EFFECT OF LODGING ON GROWTH, YIELD AND CANE QUALITY OF SUGARCANE VARIETIES GROWN IN BRAZIL

By

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Abstract

The timing and propensity of lodging in sugarcane is considered a serious problem causing direct and indirect economic losses in cane productivity. Little is known about the impact of lodging in sugarcane under Brazilian conditions, and there was a need to evaluate the effect of lodging on juice quality, stalk parameters, as well as cane and sugar productivity of three commercially grown sugarcane varieties. The field trial was conducted from March 2001 to November 2002 at the Jau Development and Research Station (APTA), in Jau, Sao Paulo, Brazil. The experimental layout was a split plot design with sugarcane varieties IAC91-5155, RB835486 and SP87-344 as main plots, and staking to keep the plants erect or non-staking to allow the plants to lodge as the split-plot treatment. The crop physiological parameters were measured and evaluated for all treatments at 100, 140, 180, 220, 260 and 300 days after the onset of lodging, which occurred in January 2002. While stalk length, weight and internode number were affected up to 300 days after lodging, the effect of lodging on pol and brix% cane, purity% cane and Recoverable Total Sugar (ATR) were, however, observed generally only at 100, 140 and 180 days after the onset of lodging. Lodging had a negative effect on cane and sugar yields.

Introduction

A review of the literature showed that not much emphasis had been given in research to assessment of the impact of lodging on growth, yield and juice quality in sugarcane. However, harvesting difficulties associated with the adoption of green cane harvesting have led to a focus on selection of genotypes with an erect growth habit in efforts to improve productivity (Cuenya and Mariotti, 1984).

However, as variety selection takes on average 10–15 years, the time factor was recognised as a major constraint towards the development of commercial varieties that satisfy all the criteria, particularly stalk erectness for mechanised harvest (Landell et al., 1999).

The resistance to lodging, as pointed out by Jackson et al. (2000), is defined as the ability of a variety to stay erect in the growing season until harvest.

However, lodging in sugarcane had been reported to affect juice quality (Amaya et al., 1996) and to be the principal constraint in achieving high sugarcane yields in differing environments.

In Australia, (Singh et al., 2000) found yield reductions from 15 to 35% when compared to crops which had been kept erect. Despite the negative impact that lodging had on sugarcane production, its causes and consequences were, however, not fully understood (Hurley and Berding, 2000).

To date, little information exists on the impact of growth habit ideotype of varieties (erect or lodged) of sugarcane grown in Brazil on yield or on the effect of lodging per se on cane quality, stalk dimensions, and final yield.

Consequently, this study was initiated to quantify the effect of lodging on three commercially grown sugarcane varieties in Brazil by assessing cane quality characteristics (brix, pol, purity, fibre% cane and total recoverable sugar (ATR - Açúcar Total Recuperável), stalk dimensions (length, diameter, weight and internode number) as well as associated cane and sugar yields.
Material and methods

A field trial was initiated in March 2001 on a loamy soil in the Research and Development Unit of Jaú (APTA) in the State of São Paulo, Brazil, using a split plot design with sugarcane varieties IAC91-5155, RB835486 and SP87-344 as the main plot treatment and lodging (erect plants or lodged plants) as sub-plot treatments.

Each main and sub-plot was replicated six times and each sub-plot was 75 m², consisting of five sugarcane rows, 10 m long and spaced 1.5 m apart. The sub-plots were established early in January 2002, 10 months after planting. Thus, in each sub-plot, where the sugarcane stalks were kept erect, cane shoots in each of the five rows were staked (S) with treated eucalyptus poles.

The poles (2.4 m long x 0.14 m diameter) were inserted in the soil at 2.5 m intervals along the cane row. Stakes were linked by a network of metal wires attached at 0.9 and 1.8 m above ground level to support stakes.

The shoots in the second sub-plot were left un-staked (NS) so that they assumed a natural growth habit and were allowed to lodge. Variety IAC91-5155 had a natural growth habit to produce erect stalks, whereas varieties RB835486 and SP87-344 were susceptible to lodging.

Heavy precipitation on January 12 2002 (100.0 mm) followed by strong winds (52.6 km/h) marked the beginning of lodging. Collection of stalk measurements and juice quality parameters began in April 2002, 100 days after the onset of lodging and thereafter at 40 day intervals up to 300 days after lodging, when the cane was harvested in November 2002.

On each sampling occasion, 10 stalks were collected from the central three cane rows; stalk length was measured from the base to the point of attachment of the sheath of the third leaf, and stalk diameter was recorded using a pachymeter according to the procedure of Landell and Silva (1995) at a height approximately one third of the length of the stalk from the base.

The number of internodes was counted and the weight of the 10 stalks recorded. The weight of remaining cane in each sub-plot was determined at the final harvest and was added to weight of cane from each previous sampling to obtain the total weight of cane from each sub-plot.

Each sample was analysed for brix% cane, pol% cane, purity% cane, fibre content and total recoverable sugar (ATR). ATR is used as a reference for cane payment, and it uses Pol% cane and the Purity% cane as the basis. The formulae are:

\[ \text{ATR} = 9.26288 \times \text{PC} + 8.8 \times \text{ARC} \]
\[ \text{ARC} = (3.641 - 0.0343 \times P) \times (1 - 0.01 \times F) \times (1.0313 - 0.00575 \times F) \]

where PC = Pol% cane; P = Purity% cane; F = Fibre% cane; ARC = Cane Reducing Sugars.

Results and discussion

Juice quality

Pol% cane was affected significantly (p ≤0.05) by lodging in the non-staked sub-plots at the first three samplings. However, this effect was not observed for the 220, 260 and 300 day samplings. These results are similar to those of Singh et al. (2000) in Australia, where pol% cane was affected only immediately in the period after lodging.

The observation of average pol% for each variety in staked and non-staked sub-plots (Figure 1) showed that pol% cane did not vary with staking treatment in the variety IAC91-5155 (erect ideotype). However, for the lodging varieties (RB835486 and SP87-344), pol% was significantly higher (p≤0.05) in the staked treatments for the first three times of sampling. In the period of 100 to 180 days, there was a reduction of pol% cane in the non-staked sub-plots, varying from 7.22 to 11.01% for RB835486 and from 6.59 to 16.08% for SP87-344.

The varietal response in brix% cane to sub-plot staking treatments (Figure 2) followed a similar pattern to pol% data in Figure 1. Brix was significantly higher (p ≤0.05) in staked cane for the lodging ideotypes only for evaluations at 100, 140 and 180 days. This might be expected because brix is highly correlated to sucrose content (Silva, 1996).

The average varietal responses for purity (data not shown) were generally similar to those for brix and pol. This result might be expected if brix and pol are affected to the same degree by treatment (Larrahondo et al., 1989), because the purity is the relationship between the sucrose content and the total soluble solids content of a sugary solution.
Days After Lodging

**Fig. 1**—Average values of pol% cane for three sugarcane varieties maintained erect by staking (S), and for natural growth habit, non staked (NS). Treatments marked with the same letters are not significantly different (p ≤0.05 – Tukey’s test) within the same variety.

The interaction (variety x growth habit) was not significant for fibre% at any sampling time after lodging (data not shown). This finding was consistent with results of Amaya et al. (1996), where the fibre content stayed constant over the appraised period. According to Stupiello (1987), the fibre content increases with age of the plant, and this trend was observed over the experimental period and was independent of the varietal growth habit and staking treatment.

The values of ATR did not differ significantly (p ≤0.05) in the sub-treatments for the erect variety IAC91-5155 (Figure 3), following the same tendency as for pol and brix% cane. For the lodging variety ideotypes, we also noted a generally similar response in ATR as for pol%, largely because ATR is a direct function of that parameter. Differences between staking treatments for SP87-344 were significant (p≤0.05) at the 100, 140, 180 and 260 days after lodging, and for the 140 and 180 day samplings, only, for RB835486. Singh et al. (2000) also found that significant differences in recoverable sugar between lodging treatments generally disappeared when crops were mature.

Fig. 3—Average values of ATR of three sugarcane varieties maintained erect, staked (S), and with natural growth habit, non-staked (NS). Treatments marked with the same letters are not significantly different (p ≤0.05 – Tukey’s test) within the same variety.

Stalk dimensions

In the erect variety IAC91-5155, there was no significant difference (p ≤0.05) in values of stalk length between staking treatments up to and including sampling at 220 days after lodging (Figure 4). However, at 260 and 300 days after lodging, stalks in the staked sub-plots were significantly longer than in the non-staked sub-plots.

This effect may have been due to high temperatures in the period, August (22.8°C), September (21.4°C), October (27.2°C) and November (24.7°C) that followed un-seasonal precipitation in the month of August (69.8 mm). For the last ten years, the average temperatures for those months were 18.5, 21.5, 23.4 and 24.6°C, respectively, and the average rainfall was 23.3 mm. This combination of events favoured
Fig. 8—Average values of tonnes pol/ha at 300 days after lodging for three sugarcane varieties maintained erect, staked (S), and with natural growth habit, non-staked (NS). Treatments marked with the same letters are not different (p ≤0.05) by Tukey's test, within the same variety.

Conclusions

Lodging had negative effects on pol and brix% cane, purity% cane and ATR, with the effects being significant for the varieties RB835486 and SP87-344 (lodging ideotypes) generally at 100, 140 and 180 days after lodging. A significant effect was not observed for fibre during the whole experimental period. Stalk length, weight and internode number but not the diameter were affected in lodged varieties during the whole period of evaluation. Therefore, lodging had a negative impact on cane and sugar productivity.

When a lodging variety is used, producers can use agronomic practices that minimise lodging, such as deeper planting, greater hillling up, less fertiliser in areas of fertile soils, and high planting density.

The best practice is to use erect varieties. Thus, plant breeders need to develop methods of selection for lodging resistance.

REFERENCES


EFFET DE LA VERSE SUR LES PARAMÈTRES TECHNOLOGIQUES ET BIOMÉTRIQUES DE VARIÉTÉS DE CANNE À SUCRE

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Résumé

La verse de la canne à sucre peut être considérée comme un problème sérieux dû aux pertes indirectes qui peuvent varier avec son intensité et sa durée. Le travail présent avait comme objectif l'évaluation de la verse de la canne à sucre sur la qualité du jus, sur les paramètres biométriques, et sur la productivité en sucre de différentes variétés. L'essai a été conduit de mars 2001 à novembre 2002 au Poste de Recherche et de Développement de Jaú (APTA), à Jaú, dans l'état de São Paulo, au Brésil. L'essai a été planté dans des blocs randomisés. Le traitement principal était de 3 variétés (IAC91-5155, RB835486 et SP87-344) avec 2 différentes habitudes de croissance. Le deuxième traitement était avec ou sans tuteur. Les traitements ont été évalués à 100, 140, 180, 220, 260 et 300 jours après la verse, produite en janvier 2002. Les résultats montrent que la verse a affecté la teneur en sucre (en %), la pureté (en %), le brix (en %) et l'ATR, avec une diminution plus significative pour les traitements correspondants à 100, 140 et 180 jours après la verse. La hauteur, le poids et le nombre d'entre-noeud ont été affectés tout au long de la période d'étude. Également, la productivité en tiges et en sucre a été affectée négativement.

EFFECTOS DE LA CAIDA DE LA CAÑA SOBRE EL RENDIMIENTO Y PARAMETROS TECNOLÓGICOS Y BIOMÉTRICOS

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Resumen

El presente trabajo tiene por objeto determinar los efectos de la caída de diferentes cultivares de caña de azúcar sobre el rendimiento cultural, sacarino y en las características tecnológicas y biométricas. Un experimento fue conducido en la Unidad de Investigaciones y Desarrollo de Jaú – S.P., do Pólo Regional de Desenvolvimento Tecnológico dos Agronegócios do Centro Oeste (DDD/APTA). El diseño experimental fue en bloques al azar, en parcelas sub-divididas. Los tratamientos principales fueron constituídos de tres cultivares de caña de azúcar (IAC91-5155, RB835486 y SP87-344) y como sub-parcelas en condiciones de plantas erectas y caídas. Las determinaciones de los sub-tratamientos fueron realizadas a los 100, 140, 180, 220, 260 y 300 días posteriores a la caída, la cual sucedió en enero del año 2002. Fueron determinados los rendimientos culturales, sacarinos, los parámetros: tecnológicos (Pol%, Brix%, Fibra%, Pureza% y ATR) y biométricos (altura, masa, diámetro de tallo y número de entrenudos). Los resultados permiten concluir que la caída afectó la producción de caña y azúcar en los cultivares RB835486 y SP87-344, la composición de Pol%, Brix%, Pureza% y ATR, siendo que los efectos fueron prejudiciales en los cultivares RB835486 y SP87-344 en las determinaciones realizadas a los 100, 140 e 180 días después de la caída. Tal efecto no fue observado para Fibra, durante todo el período experimental. La altura, masa de 10 tallos, y número de entrenudos fueron afectados en los cultivares RB835486 y SP87-344 en todo el período evaluado, lo mismo no fue observado para diámetro.