NITROGEN IN SUGARCANE DERIVED FROM FERTILISER

By

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KEYWORDS: Green-cane, ^{15}N Labelled Urea,
Sugarcane Trash, *Saccharum spp.*

Abstract

NITROGEN fertilisation in the sugarcane crop is a universal practice used to reach sustainable levels of productivity, both in the plant cane and especially in ratoon cycle. However, when evaluating N in the plant derived from fertiliser (^{15}N) at crop harvest, one sees that this contribution is in the order of 20% of the total N, which gives rise to questions regarding the efficiency of this fertilisation. Therefore, field experiments were undertaken at two locations with sugarcane mechanically harvested and without burning of the sugarcane in the State of São Paulo, Brazil. Nitrogen fertilisation of both the plant cane (rates of 40, 80 and 120 kg/ha of N as urea) and the first ratoon (rates of 50 and 100 kg/ha of N as ammonium sulfate) was labelled on the stable isotope of ^{15}N. It was observed that the N from nitrogen fertilisation represented up to 40% of the total N of the plant cane in the initial stages of its growth, decreasing in the stages of pre-maturity and at maturity to levels in the order of 10% at harvest. In the ratoon crop, participation of N fertiliser on crop nutrition was more effective, constituting up to 70% of total N in the initial stages of development, especially at greater rates of N, decreasing through the cycle of the first ratoon. Nevertheless, it stands out that, throughout the growth of the ratoon, the contribution of N fertiliser was greater than that for the plant cane, to the order of 30% of the total N of the plant. This confirms that N fertilisation in the ratoon crop, with little or no soil tillage, together with the maintenance of crop residues on the soil surface, is one of the most important sources of N for the crop.

Introduction

In studies with sugarcane, one of the most controversial and polemical matters is in respect to nitrogen fertilisation at planting (plant cane), considering that many studies have shown sugarcane has little response to this practice (Trivelin, 2000; Franco, 2008). One sees in the literature a lack of response in most experiments with the plant crop when the sugarcane is burnt prior to harvest (Trivelin, 2000). For the regrowth, with burnt cane, most of the experiments showed a response (Trivelin, 2000). Many explanations have been given, such as biological fixation of atmospheric N, losses through leaching of N fertiliser, the vigour of the root system of the plant cane compared to that of the ratoons, the climatic conditions, the improvement in soil fertility associated with liming, mechanical soil preparation and the incorporation of residues from the previous crop (Orlando Filho *et al*., 1999; Urquiaga *et al*., 1992). According to the review of Salcedo and Sampaio (1984), in ratoon cane, response is more frequent due to a smaller quantity of mineral N accumulated in the soil profile at the beginning of the ratoon growth cycle compared to that of the plant cane, less mineralisation of N from the soil due to reduced soil tillage, and less efficiency of the ratoon root system in uptake of fertiliser-N.

In this context, for the purpose of understanding in a more detailed way the N cycle in the soil-plant system and its effect on the development and productivity of sugarcane in Brazil, studies with the use of the isotope tracer method for nitrogen (^{15}N) were begun in 1983 at the Center for Nuclear Energy in Agriculture, at the University of São Paulo. One of the evaluations that may be undertaken with the use of the isotope tracer technique is an estimate of the percentage of nitrogen in the plant derived from fertiliser (%NDFF) and the efficiency in the use of N fertiliser by the crops. In the sugarcane crop, this technique may be used during its growth cycle. The hypothesis in these experiments with sugarcane is that the F+3 of the plant represents the abundance of ^{15}N in the above ground part of the crop (shoot of the crop) and in view of this, the isotopic abundance is used to estimate the NDFF of the above ground part (Takahashi, 1967; Sampaio *et al*., 1984; Trivelin, 2000).

Recently, due to the small contribution, around 20% or less, of the N fertiliser in the total N accumulated in the above ground part of the plants, at the harvest of the sugarcane fields (Sampaio *et al*., 1984; Trivelin *et al*., 1995; Trivelin, 2000; Gava *et al*., 2001; Franco, 2008), the experts of sugarcane management began to question the efficacy of nitrogen fertilisation in the sugarcane producing regions of the Central-South of Brazil. In this context, with the objective of better understanding of the participation of N fertiliser throughout the growth cycles of the plant cane and the first crop regrowth, two field experiments were developed with the objective of evaluating the contribution of ^{15}N-fertiliser (urea in the plant cane and ammonium sulfate in the first ratoon) in the total nitrogen accumulated in the above ground part of the sugarcane during both growth cycles.

Material and methods

Location, trial design and ^{15}N labelled fertiliser

The experiments were developed in two sugarcane producing areas located in the State of São Paulo, Brazil. The first belongs to the São Luiz Sugar Mill (USL), in the Pirassununga county (Latitude 21º55’54’’S, Longitude 47º10’54’’W). This area had been cultivated with sugarcane since 1977. The altitude is 650 m and the climate is Aw (Tropical Savanna, in the Köppen classification). The area presents a slightly rolling slope (< 5%) and the soil is Typic Eutrustox. Planting of the sugarcane occurred from February 21 to 24, 2005. The second area, belonging to the Santa Adélia Sugar Mill (USA) is in the Jaboticabal county (Latitude 21º19.98’S, Longitude 48º19.03’W), with predominant altitude in the region of 600 m and climate Aw (Tropical Savanna, in the Köppen classification). This area had been cultivated with sugarcane since 1951. The area presents a slightly rolling slope (<5%) and the soil is an Arenic Kandiustults. The experiment was planted from April 4 to 8, 2005. The variety used was SP81-3250, and 17 to 20 buds were planted per metre of row and were covered with soil. In all the plots, at the bottom of the furrow, 120 kg/ha of K_2O and 120 kg/ha of P_2O_5 were applied.

Treatments for the plant cane were three rates of N (40, 80 and 120 kg/ha as urea) applied at the bottom of the planting furrow, plus one control without nitrogen fertiliser. Treatments were distributed in a randomised block design with four replications. The experimental plots consisted of 48 rows of 15 metres in length with a space between rows of 1.5 m. In the inside of each plot (20th row), a microplot was installed, with the dimensions of 2 m in length and 1.5 m width, totalling 3 m^2, which received the urea labelled with ^{15}N (5.04 atoms % of ^{15}N).

Harvesting, sampling and statistical analysis

During the growth cycle of the plant cane, samples were taken to evaluate the accumulation of N in the aboveground biomass of sugarcane. At USL, these evaluations were undertaken on July 7, 2005 (134 days after planting–DAP), October 25, 2005 (244 DAP), December 13, 2005 (293 DAP), February 20, 2006 (358 DAP), April 12, 2006 (413 DAP) and June 6, 2006 (468 DAP), for a total of 6 samplings. In the experiment at USA, sampling occurred on October 11, 2005 (186 DAP), December 9, 2005 (246 DAP), February 8, 2006 (307 DAP), April 5, 2006 (363 DAP) and July 10, 2006 (459 DAP), for a total of 5 samplings. In sampling, collection of the entire above ground part of the plant in 2 metres of the row was made at locations previously drawn by lot. The mass of all the plant material (dry leaves, top and stems) from each plot was obtained directly in the field, by means of weighing on an electronic scale. After weighing, each plant sample was chopped in a forage chopper. The sub-samples were packed in plastic bags and were weighed on an analytic scale, before and after drying in a ventilated laboratory dryer at 65^{o}C (72 hours) for determination of the moisture of the material. The dried sub-samples were ground for the chemical determination of total-N content (g/kg) according to Malavolta *et al*. (1997).

At the same sampling times of the above ground part of the sugarcane, samples of leaves +3 (F+3) were collected in the microplots that received urea-^{15}N. The F+3 were collected according to the methodology described by Trivelin *et al*. (1994). In these evaluations, samples of leaves +3 using the Dillewijn system are collected in microplots that received the fertiliser labelled with ^{15}N, for determination of the abundance in atoms % of the isotope, thus allowing the determination of estimates of NDFF (kg/ha); also making use of measurements of N accumulated by the crop, obtained in plants collected in other rows of sugarcane in the same plot (treatment). These samples were dried in forced air circulation laboratory ovens at 65^{o}C and the abundance of ^{15}N (atom % of ^{15}N) in them was determined in a mass spectrometer. With the values of the abundance in atoms % of ^{15}N in the samples of leaf +3 and the accumulated N in the above ground part of sugarcane, it was possible to calculate the NDFF (nitrogen in the above ground part of the plant derived from fertiliser) according to the methodology described by Trivelin *et al*. (1994).

After the harvest of the plant cane (June 6, 2006 at USL and July 10, 2006 at USA), the plots of the two experiments were split into four subplots that received the treatments: 50, 100 and 150 kg/ha of ammonium sulfate, plus a control without application of nitrogen fertiliser. The application of nitrogen fertiliser was made over the cultural residue (trash) coming from the mechanical harvesting without straw burning, at approximately 20 cm from the row, applying together with this 150 kg/ha of K_2O.

Inside the plots of the ratoons that received the rates of 50 and 100 kg/ha of N, microplots were demarcated with dimensions of 2 m length and 1.5 m width (3 m^2) which received the ammonium sulfate labelled with ^{15}N (2.31% and 2.97 atoms % of ^{15}N, respectively, in the rates of 100 and 50 kg/ha of N), the application of which followed the same procedure as described for the rest of the plots. The fertilisers were applied on October 8 and on November 1st, 2006, respectively, at USL and USA.

In the cycle of the first ratoon, samples of plant material were undertaken in the two locations. This sampling followed the same procedure adopted for the plant cane, determining the plant dry matter and the accumulated N in the above ground part of the sugarcane in each period.

At the same times of collection of plant material, leaves +3 of plants from the microplots that received the ammonium sulfate labelled with ^{15}N were collected, and the same protocol of collection of the leaves as used in the plant cane was carried out (Trivelin *et al*., 1994), as well as in determination of the ^{15}N abundances.

The results of total N (kg/ha) and NDFF (% and kg/ha) were submitted to ANOVA as plots subdivided in time (rates as main treatment and periods as secondary) and the Tukey test for comparison of the averages within each treatment.

Results and discussion

Plant cane crop cycle

In the two experiments, approximately 180 days after the nitrogen fertilisation at planting (October 2005), the sugarcane had already absorbed practically all the N fertiliser, especially for the doses of 40 and 80 kg/ha of N (Table 1), differently from the total N in the plants, which continued being accumulated with the growth of the crop (Table 2). The accumulation of nitrogen (kg/ha) increased in a linear way with nitrogen fertilisation in the USL experiment; however, there was no effect at USA. The stalk yield was increased with 40 kg N/ha in the USL site (134 t/ha without N and 142 t/ha with 40 kg N/ha), but in USA there was no response in cane yield to N rates (Franco, 2008). At USL, the increases began to be significant as of October, coinciding with the beginning of the maximum growth stage of the crop (Franco, 2008) when the climatic conditions (temperature, solar luminosity and rainfall) began to be raised.

Table 1—Estimate of the nitrogen in the plant derived from fertiliser (NDFF) during the plant cane cycle in the São Luiz and Santa Adélia Sugar Mills experiments (2005/2006 harvest).

São Luiz Sugar Mill						
Rates of N kg/ha	July	October	December	February	April	June/July*
	NDFF, kg/ha					
40	6.13A	8.46A	8.82A	9.23A	7.46A	7.80A
80	11.89B	20.08AB	21.97A	15.82AB	23.76A	18.58AB
120	17.10B	23.48B	24.97B	25.28B	36.96A	22.89B
L.S.D = 8.0 CV = 28%						
Santa Adélia Sugar Mill						
40		16.28A	14.46A	13.95A	11.08A	10.50A
80		40.30A	31.38AB	28.17B	33.40AB	31.02AB
120		49.19A	30.62BC	35.18B	30.03BC	20.92C
L.S.D = 6.4 CV = 22%						

Equal capital letters in the line do not differ among themselves by the Tukey test at 5% probability. L.S.D.: least significant difference; CV: coefficient of variation; *June/July: June at the São Luiz Sugar Mill and July at the Santa Adélia Sugar Mill.

Table 2—Accumulation of nitrogen in the above ground part of sugarcane plant season in two fields of the State of São Paulo, Brazil.

Rates of N (kg/ha)	July	October	December	February	April	June/July*
	São Luiz Sugar Mill					
	Accumulation of N, kg/ha					
0	30 D	66 D	106 BC	122 AB	162 A	132 AB
40	32 C	91 B	84 B	123 AB	152 A	154 A
80	43 C	100 B	136 B	142 B	224 A	207 A
120	39 E	91 D	115 CD	158 BC	254 A	192 B
R^2-L.R.	NS	0.55**	0.23*	0.91**	0.84***	0.77***
R^2-Q.R.	NS	0.99*	NS	NS	0.89***	0.87*
L.S.D. = 49 C.V. = 19%						
	Santa Adélia Sugar Mill					
0	–	114 C	111 C	148 BC	183 AB	204 A
40	–	108 B	118 B	164 A	173 A	184 A
80	–	111 D	139 CD	154 BC	195 AB	227 A
120	–	113 B	134 B	196 A	181 A	183 A
Avarege	–	111 C	126 C	166 B	183 AB	199 A
L.S. D. = 21 C.V. = 13%						

Equal capital letters in the line do not differ among themselves by the Tukey test at 5% probability. R.L: liner regression; R.Q: quadratic regression; L.S.D.: least significant difference; CV: coefficient of variation; *June/July: June at the São Luiz Sugar Mill and July at the Santa Adélia Sugar Mill.

The quantities of N accumulated by the above ground part of the plant cane (190 kg/ha on average) are much more than the rates of N applied (Table 2).

Consequently, it may be inferred that the majority of N absorbed by the plants originated from other sources; the net mineralisation through soil organic carbon rundown, the mineralisation of crop residues (Ng Kee Kwong *et al*., 1987), and the biological nitrogen fixation by micro-organisms associated with the crop or not (Urquiaga *et al*., 1992) may be highlighted.

In relation to the results of NDFF (%) and use of the ^{15}N-urea (kg/ha) by the plant cane, it may be highlighted that in the two experiments, the greatest values of NDFF (%) were obtained in the first samplings, showing that, in the initial stages of development of the crop, a substantial part of the total N of the plants was derived from the fertiliser, especially in the 120 kg/ha rate of N (Figure 1). This can be related to the soil organic carbon immobilising fertiliser N, creating a direct competition with the crop. In addition, at the end of the plant cane cycle, the N fertiliser represented a small fraction of the total N of the above ground part of the plant, indicating that the sugarcane obtains a significant quantity of N from other sources, as previously cited.

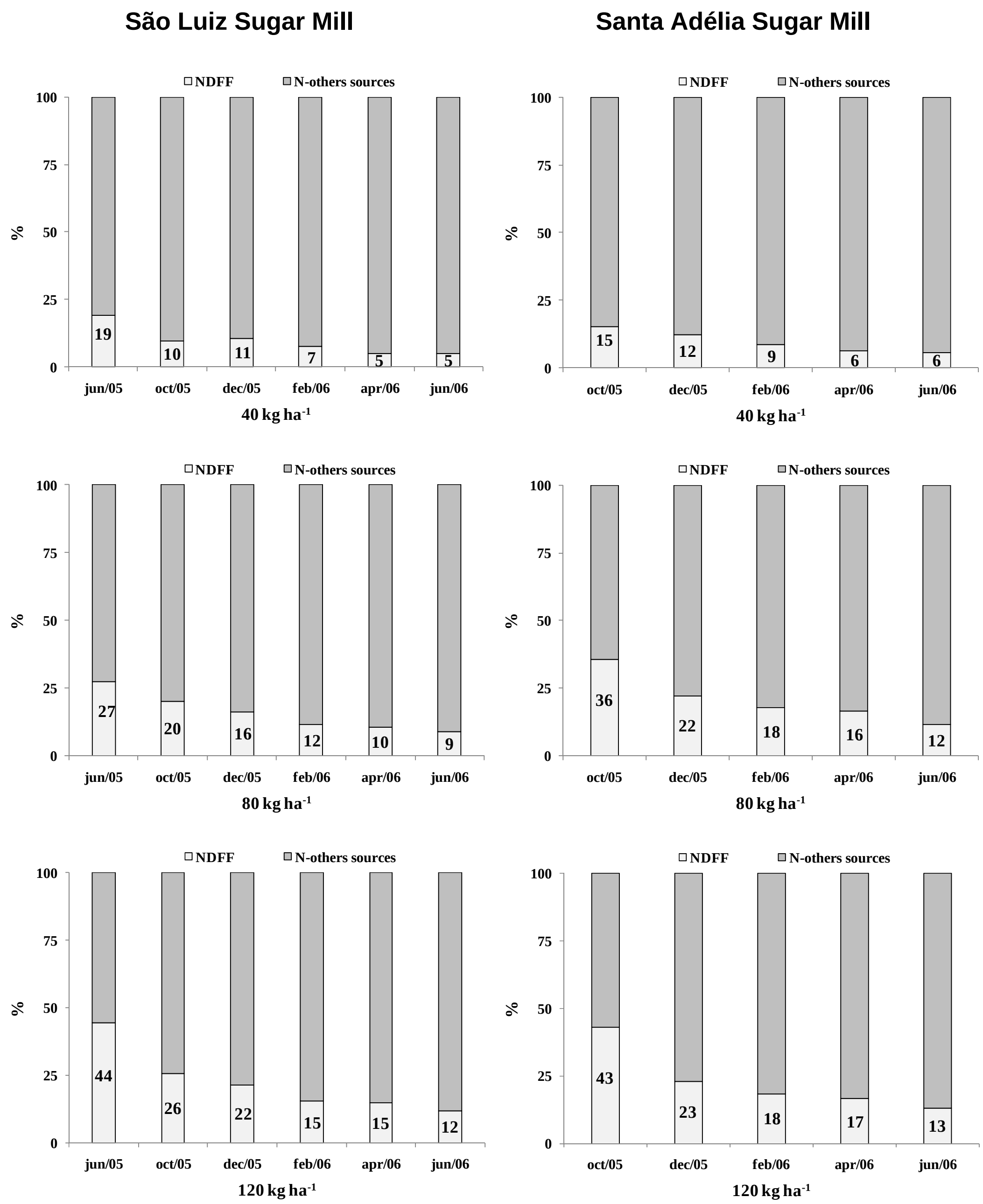

Fig. 1—Nitrogen derived from fertiliser in the total N of the above ground part of sugarcane plant crop for the experiments at the São Luiz and Santa Adélia Sugar Mills for the treatments 40, 80 and 120 kg/ha of N.

Analysing the participation of N fertiliser throughout the growth cycle of the plant cane (Figure 1), this participation proved to be low at harvest of the crop (around 10% of the total N accumulated by plant cane). This information, when analysed in an isolated way, may lead to over-hasty conclusions regarding the importance of nitrogen fertilisation in the nutrition of the plant cane and, to a lesser degree in ratoon cane. Since, in most studies with application of fertilisers labelled with ^{15}N in sugarcane, evaluation is undertaken at harvest of the crop, a great deal of information and explanations regarding the effects of N fertiliser in plant nutrition are not addressed.

However, when the contribution of N fertiliser is evaluated throughout the plant cane cycle, there proves to be a contribution of approximately 40% of total N of the crop in the first stages of evaluation (Figure 1). What is the importance of this information regarding nutrition of the plant cane? The answer is in the accumulation of N fertiliser in the cell vacuoles in the form of NO_3^- or assimilated as glutamate (Taiz and Zeiger, 2009), for later use.

In this sense, the plants, after absorbing the N fertiliser in the initial stages of growth, would enter in dormancy due to the beginning of the fall-winter seasons, characterised by climatic conditions adverse to plant development (low temperatures, lack of rain, water deficit and short days); with the spring, when the climatic conditions come to be favourable for the growth of sugarcane (beginning of rains and increase in temperature), the plants use this N reserve to help in their metabolism. Therefore, plants that received N fertiliser at the beginning of the crop cycle would have greater growth and development potential due to their greater reserve of N accumulated in the initial stages of growth. That way, in environmental conditions favourable to the development of the plant, the crop would respond in terms of productivity to the nitrogen fertilisation in comparison to the non-fertilised plants, even with the N fertiliser representing a small fraction of the total N (10 to 20%) of the plant when evaluated at harvest of the plant cane.

Ratoon crop cycle

After the harvest of the plant cane, the rates of N fertiliser were applied over the straw residue when the plants of the first regrowth were around 90 days of growth (October 8 and November 1, 2006 in the experiments at USL and USA, respectively). Later, in December 2006, the first estimate of the contribution (accumulation) of N fertiliser in the above ground part of the ratoon cane was undertaken. The results showed that, in this first evaluation time, the plants had absorbed practically all the fertiliser-N accumulated throughout the growth cycle of the crop; there was no statistical difference between the accumulated fertiliser-N in the plants (kg/ha) between the periods of evaluation within each treatment (Table 3).

Table 3—Estimate of the nitrogen in the plant derived from fertiliser (NDFF) during the cycle of the first regrowth in the São Luiz and Santa Adélia Sugar Mills experiments (2006/2007 harvest).

Treatments (kg/ha)	São Luiz Sugar Mill			
	December	March	May	June/July*
	NDFF. kg/ha			
120–0	1.2 A	3.0 A	3.0 A	5.1 A
0–50	11.5 A	16.9 A	10.0 A	15.6 A
120–50	13.9 A	13.7 A	11.7 A	12.0 A
0–100	18.0 A	26.4 A	15.9 A	26.2 A
120–100	26.9 A	33.2 A	28.4 A	31.8 A
L.S.D. = 12.1 CV = 39%				
	Santa Adélia Sugar Mill			
120–0	3.0 A	2.7 A	3.5 A	4.1 A
0–50	29.4 A	20.7 A	14.1 A	19.9 A
120–50	24.9 A	24.6 A	20.6 A	38.7 A
0–100	36.9 A	45.1 A	38.7 A	45.5 A
80–100	34.2 A	51.0 A	40.0 A	43.7 A
120–100	41.6 AB	46.1 A	29.4 AB	26.3 B
L.S.D. = 18.4 CV = 34%				

Equal capital letters in the line do not differ among themselves by the Tukey test at 5 % probability. L.S.D.: least significant difference; CV: coefficient of variation; *June/July: June at the São Luiz Sugar Mill and July at the Santa Adélia Sugar Mill.

The accumulation of total N in the above ground part of ratoon cane (Table 4) in this work presented the same tendency of accumulation as in the plant cane; in other words, at the end of the maximum growth phase of the crop (May 2007) the plants had already accumulated a large part of the total N obtained at harvest.

Table 4—Accumulation of nitrogen in the above ground part of the sugarcane in the cycle of the first regrowth in the experiments at the São Luiz and Santa Adélia Sugar Mills (2006/2007 harvest).

Treatments (kg/ha)	São Luiz Sugar Mill			
	December	March	May	June/July*
	N, kg/ha			
0–0	33 B	62 AB	83 A	91 A
120–0	17 C	52 BC	56 B	101 A
0–50	25 C	72 AB	63 BC	106 A
120–50	28 B	73 A	70 A	107 A
0–100	33 B	70 B	62 B	111 A
120–100	37 B	66 AB	73 AB	95 A
L.S.D. = 38 CV = 30%				
	Santa Adélia Sugar Mill			
0–0	51 B	92 AB	102 A	124 A
120–0	98 A	101 A	131 A	133 A
0–50	81 A	93 A	92 A	119 A
120–50	74 B	109 AB	117 AB	154 A
0–100	93 B	112 AB	115 AB	149 A
80–100	83 B	116 AB	122 AB	149 A
120–100	98 A	120 A	112 A	119 A
L.S.D. = 47 CV = 23%				

Equal capital letters in the line do not differ among themselves by the Tukey test at 5% probability. L.S.D.: least significant difference; CV: coefficient of variation; *June/July: June at the São Luiz Sugar Mill and July at the Santa Adélia Sugar Mill.

As indicated and discussed in the plant cane, in the initial growth stages of first regrowth cycle, the N coming from the nitrogen fertilisation (NDFF) was one of the main sources of N for the crop, emphasising that, in some treatments, it represented around 70% of the total N of the above ground part (Figures 2 and 3).

With the development of the ratoon cane, the fertiliser-N diminished its participation in the total N in the above ground part of the sugarcane, representing, on average, 30% of the total N at harvest.

It is to be emphasised that this contribution is significantly greater than that observed for fertilisation of the plant cane, which was in the order of 5 to 10% of the total N of the above ground part.

This probably relates to the higher mineralisation rates of soil organic carbon expected from tillage in the plant crop. Sampaio *et al*. (1984) found that the contribution of N from urea for the rates of 20 and 60 kg/ha of N was less than 10% of the total accumulated in the entire sugarcane plant.

Trivelin *et al*. (2002) obtained values of 11.5% for plant cane for the rates of N of 30, 60 and 90 kg/ha applied as urea. Gava *et al*. (2001) verified that the N in the plant coming from fertiliser represented 10 to 16% of the total accumulated N in the above ground part of the ratoon crop, while Trivelin *et al*. (1995) obtained a value less than 15% in ratoon cane at harvest.

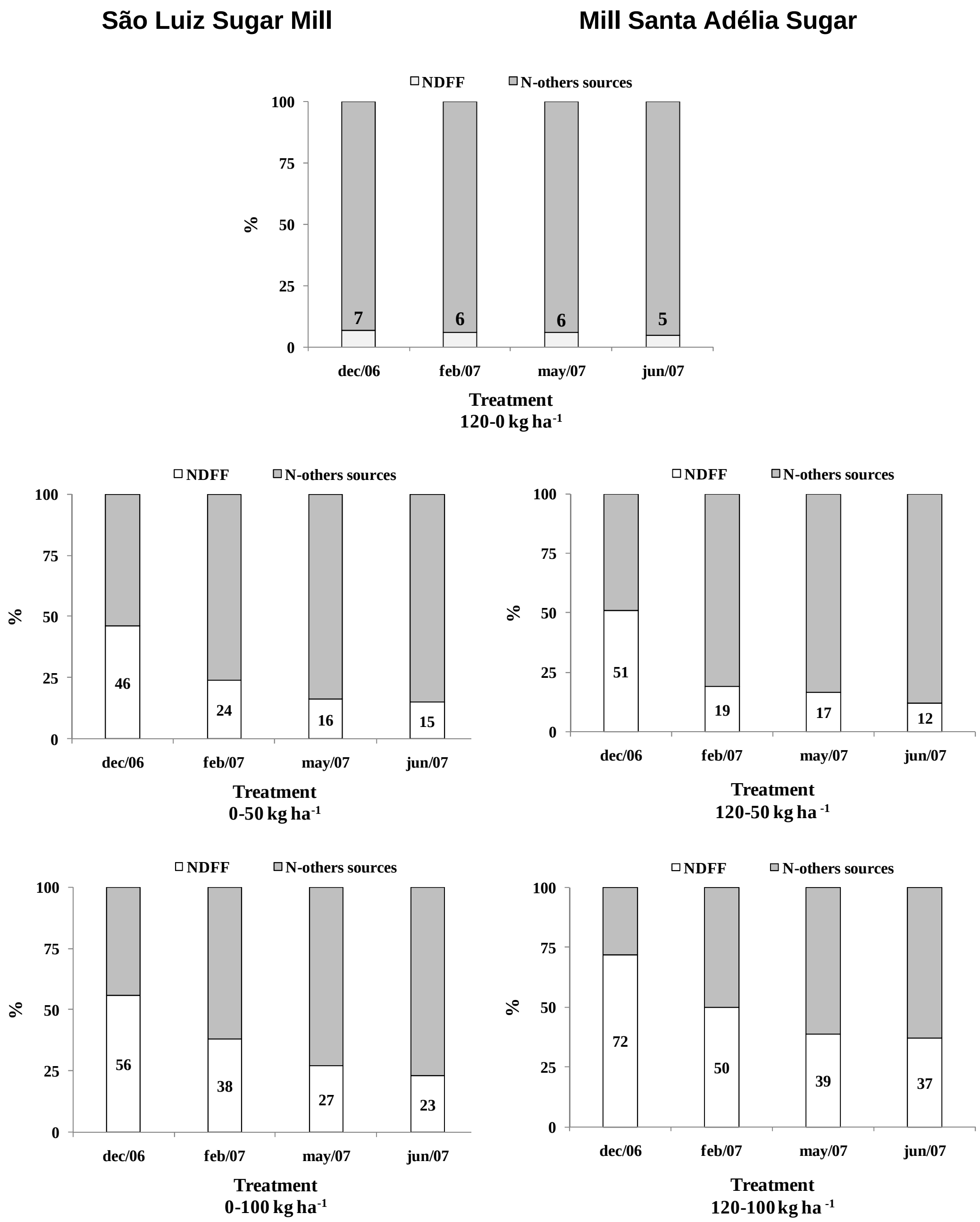

Fig. 2—Nitrogen derived from the fertiliser (NDFF) in the total N of the above ground part of first ratoon crop in the experiment at the São Luiz Sugar Mill for the treatments 120–0 (the residual effect was evaluated from the dose of 120 kg/ha of ^{15}N-urea on the plant cane and without fertilisation with N on the first ratoon); 0–50 (without fertiliser-N on the plant cane and 50 kg/ha of N with ^{15}N-ammonium sulfate on the first ratoon); 120–50 (120 kg/ha of urea-N on the plant cane and 50 kg/ha of N with ^{15}N-ammonium sulfate on the first ratoon); 0–100 (without N on the plant cane and 100 kg/ha of N as ^{15}N-ammonium sulfate on the first ratoon); 120–100 (120 kg/ha of urea-N on the plant cane and 100 kg/ha N of ^{15}N-ammonium sulfate on the first ratoon).

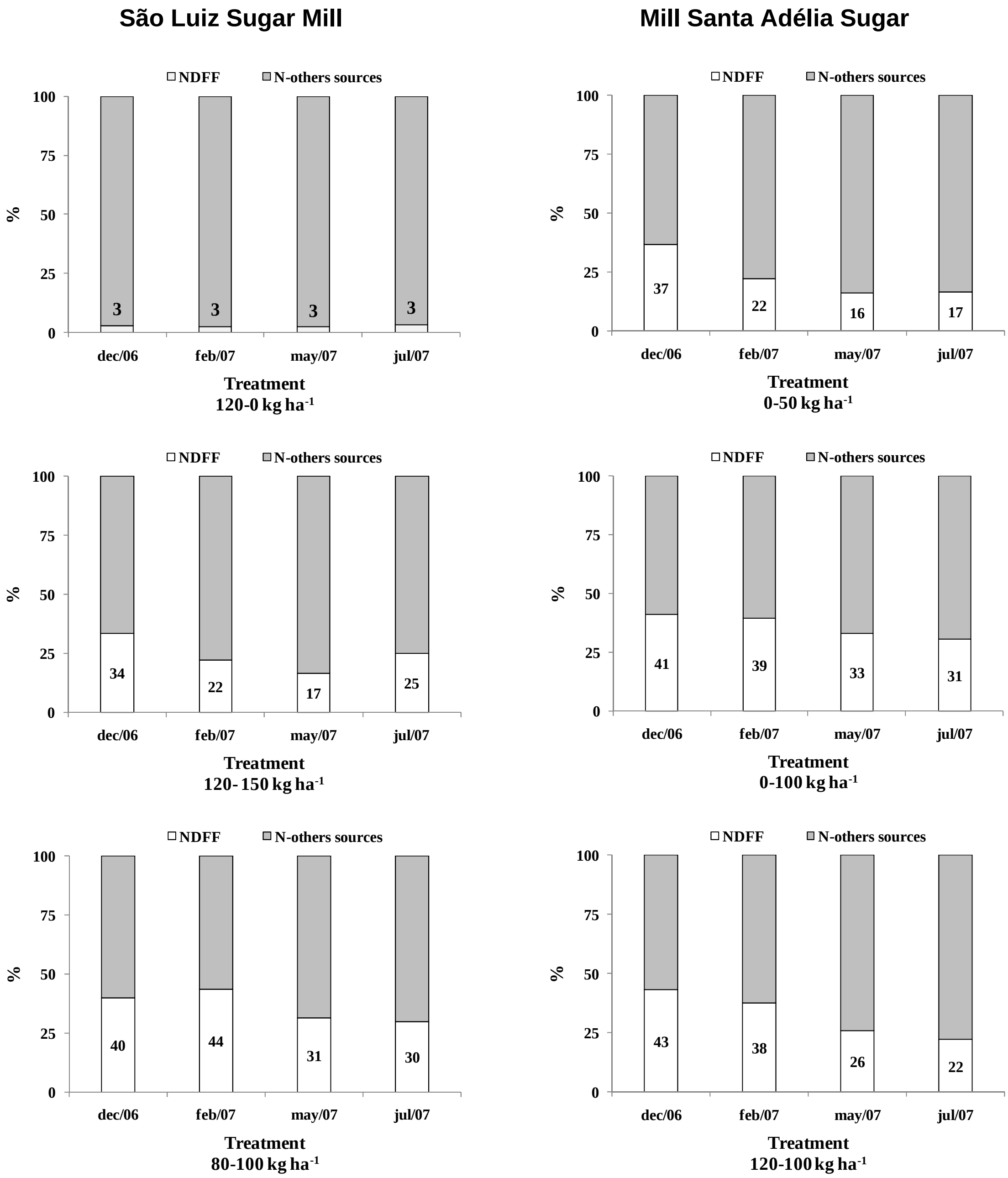

Fig. 3—Nitrogen derived from the fertiliser (NDFF) in the total N of the above ground part of first ratoon season in the experiment at the Santa Adélia Sugar Mill for the treatments 120–0 (the residual effect was evaluated from the dose of 120 kg/ha of ^{15}N-urea on the plant cane and without fertilisation with N on the first ratoon); 0–50 (without fertiliser-N on the plant cane and 50 kg/ha of N with ^{15}N-ammonium sulfate on the first ratoon); 120–50 (120 kg/ha of urea-N on the plant cane and 50 kg/ha of N with ^{15}N-ammonium sulfate on the first ratoon); 0–100 (without N on the plant cane and 100 kg/ha of N as ^{15}N-ammonium sulfate on the first ratoon); 80–100 (80 kg/ha of urea-N on the plant cane and 100 kg/ha of N with ^{15}N-ammonium sulfate on the first ratoon) 120–100 (120 kg/ha of urea-N on the plant cane and 100 kg/ha N of ^{15}N-ammonium sulfate on the first ratoon).

Conclusion

During the entire stage of growth of the ratoon cane, the contribution of fertiliser-N was greater than that of the plant cane, providing evidence that, in regrowth of sugarcane, in which there is little soil tillage, together with the maintenance of crop residues on the soil surface, the N fertiliser is one of the most important sources of the nutrient for the crop.

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L'AZOTE DE LA CANNE A SUCRE PROVENANT DES ENGRAIS

Par

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MOTS-CLES: Canne Récoltée en Vert, Urée Marquée avec ^{15}N, Paillis de Canne, *Saccharum Spp.*

Résumé

LA FERTILISATION azotée en culture de canne à sucre est une pratique universellement utilisée pour atteindre des niveaux durables de productivité, à la fois en canne plantée et spécialement en repousse. Cependant, lors de l'évaluation à la récolte de l'azote de la plante provenant des engrais (^{15}N), on observe que cette contribution est de l'ordre de 20% de l'azote total mobilisé; ce qui pose des questions concernant l'efficacité de cette fertilisation. Aussi, des essais furent réalisés sur deux sites, avec de la canne à sucre mécaniquement récoltée en vert; localisés dans l'état de Sao Paulo, Brésil. La fertilisation azotée de la canne plantée (doses de 40; 80 et 120 kg/ha de N sous forme d'urée) et de la repousse (doses de 50 et 100 kg/ha sous forme de sulfate d'ammonium) fut marquée à l'aide de l'isotope stable ^{15}N. En canne plantée, la contribution des engrais représentait 40% de l'azote total de la plante lors des étapes initiales de croissance, puis décroissait durant les stades de pré-maturité et maturité pour atteindre 10% à la récolte. En repousse, la contribution des engrais à la nutrition minérale fut plus efficace, avec 70% de l'azote total de la plante provenant des engrais dans les étapes initiales de croissance, spécialement pour les doses élevées en azote, puis diminua jusqu'à la récolte de la première repousse. Néanmoins, on remarqua que, pendant toute la croissance de la repousse, la contribution de l'azote de l'engrais fut plus élevée que celle de la canne plantée, de l'ordre de 30% de l'azote total de la plante. Ceci confirme que la fertilisation azotée de la repousse, avec peu ou pas de travail du sol, associé avec le maintien des résidus en surface, est une des sources d'azote les plus importantes pour la culture.

NITROGENO DERIVADO DEL FERTILIZANTE EN CAÑA DE AZUCAR

Por

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PALABRAS CLAVE: Caña Verde, ^{15}N Urea Marcada, Residuos de Caña, *Saccharum spp.*

Resumen

LA FERTILIZACIÓN nitrogenada en el cultivo de caña de azúcar es una práctica universal utilizada para alcanzar niveles sostenibles de la productividad, tanto en la plantilla y sobre todo del segundo ciclo en adelante. Sin embargo, cuando se evalúa en la plantilla el N derivado del fertilizante (^{15}N) al momento de cosecha, se observa que esta contribución es del orden del 20% del N total, lo que da lugar a preguntas acerca de la eficiencia de la fertilización. Por lo tanto, se llevaron a cabo dos experimentos de campo en dos lugares cosechados mecánicamente y sin quema de la caña de azúcar en el Estado de São Paulo, Brasil. La fertilización con nitrógeno, tanto en la plantilla (40, 80 y 120 kg/ha de N como urea) y primera soca (50 y 100 kg/ha de N como sulfato de amonio), fueron marcados con el isótopo estable ^{15}N . Se observó que el N de la fertilización nitrogenada representa hasta el 40% del N total de la caña en la plantilla en las etapas iniciales de su crecimiento, disminuyendo en las etapas de pre-madurez y madurez a niveles del orden del 10% en la cosecha. En las socas, la participación del fertilizante nitrogenado en la nutrición del cultivo fue más efectiva, constituyendo hasta el 70% del N total durante las etapas iniciales de desarrollo, especialmente cuando se aplicaron altas tasas de N, disminuyendo a través del ciclo de la primera soca. Sin embargo, se destaca que, durante todo el crecimiento de la soca, la contribución de los fertilizantes nitrogenados fue mayor que durante la plantilla, alcanzando el 30% del N total de la planta. Esto confirma que la fertilización con N en las socas, con poca o ninguna labranza del suelo, junto con el mantenimiento de residuos en la superficie del suelo, es una de las fuentes más importantes de N para el cultivo.