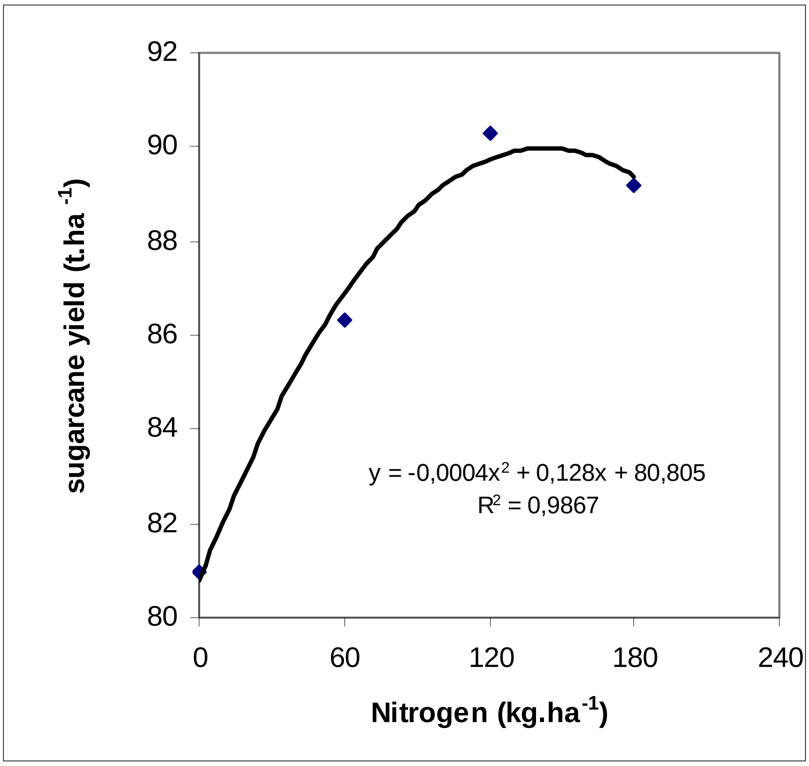

Fig. 3—Sugarcane ratoon yield response to nitrogen fertilisation rates. (Average for 15 field experiments).

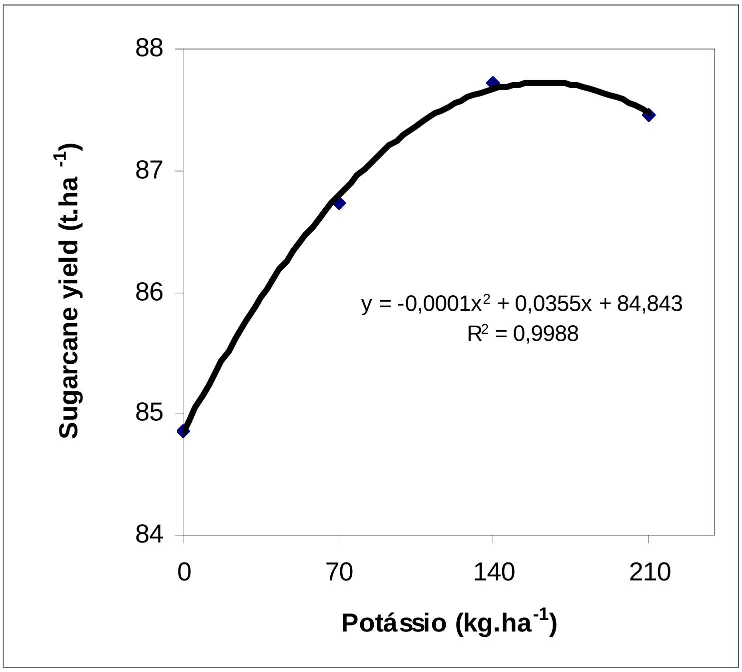

Fig. 4—Sugarcane ratoon yield response to potassium fertilisation rates. (Average for 15 field experiments).

Conclusions

N fertilisation significantly increased cane yield in green cane systems in 14 of 15 locations whereas K fertilisation increased cane yield at only 7 locations.

Nitrogen and potassium fertilisation rates for optimum cane yields were: N = 148 kg/ha K_2O = 125 kg/ha. However, the most profitable rates were: N = 120 kg/ha and K_2O = 70 kg/ha.

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FERTILISATION AZOTEE ET POTASSIQUE SUR DES REPOUSSES DE CANNE A SUCRE RECOLTEES SANS BRULAGE

Par

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MOTS CLÉS: Canne en Vert, Nutrition de la Canne à Sucre, Potassium, Azote.

Résumé

DE NOS JOURS, la capacité de production de canne à sucre du Brésil est principalement concentrée dans l'Etat de São Paulo avec environ 60% de la production nationale. L'Etat de São Paulo obéit à des règles environnementales interdisant le brûlage de la canne avant la récolte. Les résidus laissés sur le sol peuvent interférer avec la fertilisation en recyclant des éléments nutritifs et aussi en rendant plus difficile l'incorporation de la fertilisation. Afin de vérifier si les taux de N et K recommandés pour les repousses d'une canne coupée après brûlage sont différents pour la canne coupée en vert, nous présentons dans ce papier la réponse de la canne en repousse à divers niveaux d'engrais azoté et potassique épandus après une coupe en vert. Quinze essais ont été implantés dans diverses régions de l'Etat de São Paulo, Brésil. Tous les essais avaient des résidus de récolte (paillis) à la surface du sol puisque la canne en vierge avait été récoltée mécaniquement sans brûlage. Les engrais avaient été appliqués sur le paillis aux taux de: 0, 60, 120 et 180 kg/ha pour N et 0, 70, 140 et 210 kg/ha pour K_2O. Chaque essai a été récolté à l'âge de 12 mois. Nos résultats ont montré des réponses significatives à l'application de N dans 14 essais et dans 7 essais pour K. Les taux de N et K_2O qui ont produit les rendements canne optimums ont été: 148 kg/ha pour N et 125 kg/ha pour K_2O, cependant économiquement la dose rentable est de 120 kg/ha pour N et 70 kg/ha pour K_2O. Les gains de productivité n'ont pas compensé les coûts quand les taux d'application étaient plus élevés que 120 kg/ha en N et 70 kg/ha en K_2O. Les résidus de canne à sucre contribuent principalement à la nutrition potassique de la canne à sucre.

FERTILIZACION CON N Y K DE CANA DE AZUCAR EN SOCAS COSECHADAS SIN QUEMAR

Por

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PALABRAS CLAVE: Cosecha en Verde, Nutrición de Cana de Azúcar, Potasio, Nitrógeno.

Resumen

LA CAPACIDAD de producción actual de la caña de azúcar en Brasil tiene base principalmente en el estado de São Paulo, pues representa el 60% de la producción nacional. El estado de São Paulo posee regulaciones ambientales que prohíben la quema de la caña de azúcar antes de cosecharla. La capa de residuos que queda sobre la superficie del suelo puede interferir con la fertilización, a través del reciclaje de algunos nutrientes, pero también dificultando la incorporación de fertilizante. Con el fin de verificar si las dosis de N y K recomendadas para la cosecha de caña quemada difieren de aquellas para cosecha de caña en verde, en el presente trabajo se reporta la respuesta del cultivo de la caña de azúcar en socas, a la aplicación de diferentes dosis de fertilizantes nitrogenados y potásicos en cosecha en verde. Se establecieron 15 experimentos en diversas regiones del estado de São Paulo, Brasil. Todos los experimentos tenían residuos de la cosecha (trash) sobre la superficie del suelo, pues la caña se cosecho mecánicamente, sin quemar. Los fertilizantes se aplicaron sobre el trash, en dosis de 0, 60, 120 y 180 kg/ha de N y 0, 70, 140 y 210 kg/ha de K_2O. Cada experimento se cosecho después a los 12 meses. Los resultados muestran respuestas significativas a la aplicación de N en 14 experimentos, asi como respuestas significativas a la aplicación de K en siete experimentos. Las dosis de N y K_2O que produjeron rendimientos optimos fueron: N = 148 kg/ha y K_2O = 125 kg/ha; sin embargo, las dosis optimas económicas fueron: N = 120 kg/ha y K_2O = 70 kg/ha. Las ganancias en productividad no compensaron los costos cuando las dosis fueron mayores a 120 kg/ha of N and 70 kg/ha of K_2O. Los residuos contribuyeron, principalmente con los requerimientos de potasio de la caña de azúcar.