PRELIMINARY RESULTS OF MANAGED INITIATION OF SUGARCANE FLOWERING UNDER TROPICAL CONDITIONS OF ECUADOR

By

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Abstract

FLOWERING of sugarcane in the tropics is poor. Sugarcane growing areas in Ecuador lie between 0 to 2.5°S Lat. and have an almost uniform day length during the whole year (12 h 00 min to 12 h 15 min). Gene bank evaluations showed that only 30% of clones available in Ecuador flower under natural conditions. The flowering of clones, and their flower intensity, varies over years. A breeding program was established at the Sugarcane Research Center of Ecuador (CINCAE) to develop local cultivars. Therefore, the need to have flowers available from clones desired for use as parents in cross pollination is clear. A preliminary field experiment using a 13 h 00 min commencing day length, reducing by 1 min/d produced flowering in 50% of the 24 clones used. Based on these results, CINCAE built a photoperiod facility (PF), with light and temperature control, during 2003. The initial initiation experiment in the PF used 96 clones and a commencing day length of 13 h 00 min, reduced 1 min/d to 11 h 00 min, and produced flowers in 86 clones. Only four of the 96 clones produced flowers in a field experiment planted as a control. These results showed that managed initiation using a PF dramatically increased the number of clones available for cross pollination. Therefore, the CINCAE breeding program can now use genetic diversity of local relevance and interest.

Introduction

The sugarcane cultivation in Ecuador lies between 0 to 2.5°S Lat. with a nearly constant day length of about 12 h 00 min. This condition prevents flowering in many clones in the CINCAE parental collection. Previous studies on flowering have shown that only 30% of this collection flowered under ambient photoperiod in the field. Most of the high quality clones of the collection do not flower, reducing the possibility of making crosses involving these clones to produce progenies with good quality and agronomical performance. The low number of clones with flowers in the field has been one of the main limitations to implementing a crossing program at CINCAE. To improve flowering, a photoperiod facility (PF) with three chambers was built at the research station to induce flowering of the best cultivars/clones from the collection.

The PF facility has a programmable light system to allow photoperiodic control and air conditioning to keep PF air temperature < 32°C during initiation. The PF also offers the opportunity to synchronise flowering of most clones by manipulating initiation times through control of environmental parameters (Berding and Moore, 2001; Nuss and Berding 1999; Viveros and Cassalett, 1996).

Materials and methods

Data was recorded at CINCAE research station located at 02° 19' 33'' S, 79° 26' 83'' W, temperature average of 25°C, altitude 45 masl. Two trials were arranged:

Experiment 1

A preliminary non-replicated field experiment was planted in a clay soil type. Ten clones were planted in plots of 5 m long in mid September, deep irrigated every ten days, and fertilised at 120-60-80
Incandescent bulbs (200 W) were placed two metres apart, and immediately over the canopy, to provide artificial day length. The commencing day length of 13 h 15 min on 14 January was obtained by switching on the lights at 05:30 h. The plants were subjected to natural sunsets. End of day was deemed to occur 11 min after almanac sunset \[= 0.5 \times \text{(evening civil twilight – almanac sunset)}\].

This end point is almost invariant between 14 January and 28 February at this latitude. The lights were switched on 1 min later each day after 14 January until 28 February. The lights were switched off at 06:45 h daily. Another planting of this set of 10 clones subjected to the same agronomy as described above acted as a control, i.e., received only ambient photoperiod.

**Experiment 2**

This experiment was performed using the PF, which has three dark rooms (chambers). Each room has a combination of 63 x 36 W fluorescent lamps and 9 x 200 W incandescent bulbs. Temperature control was set up to 23±2°C because, under tropical conditions, temperature can easily rise above 32°C in closed environments. Two-eye stem cuttings were planted in pots of 35 L capacity. Only four stalks per pot were grown for treatment. Pots were placed into three trolleys per chamber. Pot substrate was a mixture of equal proportion of organic soil:cachaza. A mixture of 14.67 g, 9.78 g, and 11.25 g of N–P–K fertiliser was added per pot.

Two photoperiod treatments were applied. Treatment 1 was set up in chambers 1 and 2 with a managed photoperiod treatment of 13 h 00 min to 11 h 00 min reduced by 1 min/d. Plants were placed into dark chambers at 18:00 h each day. On day one, light were switched on at 05:00 h, but this was delayed by 1 min/d until the lights were on at 07:00 h. Ninety six clones were potted in each chamber for replication. Trolleys were extracted from the lit chambers at 07:00 h daily.

Treatment 2 was applied in chamber 3, with a photoperiod of 13 h 00 min commencing day length reduced by 1 min/d to reach 11 h 30 min. The implementation of the photoperiodic regime was as described for Chambers 1 and 2 except the incremental delay for lights on in the morning ceased when 06:30 h was reached for the first time. Forty eight clones were potted in two replications in this chamber. Lights were turned on at five o’clock in the morning on 1 May, using an automatic PLC system (Magelis) for both treatments. Trolleys were placed in the chambers at five o’clock in the afternoon and left the chambers at 7 o’clock in the morning. The same clones were planted as an external control in a non-replicated design. Potting conditions were similar to those described above. The in-field potted plants were exposed to ambient photoperiod but protected from artificial light.

**Results and discussion**

**Experiment 1**

There was a dramatic response to the artificial photoperiodic treatment applied in-field. The six clones that flowered under the ambient in-field photoperiod showed a mean improvement in flowering from 34.3% to 61.7% flowered stalks in the artificial photoperiodic regime. Four clones produced no flowers under the ambient photoperiod but all responded to the artificial regime (Q96 – 38%; PCGA12-745 – 67%; C323-68 – 41%; and Amarilla – 27% flowered stalks; Table 1). The mean flowering over all 10 clones improved from 20.6% to 54.3%. Flowering under the artificial regime ranged from 27% to 96% flowered stalks.

**Table 1**—Percent flowered stalks of 10 sugarcane clones after treatment with an in-field photoperiodic regime reducing from 13 h 15 min day length (14 January) to 12 h 30 min (28 February) at 1 minute reduction per day at CINCAE-Ecuador (2.33°S, 79.46°W).

<table>
<thead>
<tr>
<th>Cultivar/Clone</th>
<th>Photoperiod</th>
<th>Natural</th>
<th>Artificial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co 270</td>
<td>25</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Co 421</td>
<td>21</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>PGM 89-118</td>
<td>76</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>PGM 89-968</td>
<td>40</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Q 96</td>
<td>0</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>B 74-132</td>
<td>16</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>PCGA 12-745</td>
<td>0</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>C 323-68</td>
<td>0</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>ECUSP 98-594</td>
<td>28</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Amarilla</td>
<td>0</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Mean flowering</td>
<td>20.6</td>
<td>54.3</td>
<td></td>
</tr>
</tbody>
</table>
Experiment 2

Treatment 1 produced flowers in 86 clones. Mean flowering was 71% and 66% of stalks in Chambers 1 and 2, respectively (Table 2). Their flowering ranged from 70% to 98% of stalks in Chamber 1 and 65% to 88% in Chamber 2.

Flowering in Chamber 3 was 68% and 63% of stalks in the two replicates. The flowering in this treatment, in which day length was reduced to 11 h 30 min, did not differ from that obtained in Chambers 1 and 2, where day length was reduced to 11 h 00 min.

Ragnar, which does not flower under natural conditions in Ecuador, produced 98% flowered stalks. Only four clones produced flowers in the in-field control treatment.

These results showed that flower initiation using a managed PF would dramatically increase the number of clones available for cross pollination.

Pollen shed and panicle length differed between the in-field and the PF. More abundant pollen shed and bigger panicles were observed in the in-field panicles (data not shown).

<table>
<thead>
<tr>
<th>Treatment 1</th>
<th>Mean number per pot</th>
<th>Percent flowered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stalks</td>
<td>Panicles</td>
</tr>
<tr>
<td>Chamber 1</td>
<td>2.66</td>
<td>1.89</td>
</tr>
<tr>
<td>Chamber 2</td>
<td>2.66</td>
<td>1.75</td>
</tr>
<tr>
<td>Chamber 3</td>
<td>2.04</td>
<td>1.40</td>
</tr>
<tr>
<td>External control</td>
<td>3.01</td>
<td>0.06</td>
</tr>
</tbody>
</table>

'n = 96 clones for Chambers 1 and 2; n = 95 for the external control, and n = 48 clones with two reps for Chamber 3.

Conclusions

Flower induction using a managed PF dramatically increased the number of flowered clones, and their level of flowering, available for cross pollination. Flowering in a smaller in-field applied photoperiod regime trial also increased the number of flowered clones and their level of flowering as compared with natural flowering.

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REFERENCES


RÉSULTATS PRÉLIMINAIRES SUR L'INDUCTION FLORALE DE LA CANNE À SUCRE SOUS DES CONDITIONS TROPICALES EN EQUATEUR
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MOTS CLÉS: Canne à Sucre, Amélioration Variétale,
Photopériode, Induction Florale, Clones.

Résumé
La floraison de la canne à sucre dans les zones tropicales est faible. Les régions productrices de canne en Equateur se situent entre les latitudes 0° et 2,5°S et ont une longueur de jour presque uniforme durant toute l'année (de 12 heures à 12 heures 15 minutes). Les évaluations du germoplasma ont démontré que seulement 30% des clones disponibles en Equateur fleurissaient sous des conditions normales et la floraison des clones et leur intensité varient d'une année à l'autre. Un programme d'amélioration a été établi au Sugarcane Research Center of Ecuador (CINCAE) pour développer des cultivars locaux. D'où la nécessité de disposer de fleurs des clones désirables afin de les utiliser comme parents dans les croisements. Un essai préliminaire au champ utilisant au début, une longueur de jour de 13 h et réduite d'1 min/j, a permis d'induire la floraison dans 50% des 24 clones utilisés. À partir de ces résultats, le CINCAE a établi en 2003 un système photopériodique avec contrôle de la lumière et de la température. Dans le premier essai d'induction florale, 96 clones ont été utilisés avec, au début, une longueur de jour de 13 h réduite d'1 min/j jusqu'à 11 h, et des fleurs ont été produites chez 86 clones. Seulement quatre des 96 clones avaient produit des fleurs dans un essai de contrôle au champ. Ces résultats ont démontré qu'il est possible d'induire la floraison par le contrôle photopériodique, augmentant ainsi considérablement le nombre de clones disponibles pour les croisements. Par conséquent, le programme d'amélioration variétale du CINCAE peut maintenant exploiter la diversité génétique d'une façon ciblée pour les besoins locaux.

RESULTADOS PRELIMINARES DE UN SISTEMA DE FLORACIÓN CONTROLADO BAJO LAS CONDICIONES TROPICALES DE ECUADOR
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PALABRAS CLAVE: Caña de Azúcar, Fitomejoramiento,
Fotoperíodo, Inducción a la Floración, Clones.

Resumen
La floración en los trópicos generalmente es pobre. Las áreas de producción de caña de azúcar en Ecuador se ubican en latitudes entre los 0 a 2,5° S con un largo de día similar a todo el año (12h a 12h15'). Las evaluaciones del banco de germoplasma han mostrado que solamente el 30% de los clones en la colección florecen en forma natural. Se ha observado que la floración de los clones y su intensidad varía a través de los años. Un programa de mejoramiento fue establecido en el Centro de Investigación de la Caña de Azúcar (CINCAE) para desarrollar variedades locales. Por tanto, la necesidad de disponer variedades de caracteres deseables con flores es clara. Un ensayo preliminar de campo usando 13h de inicio de luminosidad, con reducciones de 1 minuto por día, produjo mejor floración en el 50% de los 24 clones usados. Basados en estos resultados, el CINCAE durante el 2003 estableció una casa de foto período con control de luces y temperatura. Un ensayo inicial de inducción de 96 clones con foto período inicial de 13 h, reduciendo un minuto por día, hasta llegar a las 11 h, produjo flores en 86 clones. Al mismo tiempo, las mismas variedades/clones se sembraron en campo abierto, donde solamente cuatro clones produjeron flores en forma natural. Estos resultados muestran que usando una casa de foto período para inducir la floración incrementa el número de clones disponibles para cruzamiento. Una vez se disponga de flores, CINCAE puede usar la diversidad genética de interés local.