# PRELIMINARY RESULTS OF A NETWORK OF TRIALS RELATED TO SUGARCANE NUTRITION IN REUNION ISLAND

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**KEYWORDS: *Saccharum* spp., Sugarcane, Agronomical Trials, Fertilisation.**

## Abstract

IN REUNION ISLAND, sugarcane is grown under highly contrasting climatic conditions, from the sea level to the highlands (up to 1000 m altitude), with very different soil types. Taking this diversity into account, a network of agronomic trials was implemented in 2005 on grower farms across the island. Four main fertilisation or amelioration techniques were tested: i) reduction of soil acidity using mill ash compared to liming materials, Mag lime and Physiolith; ii) sustainable nutrient management based on soil analysis, iii) effect of a slow release fertiliser-polymer-coated granular urea and iv) effect of splitting nitrogen application. In each trial, the traditional grower practices were used as control. Outcomes of the trials included: correction of soil acidity using mill ash with a sugar yield 10 to 23% higher than the control; a better sugar yield per ha using sustainable nutrient management (in one of two trials); a sugar yield loss using a reduced rate (–30%) of polymer-coated granular urea; a positive impact on ratoon yield when nitrogen application was split into two events. Such a network of trials should facilitate a faster adoption of research recommendations by the growers as it allows a direct exchange of information between sugarcane farmers and agronomists and addresses growers' issues.

## Introduction

Reunion Island is a volcanic island in the Indian Ocean, located at 55°30' longitude east, and 21°05' latitude south, with an area of 2510 km$^2$ and the highest summit of 3069 m whose soil types are results of:

- The age of lava flows issued from the two volcanos that created the island.
- Varying climatic conditions characterised by a huge rainfall gradient from 600 to more than 4000 mm in sugarcane areas.

The soils are silty clay textured; well-drained and varied in fertility. Heavy applications of phosphorus may be necessary in andic cambisol soil types, whereas their potassium level is naturally very high (Fillols *et al*., 2007).

In nitisol and andic cambisol soil types, a moderate nitrogen application is generally required. Considering all soil types within the sugarcane area, 36% have pH<5 and 26% have pH between 5 and 5.5, so liming is often advised.

Sugarcane is grown on about 26 000 ha from sea level up to 1000 m altitude and there are slightly fewer than 4000 sugarcane growers. Their farm management practices often differ from the recommendations given by research and development institutes, especially in terms of nutrient management.

A network of trials has been implemented since 2005 on growers' farms across the island in order to facilitate the adoption of technical advice by farmers. These trials also take into account the island diversity and help researchers to refine their recommendations.

## Materials and methods

In total, nine trials have been implemented: eight on grower's farms across the island and one (T4) in an experimental station (Table 1)

**Table 1**—Trial sites with altitude, rainfall, soil type, pH and number of harvests.

| Trial | Site | Altitude (m) | Rainfall (mm) | Soil type | pH (water) | Number of harvests |
|---|---|---|---|---|---|---|
| T1 | Bourbier les Hauts | 150 | 3300 | Andosol | 4.6 | 3 |
| T2 | Sainte Marie Hauts | 400 | 2800 | Andic Nitisol | 4.7 | 3 |
| T3 | La Rivière | 460 | 1250 | Andosol | 4.3 | 2 |
| T4 (I) | La Mare Ste Marie | 50 | 1900 | Nitisol | 5.2 | 3 |
| T5 | Piton Sainte Rose | 340 | 3600 | Nitisol | 6.0 | 3 |
| T6 | Sainte Anne | 80 | 3500 | Andic Cambisol | 4.9 | 3 |
| T7 | Sainte Marie Bas | 100 | 1900 | Nitisol | 5.6 | 2 |
| T8 | Saint Joseph | 400 | 2000 | Andosol | 5.6 | 3 |
| T9 | Vincendo | 20 | 2200 | Andic Cambisol | 5.2 | 2 |

(I): Irrigated

Four topics studied are:

- Liming products: mill ash, Mag lime, Physiolith® (calcified seaweed) (Tables 2 and 3).
- Split nitrogen applications: one application of nitrogen full rate in the furrow at planting (Table 4, T4-M1 and T5-M1), 1/2 rate N at planting then 1/2 rate 2 months later (Table 4, T4-M2 and T5-M2), 1/3 rate N at planting, 1/3 rate 2 months later and 1/3 rate at 4 months (Table 4, T5-M3). In ratoons, the first application of nitrogen was done at 2 months after harvesting and the following applications were done at 2 months apart.
- Physical forms of urea fertiliser: prill urea, coated urea.
- Sustainable nutrient management using soil analysis compared to traditional growers' practice (Table 5).

**Table 2**—Composition of liming products.

| Liming product | CaO% | MgO% | $P_2O_5$% | $K_2O$% |
|---|---|---|---|---|
| Mill ash | 5 | 2.6 | 1.7 | 2.1 |
| Mag lime | 59 | 39 | – | – |
| Physiolith® granulated | 36 | 2.5 | – | – |

**Table 3**—Trials on liming products. Nutrients applied in kg/ha/y (plant cane/ratoon).

| Trial | Liming product | | | | From fertiliser | From fertiliser/mill ash | |
|---|---|---|---|---|---|---|---|
| | Type | t/ha | CaO | MgO | N | $P_2O_5$ | $K_2O$ |
| T1 | Mill ash | 62 (1) | 3120/0 | 1590/0 | 160/160 | 1050/200 | 1310/0 |
| | Mag lime | 2 | 1180/0 | 780/0 | | 770/200 | 400/400 |
| | Physiolith® | 1.2 | 490/0 | 28/0 | | | |
| | Control | 0 | 0/0 | 0/0 | | | |
| T2 | Mill ash | 55 (1) | 2770/0 | 1410/0 | 120/120 | 935/200 | 1165/0 |
| | Mag lime | 2 | 1180/0 | 780/0 | | 180/180 | 400/400 |
| | Physiolith® | 1.2 | 490/0 | 28/0 | | | |
| | Control | 0 | 0/0 | 0/0 | | | |
| T3 | Mill ash | 95 (1) | 4200/0 | 2750/0 | 200/160 | 1425/0 | 2560/200 |
| | Mag lime | 2 | 1180/0 | 780/0 | 200/220 | 200/200 | 200/200 |
| | Physiolith® | 1.2 | 490/0 | 28/0 | | | |
| | Control | 0 | 0/0 | 0/0 | | | |

(1): dry weight

Soils in all trial sites were sampled and analysed before planting. Liming products and nutrients were applied according to the recommendations of the soil laboratory, unless specified otherwise in the trial procedures (Pouzet *et al.*, 1997).

Liming products were buried prior to planting. If not specified otherwise in the procedures, fertilisers were localised in the furrow at planting and between one and two months after harvest in ratoons. Soil testing was done at least once a year after harvest.

The same trial design was used in all trials, with three replicates and plot size of 20 m * 9 rows, comprising four guard rows, two rows for measurements of stalk number, growth foliar analysis and CCS, and three central rows for yield assessment.

An economic study consisted here of comparing the gross margin in €/ha/y obtained in a tested treatment to the one that resulted from the grower's usual practice (control).

The expenses taken into account were the cost of products per hectare (liming products, fertilisers), transportation, mechanical application and incorporation (liming products), and application by hand (fertilisers).

All other farming practices were considered similar between treatments and not taken into account in the calculation. Costs of cane hauling and transport after harvest were not included.

The income calculation was based on the payment of cane for a CCS of 13.8%. It was calculated for a 10 ha average farm and the different governmental subsidies were added.

**Table 4**—Trials on split nitrogen application and different physical forms of urea nutrients applied in kg/ha/y (plant cane/ratoon).

| Trial | Treatment | | N | $P_2O5$ | $K_2O$ |
|---|---|---|---|---|---|
| T4 | M1 | Prill urea * 1 application | 170/170 | 128/120 | 300/280 |
| | M2 | Prill urea * 2 applications | | | |
| | M3 | Coated urea * 1 application | | | |
| | M4 | Coated urea – 30% * 1 application | 120/120 | | |
| | M5 | NPK granular fertiliser | 176/176 | 110/110 | 286/286 |
| T5 | M1 | Prill urea * 1 application | 160/160 | 690/260 | 490/490 |
| | M2 | Prill urea * 2 applications | | | |
| | M3 | Prill urea * 3 applications | 165/165 | | |
| T6 | NR | Coated urea * 1 application | 130/130 | 90/90 | 260/260 |
| | NT | Prill urea * 1 application | | | |
| T7 | NR | Coated urea * 1 application | 155/155 | 90/90 | 260/260 |
| | NT | Prill urea * 1 application | | | |

**Table 5**—Trials on sustainable nutrient management Nutrients applied in kg/ha/y (plant cane/ratoon).

| Trial | Treatment | | N | $P_2O_5$ | $K_2O$ | CaO | MgO |
|---|---|---|---|---|---|---|---|
| T8 | FC | SNM | 140/143 | 560/217 | 210/217 | 590/0 | 390/0 |
| | FT | GNM | 195/144 | 156/56 | 312/216 | 0/0 | 0/0 |
| T9 | FC | SNM | 120/160 | 0/0 | 0/264 | 1180/0 | 780/0 |
| | FT | GNM | 150/156 | 120/80 | 240/240 | 410/0 | 270/0 |

SNM: Sustainable nutrient management. GNM: Grower's nutrient management.

## Results and discussion

### Trials on liming products

These trials were implemented on farms where the soil was very acidic and the soil analysis recommended 3.5 to 4 t/ha of CaO + 1.8 to 2 t/ha MgO. However, liming products in Reunion are expensive and growers cannot afford to apply these high rates. This is the reason why Mag lime and Physiolith®, 2 commercial liming products, have been applied at reduced rate in the trials, whereas the full advised rate of mill ash has been used.

In all trials, the application of mill ash, Mag lime and Physiolith® significantly increased cane yield by 19.0%, 15.2% and 14.0% respectively, and sugar yield by 24.0%, 18.1% and 15.5% respectively, compared to the control (Table 6). However, there was no statistical difference in yield response between the three products.

The values of foliar and soil analysis should reflect the nutritional status of the plant and the fertility status of the soil according to the treatments applied, but are not always significantly correlated with cane and sugar yield. Mill ash treatment tended to improve soil parameters (Barry *et al*., 2001), especially calcium, magnesium, pH and CEC. In trial T3, the mill ash treatment significantly improved soil pH, Ca (Figure 1) and Mg values, but did not affect levels of nutrients in the leaves. In trial T1, foliar values of Ca and Mg were significantly higher in the mill ash treatment than in the Physiolith® and in the control treatments (data not included in this report).

**Table 6**—Trials on liming products – Cane yield, sugar yield and difference of gross margin compared to the control in €/ha/y 3-year yield average (T1 + T2) – 2-year yield average (T1 + T2 + T3).

| Treatments | T1 + T2 (3 years) | | T1 + T2 + T3 (2 years) | | |
|---|---|---|---|---|---|
| | tc/ha/y | Ts/ha/y | tc/ha/y | ts/ha/y | Gross margin €/ha/y |
| Mill ash | 102.8 a | 14.4 a | 108.5 a | 15.4 a | 1575 |
| Mag lime | 98.5 a | 13.4 a | 107.9 a | 15.1 a | 678 |
| Physiolith® | 99.5 a | 13.7 a | 106.7 a | 14.9 a | 591 |
| Control | 86.4 b | 11.6 b | 95.1 b | 13.4 b | – |
| Mean | 96.8 | 13.3 | 104.5 | 14.7 | – |
| *CV%* | *12.3* | *14.3* | *11.8* | *12.7* | – |
| *P* | *0.001* | *0.000* | *0.005* | *0.009* | – |

Means in columns followed by the same letter are not significantly different ($P$ = 0.05)

Physiolith® at 1.2 t/ha significantly improved cane and sugar yield compared with the control but did not significantly affect the soil parameters (pH, nutrients). This input represents a small amount of calcium (5.7 to 8.6 times less than mill ash and 2.4 times less than Mag lime) which is insufficient to influence soil cations and pH.

### Trials on split nitrogen application and different physical forms of urea fertiliser

For split nitrogen application, there was no significant difference in cane yield, sugar yield or gross margin between a single, two and three applications, which was consistent with the results obtained by K.F. Ng Kee Kong and Deville (1992). However, splitting nitrogen in two applications (trials T4 and T5, M2) tended to increase cane yield compared to a single application: +5.8% in T4 and +5.1% in T5. Gross margin was increased by 290 €/ha/y in the irrigated trial T4 and by 180 €/ha/y in the non-irrigated trial T5 compared to a single application.

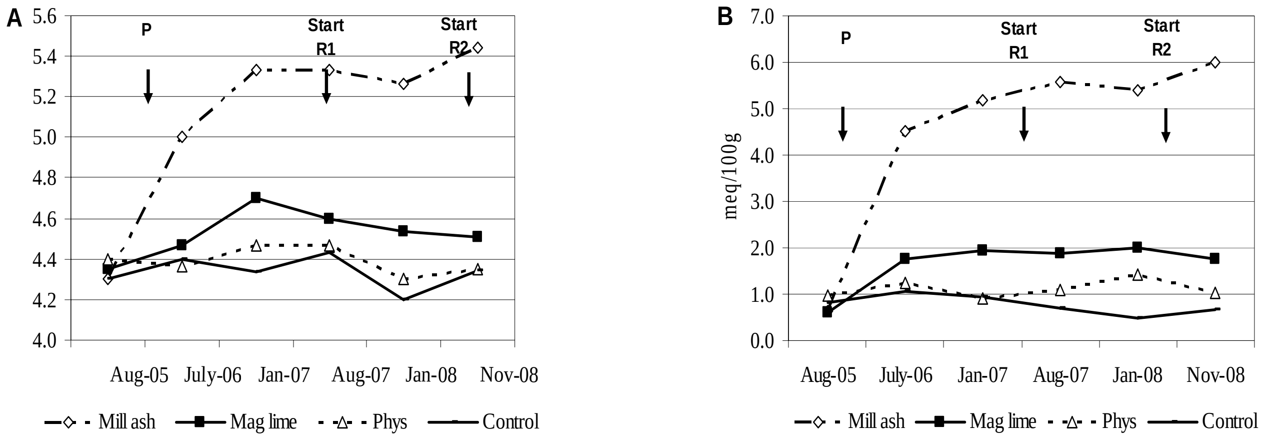


Fig. 1—T3 – Trials on liming products; soil pH response curves (A), soil exchangeable calcium response curves (B). P: plant, Start R1: Start of first ratoon, Start R2: Start of second ratoon.

Application of a common granulated NPK fertiliser 16-10-26 just after harvest (T4 – M5) was economically cheaper (+227 €/ha/y) than applying single nutrients: urea + TSP + KCl. Splitting urea in three applications resulted in a cane loss of –7.4 t/ha/y and reduced the benefit by –360 €/ha/y (not significant).

In trials T6 and T7 (Table 7), coated urea (NR) improved cane yield by 7.5% and 4.4% respectively and gross margin by +465 and +180 €/ha/y respectively when compared to prill urea (result was not significant).

**Table 7**—Trials on split nitrogen application and different physical forms of urea fertiliser. Average of cane yield (tc/ha/y) and sugar yield (ts/ha/y) and difference of gross margin compared to the control in €/ha/y.

| Trial | Treatments | | tc /ha/y | ts/ha/y | Gross margin €/ha/y |
|---|---|---|---|---|---|
| T4 Average of 3 years | M1 | Prill urea * 1 application | 101.6 | 14.3 | – |
| | M2 | Prill urea * 2 applications | 107.5 | 15.1 | + 290 |
| | M3 | Coated urea * 1 application | 94.2 | 13.1 | – 720 |
| | M4 | Coated urea – 30% * 1 appl. | 97.8 | 13.6 | – 349 |
| | M5 | NPK granular fertiliser | 105.8 | 14.6 | + 227 |
| | Mean | | 101.4 | 14.1 | – |
| | *CV%* | | *10.0* | *11.7* | – |
| | *P* | | *0.54* | *0.11* | – |
| T5 Average of 3 years | M1 | Prill urea * 1 application | 88.2 | 11.9 | – |
| | M2 | Prill urea * 2 applications | 92.7 | 12.2 | + 180 |
| | M3 | Prill urea * 3 applications | 87.2 | 11.4 | – 380 |
| | Mean | | 89.4 | 11.8 | – |
| | *CV%* | | *11.1* | *10.8* | – |
| | *P* | | *0.48* | *0.41* | – |
| T6 Average of 3 years | NR | Coated urea * 1 application | 112.0 | 17.4 | + 465 |
| | NT | Prill urea * 1 application | 104.2 | 16.1 | – |
| | Mean | | 108.1 | 16.7 | – |
| | *CV%* | | *12.1* | *13.0* | – |
| | *P* | | *0.23* | *0.22* | – |
| T7 Average of 2 years | NR | Coated urea * 1 application | 105.1 | 14.2 | + 180 |
| | NT | Prill urea * 1 application | 100.7 | 13.9 | – |
| | Mean | | 102.9 | 14.1 | – |
| | *CV%* | | *17.2* | *17.5* | – |
| | *P* | | *0.68* | *0.87* | – |

In trial T4, the quality of the coated urea used in M3 plant cane was dubious and may lead to poor results obtained in M3 plant cane. The faulty cane establishment also seemed to affect development of the ratoons resulting in mediocre cane yield for 3 years.

In the coated urea product, urea was protected by a resin coat which slows down urea solubility. This slow release nitrogen fertiliser should improve plant uptake and reduce losses to the environment compared with normal prill urea. A reduced application rate was tested in order to compensate for the high cost of the product (60% more expensive than prill urea in Reunion Island in 2008). However, reducing the rate of coated urea by 30% (T4 – M4) induced cane yield loss of –3.8 t/ha/y and decreased the benefit by 349 €/ha/y compared to applying the full rate of prill urea.

**Trials on sustainable nutrient management**

The two trials on the use of a sustainable nutrient management program led to opposite outcomes.

In trial T8 (Table 8), cane yield increased by 13% where the sustainable nutrient management treatment (FC) was applied compared to the traditional grower's nutrient management practice (FT) and the gross margin was 646 €/ha/y higher (not significantly different). Mag lime incorporated in the soil prior to planting in treatment FC progressively modified soil pH and composition in exchangeable Ca and Mg (Figure 2).

**Table 8**—Trials on sustainable nutrient management. Average of cane yield (tc/ha/y) and sugar yield (ts/ha/y) and difference of gross margin compared to the control in €/ha/y.

| Trial | Treatments | | tc /ha/y | ts/ha/y | Gross margin €/ha/y |
|---|---|---|---|---|---|
| T8 Average of 3 years | FC | Sustainable nutrient management | 99.7 | 13.1 | + 646 |
| | FT | Grower's nutrient management (control) | 87.6 | 11.6 | – |
| | Mean | | 93.6 | 12.4 | – |
| | *CV%* | | *19.1* | *19.0* | – |
| | *P* | | *0.18* | *0.21* | – |
| T9 Average of 2 years | FC | Sustainable nutrient management | 122.8 | 15.4 | – 1461 |
| | FT | Grower's nutrient management (control) | 146.4 | 18.1 | – |
| | Mean | | 134.6 | 16.7 | – |
| | *CV%* | | *17.0* | *15.3* | – |
| | *P* | | *0.111* | *0.113* | – |

In trial T9, there was no significant difference between the two treatments. However, cane yield obtained by the grower nutrient management practice (FT) was 16% higher than in the sustainable nutrient management treatment (Table 8).

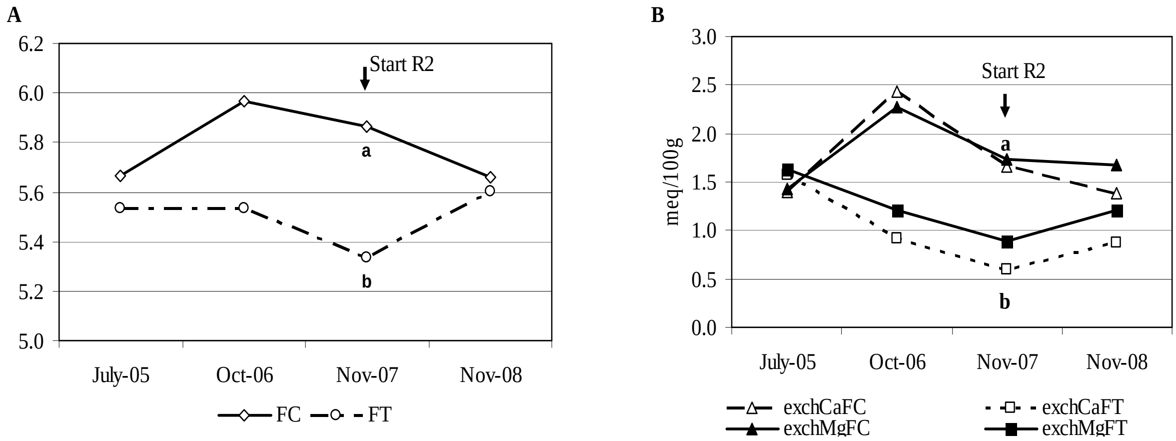


Fig. 2—Trial T8: – Impact of Mag lime on soil pH (A) and on soil exchangeable Ca and Mg (B). a, b: significant difference if different letters.

This may result from an abnormally high yield in one FT subplot (+35% higher than the yield average for the trial). In the past, pig manure was frequently spread but unevenly across the field. The soil was very rich in nutrients when the trial started and the fertilisation recommendations were advised accordingly.

A significant difference between the two treatments appeared in the second ratoon for soil pH ($P$=0.035), exchangeable Ca ($P$=0.015) and Mg ($P$=0.005). These significant differences vanished in the third ratoon, possibly meaning that the rate of liming products applied was not sufficient for a lasting efficacy.

The recommendations were also calculated on the basis of a high yield potential for the region. The yield obtained on this field in the grower treatment (FT) exceeded the maximum yield potential originally assessed. This may imply that the recommendations for the sustainable nutrient management treatment were under-estimated. This result highlighted the need to refine the calculation system for fertiliser recommendations based on soil analysis and potential yield.

**Conclusion**

Implementation and follow-up of this network of trials across Reunion Island was challenging but the data obtained will help to adjust or confirm technical advice on nutrient management currently given to sugarcane growers.

Eight trials out of nine were carried out on growers' farms. The same trends are observed in similar trials, but statistically significant differences between treatments occurred in only four trials. It is likely that the small number of replicates and the few treatments tested explain this lack of precision.

In order to obtain results with significant differences, additional treatments and /or replicates could be considered for future trials. Plot size could be reduced to five rows * 15 m instead of nine rows * 20 m to keep the total size of each trial manageable.

One main outcome of the work is the positive impact of the liming products tested (mill ash, Mag lime and Physiolith®) compared to the un-limed control, with an increase in gross margin of 1575 €/ha/y, 678 €/ha/y and 591 €/ha/y respectively if cane hauling and transport are not taken into account. Mill ash application systematically increases soil pH (significant difference in one trial).

Compared to one single application, splitting nitrogen in two applications resulted in an increase of gross margin by 290 and 180 €/ha/y in the two test trials. Splitting nitrogen into three applications penalised cane production. When compared to a single application of a granulated NPK fertiliser, splitting nitrogen in two did not improve cane yield.

In two trials out of three, using coated urea instead of prill urea increased the gross margin by 180 €/ha and 465 €/ha. In the third trial, quality of the product delivered was dubious and no conclusion could be drawn.

Cane yield was not maintained when the coated formulation, designed for a slow nitrogen release, was applied at reduced rates (–30%).

In one trial, using the sustainable nutrient management strategy resulted in a benefit of 646 €/ha/y compared to the traditional grower fertilisation plan. In another trial, the grower's practice performed better because the cane positively responded to the additional nutrients applied.

The sustainable nutrient management treatment, based on soil analysis and potential yield, underestimated the real yield potential and therefore advised an inadequately low amount of fertilisers. This last result highlights the need to refine the calculation system for fertiliser recommendations based on soil analysis and potential yield.

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# RESULTATS PRELIMINAIRES D'UN RESEAU D'ESSAIS SUR LA NUTRITION DE LA CANNE A SUCRE A LA REUNION

Par

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**MOTS CLES: *Saccharum spp.*, Canne à Sucre,**
**Essais Agronomiques, Fertilisation.**

**Résumé**

A LA REUNION, la canne à sucre est cultivée dans des conditions climatiques très contrastées, du niveau de la mer jusqu'à 1000 m d'altitude, sur des types de sol très variables. En prenant en compte cette diversité, un réseau d'essais agronomiques a été implanté en 2005 chez des planteurs de canne à sucre de l'île. Quatre pratiques de fertilisation ont été testées: i) la réduction de l'acidité du sol en comparant l'utilisation de cendres de bagasse à des amendements chaulant – chaux magnésienne et Physiolith; ii) fertilisation raisonnée basée sur les données d'analyse de sol; iii) effet d'un engrais azoté retard comparé à de l'urée perlée et iv) l'effet d'un apport fractionné d'azote. Pour chaque essai, la pratique du planteur a servi de témoin. Les résultats de ces essais mettent en évidence: une correction de l'acidité du sol par les cendres de bagasse qui augmentent la production de sucre de 10 à 23% par rapport au témoin; un meilleur rendement sucre hectare quand la fertilisation est raisonnée (un essai sur deux); une perte de rendement sucre si la dose d'urée enrobée est réduite de 30%; un impact positif sur le rendement des repousses d'un fractionnement en 2 apports de l'urée. Un tel réseau d'essais devrait faciliter l'adoption des recommandations de la recherche par les planteurs car il permet un échange direct des informations entre ces derniers et les chercheurs.

# RESULTADOS PRELIMINARES DE UNA SERIE DE ENSAYOS RELACIONADOS CON NUTRICIÓN DE CAÑA DE AZÚCAR EN LA ISLA REUNIÓN

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**PALABRAS CLAVE: *Saccharum* spp., Caña de Azúcar, Ensayos Agronómicos, Fertilización.**

**Resumen**

EN LA ISLA REUNIÓN, la caña de azúcar se cultiva bajo condiciones climáticas altamente contrastantes, desde el nivel del mar hasta el altiplano (hasta 1000 m de altitud), en tipos de suelo muy diferentes. Tomando en cuenta esta diversidad, en 2005 se implementó una serie de ensayos agronómicos en fincas de productores, a lo largo de toda la isla. Se evaluaron cuatro técnicas principales de fertilización o enmienda: i) reducción de la acidez del suelo utilizando cenizas del ingenio, comparadas con cal – cal magnesiana y Physiolit; ii) manejo sostenible de nutrientes, basado en análisis de suelo; iii) efecto de urea granulada con una cubierta de un polímero de liberación lenta y iv) efecto de aplicaciones fraccionadas de nitrógeno. En cada experimento, se usó como testigo la práctica tradicional de los productores. Los resultados obtenidos incluyen: corrección de la acidez del suelo por el uso de cenizas del ingenio, con un rendimiento de 10 a 23% más que el testigo; un mejor rendimiento de azúcar por hectárea con el manejo sostenible de nutrientes (en uno de los dos ensayos); una pérdida en el rendimiento de azúcar por la reducción en la dosis de urea granular con una cubierta de un polímero de liberación lenta (–30%); un impacto positivo en el rendimiento en soca cuando el nitrógeno se suministró en dos aplicaciones. Esta serie de experimentos debería facilitar la adopción por parte de los productores, de las recomendaciones que surgen de las investigaciones, pues permite un intercambio directo de información entre agrónomos y productores, y están enfocados en las necesidades de estos últimos.