RATOONING ABILITY IN SUGARCANE: DIRECT VS INDIRECT SELECTION BASED ON CLONAL PERFORMANCE IN YOUNGER CROPS

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ABSTRACTS

A study to evaluate the possibility of applying indirect selection for ratooning ability (RA) based on the performance of some yield components at the younger crop and to test the relationship among the traits between different crops were conducted based on two independent data sets. The data sets comprised stalk numbers at various months old or after harvest, stalk diameter, stalk length, cane yield, rendition (crystal sucrose % cane) and sugar yield of 20 and 25 clones from different series and stages of selection. The two experiments were arranged in a randomised block design, planted in separate sites but were observed in three crops namely, plant crop (PC), first ratoon (R1), and second ratoon (R2) crop. The results indicated that if RA was defined as absolute cane yield in R2 crop, it was possible to speed up selection for the RA based on clonal performance in the RI crop although the best way to do this was directly in the R2 crop, however, the selection could not be conducted based on the performance of the PC. Among the traits observed in R1 crop, cane yield was the best predictor for RA, although positive significant correlations were indicated between stalk numbers and length in the R1 crop on the one hand and cane and sugar yield in the R1 crop on the other hand. The significant genetic correlations between some traits in the younger crop with the cane or sugar yield in the R2 crop was not automatically an indication that indirect selection for RA could be done based on the those traits performance in the younger crops.

Keywords: Selection, ratooning ability, sugarcane

INTRODUCTION

Ratooning of sugarcane is a common practice in growing sugarcane in the world. This practice significantly reduces the cost for land preparation, planting and seed nurseries. However, the yield of ratoon cane generally is not the same as that of the plant crop and less ratoon cane yield is common, with complex causes. The presence of pests and diseases, competition among tillers, problem of water availability, management practices and RA of the clones planted were blamed to be responsible to the poor yield in ratoon crop (Ricaud and Arcenaux, 1968). In the ratoon crop it is common that stalk number are increasing while weight of stalk is decreasing. Competition which occurs when high tiller density in the early growth of ratoon crop resulted in reduced weight of the cane (Hunsigi, 1982; Chapman et al., 1992) and death of some tillers (Hunsigi, 1982). The two factors which are lighter stalk and less millable stalks due to tiller or stalk death are both responsible to the less cane yield in ratoon crops of sugarcane (Soopramanian, 1995).

The difficulties in shortening the sugarcane selection cycle and demands of commercial practice of good yielding clones with good RA caused some breeding programs such as in Reunion conducted the selection cycle until 16 years long, with some stages include testing the RA until third ratoon crop (Hellman and Payet, 1998). They do not concern with this long testing program since this will disappear in practice.

The possibility to reduce the time required in testing the clones in a site was reported from Australia. Jackson and Hogarth (1992) and Jackson (1992) from northern Queensland and Mirzawan et al. (1993, 1994) from southern Queensland indicated that it is possible to reduce the number of crops within a site. Moreover,
Mirzawan et al. (1994) after analysing data from different planting years reported that there were more similarities of genetic discrimination between clones among ratoon crops than those between PC and ratoon crops. They also indicated that some of the clone by crop-year interactions were repeatable. However, different from Jackson (1992) who suggested that testing RA only in a PC may be satisfactory, Mirzawan et al. (1994) argued that it is important to gain some information on RA in certain stage of the multi environment testing (MET) of the sugarcane breeding program.

Milligan et al. (1992) defined the RA as the ratio between yield of the R2 crop relative to the PC. The RA was reported to relate with stalk numbers, bud viability, vigorous root formation and biomass produced by the crop (Sundara, 1989), and the RA is usually considered as cane yield related character (Chapman, 1988). Reports on genetic and selection study of RA are quite a few. Milligan et al. (1992) indicated that significant genetic correlation was exists between stalk number at the PC and RA in a form of cane and sugar yield in the R2. However, they also noted that selection for RA is best conducted in the second ratoon as compared to those of the younger crops.

This paper reports a simulation study on sugarcane clone selection for RA based on the performance of younger crop traits and genetic correlations studies among sugarcane traits between different crops using independent data sets. The aim of this study was to obtain some more information how far selection for RA could be conducted earlier so that the limited resource available could be used more efficiently.

MATERIALS AND METHODS

Parts of data sets from one site of the MET at Jatiroto experiment substation comprising 20 clones including checks and parts of data sets from the third selection stage comprising 25 clones conducted at Pasuruan station were used for this study. The two experiments with two sets of clones which were originated from different series were arranged in a randomised block design with three replicates in Jatiroto and two replicates in Pasuruan. The experiment in Jatiroto was conducted between 1992 until 1994 harvest year, while the one in Pasuruan was conducted between 1995 until 1997 harvest year. They comprised PC, R, and R2 crop.

The data from Jatiroto consists of number of stalks at three and six months of age, cane yield (tonnes of cane yield per hectare - TCH), sugar yield (tonnes of sugar yield per hectare - TSH) and rendement (crystal sucrose % cane), all are in the PC, R, and R2 crop. The Pasuruan’s data comprised number of tillers (stalks) at three and six months after harvest (m.a.h.), stalk diameter and length, TCH, TSH and rendement at harvest, all were in the R1 and R2 crop.

The simulation study of direct and indirect selection for RA were conducted with Jatiroto’s data while the Pasuruan’s data were used to study the relationships among yield and yield component traits between younger and older crops. The RA was defined as the ratio between TSH in the R2 crop and that obtained in the PC. Since the ratooning ability is cane yield related character the ratio of TCH in the R2 and the PC was also considered. In addition, commercially, a good clone with good RA is expected to be good also in yield then the RA was also approached with the absolute yield both in cane (TCH) as well as TSH in the R2 crop. The indirect selection for RA was conducted based on the ranking of number of stalks at three and six months of age and cane yield in the PC, R, and R2 crop. These were compared with the results of direct selection for RA which conducted by ranking the clones tested based on RA when relative values of TCH and TSH and their absolute values in the R2 crop were considered. The agreement between the results of indirect selection and those of direct selection were tested using the Rank Spearman correlation coefficients (Steel and Torrie, 1980) and assessed by linear regression. The slope and intercept of the regressions were tested for departure from 1:1 relationship, which is expected if the results of direct and indirect selection for the RA coincide.

To obtain clearer information on the relationships among the traits between younger and older crops, genetic correlations among those traits were calculated according to Kempthorne (1969) using Pasuruan’s data. Standard error for genetic correlations were calculated following Becker (1992).
RESULTS AND DISCUSSION

In general there were significant rank correlations between results of direct selection for RA based on cane (TCH) and sugar yield (TSH) or absolute values of TCH and TSH in the R₂ crop on the one hand and the results of indirect selection based on TCH in the R₁ and R₂ crop on the other hand (Table 1). The agreement between the results of direct and indirect selection for relative values of RA based on stalk numbers was not consistent. Consistency of the agreement between the results of the two selection methods was obtained when the RA was expressed as the absolute values of TCH and TSH in the R₁ and R₂ crops (Table 1).

Table 1. Rank correlations between results of direct and indirect selection for ratooning ability (RA) when selection was conducted based on number of stalks at three and six month of age (m.a.) or after harvest (m.a.h.) and tonnes yield of cane per hectare (TCH) at the plant crop (PC), first ratoon (R₁) and second ratoon (R₂). The ratooning ability was defined as the ratio between cane or sugar yield at the R₂ crop and that at the PC. The RA was also approached with the absolute cane (TCH) and sugar yield (TSH) at the R₂ crop.

<table>
<thead>
<tr>
<th></th>
<th>RATCH</th>
<th>RATSH</th>
<th>TCH</th>
<th>TSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratooning Ability (RA)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Stalk no. 3 m.a. PC</td>
<td>0.36</td>
<td>0.25</td>
<td>0.43(*)</td>
<td>0.33</td>
</tr>
<tr>
<td>Stalk no. 6 m.a. PC</td>
<td>0.19</td>
<td>0.14</td>
<td>0.34</td>
<td>0.22</td>
</tr>
<tr>
<td>TCH PC</td>
<td>-0.04</td>
<td>-0.21</td>
<td>0.30</td>
<td>0.11</td>
</tr>
<tr>
<td>Stalk no. 3 m.a.h. R₁</td>
<td>0.39(*)</td>
<td>0.46(*)</td>
<td>0.54(**)</td>
<td>0.49(*)</td>
</tr>
<tr>
<td>Stalk no. 6 m.a.h. R₁</td>
<td>0.38</td>
<td>0.48(*)</td>
<td>0.53(**)</td>
<td>0.49(*)</td>
</tr>
<tr>
<td>TCH R₁</td>
<td>0.67(**)</td>
<td>0.44(*)</td>
<td>0.83(**)</td>
<td>0.60(**)</td>
</tr>
<tr>
<td>Stalk no. 3 m.a.h. R₂</td>
<td>0.46(*)</td>
<td>0.34</td>
<td>0.64(**)</td>
<td>0.45(*)</td>
</tr>
<tr>
<td>Stalk no. 6 m.a.h. R₂</td>
<td>0.45(*)</td>
<td>0.39(*)</td>
<td>0.63(**)</td>
<td>0.45(*)</td>
</tr>
<tr>
<td>TCH R₂</td>
<td>0.92(**)</td>
<td>0.75(**)</td>
<td>1.00</td>
<td>0.85(**)</td>
</tr>
</tbody>
</table>

*) significant at 5% level  
**) significant at 1% level

None of positive significant rank correlations was obtained when selection was conducted in the PC except that of stalk numbers at three month of age which was inconsistent with those of other traits. While most of the significant rank correlations between those resulted from indirect and direct selection for the RA were obtained in the R₁ and R₂ crop, the larger values were obtained from the R₂ crop except some cases with stalk numbers of R₁ crop when the RA was calculated based on TSH values. In R₁ crop cane yield appeared to be the best predictor for RA followed by stalk numbers. In the R₂ crop similar size of rank correlations between the results of indirect and direct selection was indicated when selection was based on stalk numbers either at three m.a.h. or six m.a.h. (Table 1).

However, those significant rank correlations between the results of direct and indirect selection were not a guarantee that full agreement was present between the two methods of selection. Results of the linear regression studies (Figs. 1-3) indicated that among indirect selection methods for RA based on absolute values of cane yield and sugar yield in R₂ crop and those based on relative values of sugar yield in R₂ crop/PC, only indirect selection based on cane yield in R₁ crop for RA which was defined as absolute cane yield in R₂ crop (Figs. 1-3)
2) showed regression coefficient not significantly different from one. These results indicated that cane yield in R₁ crop was the only trait which could be used as a trait for indirect selection for RA. Therefore, it is possible to speed up the selection program for ratooning ability through indirect selection for RA based on the clonal performance in the R₁ crop although the best way to do this was directly in the R₂ crop. The fact that no significant rank correlation was obtained between the results of direct selection in the R₂ crop and those based on indirect selection at the PC indicated that selection for RA could not be conducted in the PC. Therefore, to obtain selected population with good RA at least one ratoon crop should be present in the early stages of selection. Such results were in agreement with those reported by Milligan et al. (1992) and Mirzawan et al. (1993; 1994).

Figures 1. Association between the results of direct selection and indirect selection for ratooning ability (RA) based on tonnes of cane yield per hectare (TCH) in the PC and R₁ crop and stalk numbers at three and six months after harvest (m.a.h.) in the R₁ and R₂ crop when the RA was defined as the relative values of TCH in the R₂ crop over those in the PC.
Figures 2. Association between the results of direct selection and indirect selection for ratooning ability (RA) based on tonnes of cane yield per hectare (TCH) in the PC and R₁ crop and stalk numbers at three and six months after harvest (m.a.h.) in the R₁ and R₂ crop when the RA was defined as the absolute values of TCH in the R₂ crop.

Figures 3. Association between the results of direct selection and indirect selection for ratooning ability (RA) based on cane yield in the PC and R₁ crop and stalk numbers at three and six months after harvest (m.a.h.) in the R₁ and R₂ crop when the RA was defined as the absolute values of tonnes of sugar yield per hectare (TSH) in the R₂ crop.
Large significant genetic correlations were obtained between TCH, TSH, stalk numbers and stalk length in the R1 crop and TCH, TSH and stalk length in the R2 crop, while negative correlations were indicated between stalk numbers in the R1 crop and stalk diameter in the R2 crop (Table 2). These results showed that productivity in the R2 crop was determined mostly by productivity in the R1 crop and high TCH, TSH and rendement in the R1 crop indicates that high TCH, TSH and rendement in the R2 crop would be obtained. Yield components such as size of stalk numbers and stalk length in the R1 crop determined TCH and TSH in the R2 crop, while no significant positive genetic correlation was indicated between stalk diameter in the R1 crop and TCH as well as TSH in the R2 crop. No correlations was indicated between rendement in the R1 crop and all other traits in R2 crop except between rendement of the two crops itself and in a lesser extent with sugar yield in the R2 crop. This result showed that no considerable change in rendement could be expected between crops and selection for rendement can be conducted well ahead in the younger crop. Consequently variation of sugar yield in R2 crop was more determined by variation in cane yield and therefore, selection for RA could be approached from cane yield or its major components in the R1 crop. These results were generally in agreement with those reported by Milligan et al. (1992).

Table 2. Genetic correlations among some traits of the R1 and R2 crops based on the third stage selection experiment data conducted at Pasuruan.

<table>
<thead>
<tr>
<th>First Ratoon (R1) crop</th>
<th>TCH</th>
<th>Rendement</th>
<th>TSH</th>
<th>Stalk numbers</th>
<th>Stalk diameter</th>
<th>Stalk length</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCH</td>
<td>0.80**</td>
<td>-0.04</td>
<td>0.73**</td>
<td>0.04</td>
<td>-0.38**</td>
<td>1.18</td>
</tr>
<tr>
<td>Rendement</td>
<td>0.16</td>
<td>1.06</td>
<td>0.45*</td>
<td>0.16</td>
<td>0.28</td>
<td>0.45</td>
</tr>
<tr>
<td>TSH</td>
<td>0.79**</td>
<td>0.27</td>
<td>0.80**</td>
<td>0.28</td>
<td>-0.36**</td>
<td>1.32</td>
</tr>
<tr>
<td>Stalk numbers</td>
<td>0.86**</td>
<td>0.08</td>
<td>0.77**</td>
<td>0.35**</td>
<td>-0.59**</td>
<td>0.78**</td>
</tr>
<tr>
<td>Stalk diameter</td>
<td>-0.35**</td>
<td>0.35</td>
<td>-0.17</td>
<td>-0.56**</td>
<td>0.63**</td>
<td>-0.02</td>
</tr>
<tr>
<td>Stalk length</td>
<td>0.77**</td>
<td>0.13</td>
<td>0.80**</td>
<td>0.25</td>
<td>0.04</td>
<td>1.57</td>
</tr>
</tbody>
</table>

**) Correlation > 2 standard error

It is realised that the behaviour of RA character as indicated in this study may be different depending on the population. Therefore, it might be worthwhile to test these results of study on large independent data sets before it can be used to reduce the number of years to test the RA of clones being selected. When this is true then the limited resource available in a form of amount of land needed for selection could be reduced. In our selection program this result has forced our plant breeders to add one year of testing for RA in the early selection stages to obtain selected population with good RA before they are tested in the MET program.

ACKNOWLEDGMENTS

We appreciate the help of the head and staff of the ISRI’s Jatiroto experiment sub station in running the experiment and Mr Mutomo Adi from ISRI’s head office at Pasuruan for collecting the data.

REFERENCES


CAPACIDAD SOQUERA EN CAÑA DE AZÚCAR: COMPARACIÓN ENTRE LA SELECCIÓN DIRECTA Y LA INDIRECTA BASADA EN EL COMPORTAMIENTO DE LOS CLONES EN LOS PRIMEROS CORTES.

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RESUMEN

Se realizó un experimento para evaluar la posibilidad de aplicar la selección indirecta para determinar la capacidad soquera, basada en el comportamiento de algunos componentes de la producción en los primeros cortes y la relación entre caracteres y diferentes cortes. Los análisis se hicieron con dos registros independientes de datos que contenían información sobre el número de tallos en diferentes edades o después de la cosecha, diámetro del tallo, longitud del tallo, producción de caña, rendimiento (sacarosa % caña) y producción de azúcar de 20 a 25 clones de diferentes series y estados de selección. Se usó un diseño de bloques al azar para los dos experimentos, los cuales se sembraron en sitios separados y fueron observados durante tres cortes a saber: plantilla, primera y segunda soca. Los resultados indicaron que fue posible acelerar la selección para determinar la capacidad soquera con base en el comportamiento de los clones en la primera soca, aunque la mejor forma fue hacerlo directamente en la segunda soca. La selección no pudo hacerse con base en el comportamiento de los clones en la plantilla. Entre los caracteres observados en la primera soca, la producción de caña fue el que mejor explicó la capacidad soquera, aunque también hubo correlaciones positivas y significativas entre el número de tallos y la longitud del tallo en la primera soca y producción de caña y de azúcar en la segunda soca. Las correlaciones genéticas significativas entre algunos caracteres en los primeros cortes con la producción de caña o de azúcar en la segunda soca no indicaron automáticamente que la selección indirecta para capacidad soquera pudiera hacerse con base en el comportamiento de aquellos caracteres en los primeros cortes.

Palabras claves: Mejoramiento, selección, habilidad soquera, caña de azúcar.

POTENTIEL DE REPÖUSSE DE LA CANE À SUCRE: SÉLECTIONS DIRECTE ET INDIRECTE BASÉES SUR LES PERFORMANCES CLONALES DE JEUNES CULTURES

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RÉSUMÉ

Une étude basée sur deux groupes de données indépendantes a été conduite pour d’une part, évaluer la possibilité d’appliquer la sélection indirecte concernant les capacités de repousse basées sur les performances de quelques composantes du rendement d’une jeune culture, et d’autre part, tester les relations entre les caractères de différentes cultures. Les données concernaient le nombre de tiges à divers âges de la culture ou au moment
de la récolte, le diamètre des tiges, les longueurs de tiges, le rendement en canne, la richesse (sucrose % canne), et le rendement en sucre pour 20 à 25 clones de différentes séries et différentes étapes de sélection. Les deux expérimentations ont été conduites en blocs randomisés sur des sites différents et sur trois cycles de cultures, cannes plantées (PC), première repousse (R₁), et deuxième repousse (R₂). Les résultats ont montré qu’il était possible d’accélérer la sélection pour la tenue en repousse en se basant sur les performances clonales en première repousse bien que l’étude de la deuxième repousse serait plus souhaitable. La sélection ne pourrait être conduite en se basant uniquement sur les performances du cycle de canne plantée (PC). Parmi les caractères observés en première repousse (R₁), le rendement en canne a été le meilleur prédicteur de la tenue en repousse, bien que des corrélations positives significatives aient été observées entre le nombre de tiges et leurs longueurs en R₁ d’une part, et entre le rendement en canne et le rendement en sucre en R₂ d’autre part. Les corrélations génétiques significatives entre quelques caractères de la jeune culture et le rendement en canne et en sucre en R₂ n’était pas une indication systématique montrant que la sélection indirecte pour la tenue en repousse pourrait être réalisée sur la base des caractères d’une jeune culture.

Mots clé: sélection, tenue en repousse, canne à sucre.