

REPEATABILITY ESTIMATES IN EARLY MATURING SUGARCANE GENOTYPES

By

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Abstract

THE REPUBLIC OF BRAZIL (code sign RB) varieties are covering up to 58% of the Brazilian sugarcane cultivated area. The objective of this work was to evaluate the repeatability estimates in twenty two early maturing sugarcane genotypes and to recommend a minimum measurement number for real prediction of performance at the final experimental stage of selection. All these genotypes belong to the Sugarcane Breeding Program of the Federal University of São Carlos/RIDESA and are denominated RB (Republic of Brazil). Seven field trials were established in randomised complete blocks with four replicates. The assayed characters were cane yield, sucrose content, sucrose yield and fibre content. Three statistical methods were applied to obtain the repeatability estimates: analysis of variance (ANOVA), principal components and structural analysis. It was observed that the three methods presented similar performance for all the characters. The lower average value of the repeatability estimate ($r = 0.40$) for sucrose content, with a confidence around 70%, indicated a major environmental effect on this parameter in the early maturing stage. Fibre content and cane yield showed mean repeatability estimates just over 0.60, with a confidence around 80%. Therefore, this behaviour of early maturing sugarcane genotypes suggests that at least four ratoon crops should be accomplished at this stage to obtain approximate real value predictability of 80% considering all characters.

Introduction

In Brazil, the average sugarcane productivity has increased in commercial fields by about 60% over the last thirty years. This significant increment was possible due to the efficiency of the Brazilian sugarcane breeding programs in the development and release of improved genotypes.

Currently, many sugarcane varieties from different research institutes are used by sugar and alcohol industries, and RB (Republic of Brazil) varieties are covering up to 58% of the Brazilian sugarcane cultivated area.

Maturation is an important aspect in the sugarcane genetic improvement. The selection process of genotypes to release a variety takes many years and locations of experimentation (Mamet and Domaingue, 1999). Varieties must be evaluated in several periods corresponding to the beginning, middle and end of sucrose extraction. Early, intermediate and final maturing sugarcane varieties are the fundamental raw material for sugar and alcohol production in Brazil (Matsuoka, 2001).

Repeatability is an indispensable parameter in the genetic improvement of perennial crops. Repeatability is measured by the correlation for the various measurements of characters between crops and environments (Falconer and Mackay, 1996). Therefore, repeatability enables breeders to consider the characters that are repeated more than once during cultivation and to estimate a minimum measurement number for real prediction of individuals (Vencovsky, 1973).

The objective of this work was to evaluate repeatability estimates in twenty two early maturing sugarcane genotypes and to recommend a minimum measurement number for real prediction of performance at the final experimental stage of selection.

Materials and methods

Seven field trials were established at different locations (environments) of São Paulo State/Brazil and in randomised complete blocks with four replicates (single row 8 m plots) to evaluate twenty two early maturing RB (Republic of Brazil) sugarcane genotypes. These genotypes belong to the final experimental stage of the Sugarcane Breeding Program of Federal University of São Carlos/RIDESA.

The assayed characters over three ratoon crops were cane yield, sucrose content, sucrose yield and fibre content. Three statistical methods were applied to obtain the repeatability (r) estimates: analysis of variance (Cruz *et al.*, 2004), which also estimated the genetic variability and the environment coefficient of variation (CV%) for each character; principal components (Abeywardena, 1972), based on the matrix of correlations of the ratoon-crops measurements; and structural analysis (Mansour *et al.*, 1981), considering the arithmetic mean of the phenotypic correlations between genotypes in the ratoon-crops measurements.

The coefficient of determination (R^2) was calculated from repeatability estimates obtained of each applied method and location, and the minimum measurement number was obtained based on the expression related by Lush (1937).

Results and discussion

The coefficient of variation (CV%) for the characters cane yield and sucrose yield were similar and less than 10% (Table 1), indicating an acceptable precision of the experiments. For the characters sucrose content and fibre content, the CV remained around 4%, an expected value for the characters that are determined under laboratory conditions.

Table 1—Coefficient of Variation (CV%), Estimates of the Repeatability (r) and the Coefficient of Determination (R^2) obtained by the methods analysis of variance (ANOVA), principal components (PC) and structural analysis (SA) for all characters – average data from seven locations.

| Character | CV % | ANOVA | | PC | | SA | |
|-----------------|------|-------|-------|------|-------|------|-------|
| | | r | R^2 | r | R^2 | r | R^2 |
| Cane yield | 7.97 | 0.60 | 0.81 | 0.62 | 0.83 | 0.62 | 0.82 |
| Sucrose content | 3.77 | 0.40 | 0.64 | 0.43 | 0.67 | 0.42 | 0.66 |
| Sucrose yield | 9.07 | 0.50 | 0.73 | 0.52 | 0.74 | 0.51 | 0.73 |
| Fibre content | 4.03 | 0.65 | 0.83 | 0.67 | 0.85 | 0.67 | 0.85 |

The results of the three statistical methods for estimating repeatability are presented in Table 1. It was observed that the three methods gave similar results for all the characters. Results of this magnitude were also obtained by Ferreira *et al.* (2005), who estimated the coefficient of repeatability through the same statistical methods in several sugarcane genotypes over sixteen locations in Brazil.

The analysis of variance (ANOVA) method has been the most used to determine the coefficient of repeatability estimate. However, according to Abeywardena (1972), the principal components method is the most efficient when the characters have considerable genetic variation.

The average estimates of the repeatability (r) and the coefficient of determination (R^2) are presented in Table 1. The lower average values of the repeatability estimate considering the three statistical methods ($r = 0.40$; $r = 0.43$; $r = 0.42$) for sucrose content, with a confidence of about 70%, indicated a major environmental effect on this parameter in the early maturing stage. One of the possible reasons for this occurrence would be the various stresses that early maturing varieties are subjected to over the years of cultivation, due to the limited environmental conditions for vegetative growth. Fibre content and cane yield showed mean repeatability estimates just over 0.60, with a confidence of about 80%.

The minimum measurement number for real prediction of individuals is given in Table 2. Three evaluations over the years would be sufficient for the characters cane yield and fibre content, considering a confidence of approximately 80%. In contrast, sucrose content and sucrose yield would have similar confidence after six and five measurements (principal components), respectively. Santos *et al.* (2004) consider more than five measurements to be unviable economically. Therefore, this behaviour of early maturing sugarcane genotypes suggests that at least four ratoon crops should be accomplished at this stage to obtain approximate real value predictability of 80% considering all characters.

Table 2—Minimum Measurement Number obtained by the methods of analysis of variance (ANOVA), principal components (PC) and structural analysis (SA) for all characters – average data from seven locations.

| Character | ANOVA | | | PC | | | SA | | |
|-----------------|-------|-------|-------|------|-------|-------|------|-------|-------|
| | | R^2 | | | R^2 | | | R^2 | |
| | 0.80 | 0.85 | 0.90 | 0.80 | 0.85 | 0.90 | 0.80 | 0.85 | 0.90 |
| Cane yield | 2.82 | 3.99 | 6.34 | 2.62 | 3.70 | 5.88 | 2.66 | 3.77 | 5.99 |
| Sucrose content | 8.07 | 11.43 | 18.16 | 6.57 | 9.31 | 14.79 | 7.20 | 10.20 | 16.21 |
| Sucrose yield | 5.28 | 7.48 | 11.88 | 4.97 | 7.05 | 11.22 | 5.46 | 7.74 | 12.29 |
| Fibre content | 2.54 | 3.60 | 5.71 | 2.20 | 3.12 | 4.95 | 2.22 | 3.15 | 5.01 |

Conclusions

The three methods, analysis of variance (ANOVA), principal components and structural analysis, presented similar repeatability estimates. The results obtained for early maturing sugarcane genotypes suggest that at least four ratoon crops should be accomplished to obtain approximate real value predictability of 80% considering all characters.

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ESTIMATIONS DE RÉPÉTABILITÉ POUR LA SÉLECTION DES GÉNOTYPES HÂTIFS DE CANNE À SUCRE

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KEYWORDS: *Saccharum spp.*, Répétabilité,
Maturation, Amélioration Génétique.

Résumé

LES VARIETES de canne à sucre de la République du Brésil (code RB) sont cultivées jusqu'à 58% de la surface sous canne au Brésil. L'objectif de cette étude était d'évaluer les estimations de répétabilité pour 22 variétés hâtives de canne à sucre et de recommander un nombre minimum de variétés pour la prédiction réelle de la performance au stade finale de sélection. Toutes les génotypes appartiennent au Sugarcane Breeding Program de l'Université Fédérale de São Carlos/RIDESA et portent la domination RB (République du Brésil). Sept essais, disposés en blocks complets randomisés et comprenant quatre répétitions, ont été plantés. Les caractères évalués étaient le rendement en canne et en sucre ainsi que la teneur en saccharose et en fibre. Trois méthodes statistiques ont été utilisées pour obtenir les estimations de répétabilité: l'analyse de variance (ANOVA), les analyses en composantes principales et l'analyse structurelle. Il a été observé que les trois méthodes présentaient la même fiabilité pour tous les caractères. La valeur moyenne relativement faible de l'estimation de répétabilité ($r = 0.40$) pour la teneur en saccharose, avec une confiance autour de 70%, a démontré un effet majeur de l'environnement sur ce paramètre au stade précoce de la maturation. La teneur en fibre et le rendement en canne ont montré une moyenne de l'estimation de répétabilité tout juste au-dessus de 0.60, avec une confiance autour de 80%. De ce fait, le comportement des génotypes hâtifs tend à démontrer qu'au moins quatre repousses devront être évaluées à ce stade pour obtenir la valeur approximative réelle de prédiction de 80% en prenant en considération tous ces caractères.

ESTIMADOS DE REPETIBILIDAD EN GENOTIPOS DE CAÑA DE AZÚCAR DE MADUREZ TEMPRANA

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PALABRAS CLAVES: *Saccharum spp.*, Repetitividad,
Maduración Caña, Mejoramiento Genético.

Resumen

LAS VARIETADES República de Brasil (códigos RB) actualmente cubren hasta el 58% del área cultivada con caña de azúcar. El objetivo de éste trabajo fue evaluar los estimados de repetitividad de 20 genotipos de maduración temprana y recomendar un número mínimo de medidas para predicciones reales de individuos en los últimos estados de selección. Todos los genotipos pertenecen al Programa de Mejoramiento de la Universidad Federal de San Carlos/RIDESA llamadas variedades RB. Se establecieron siete ensayos de campo con un diseño de bloques al azar con cuatro repeticiones. Los caracteres evaluados fueron producción de caña, contenido azucarero, producción de azúcar y contenido de fibra. Se aplicaron tres métodos estadísticos para obtener los estimados de repetitividad: análisis de varianza (ANOVA), componentes principales y análisis estructural. Los tres métodos presentaron un comportamiento similar para los tres caracteres. El valor estimado de repetitividad más bajo fue para contenido de sacarosa ($r = 0.40$), con una confianza cercana al 70%, indicando un efecto ambiental mayor en este parámetro en estado de madurez temprana. El contenido de fibra y producción de caña mostraron una media del estimado de repetitividad justo arriba de 0.60, con una confianza cercana al 80%. Por tanto, el comportamiento de los genotipos de caña de madurez temprana sugiere que por lo menos cuatro socas deberían ser evaluadas en este estado de selección para obtener un valor real de predictibilidad de 80% de los caracteres considerados.