

## MANAGED INITIATION OF SUGARCANE FLOWERING IN KHUZESTAN-IRAN: A STUDY OF DIFFERENT PHOTOPERIODIC TREATMENTS

By

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### Abstract

MANAGED initiation of flowering is a priority of the sugarcane breeding program in Iran, as sugarcane does not flower under natural conditions in this region. Two photoperiod treatments (long and short) were studied at the Sugarcane Research Centre of Khuzestan province. A sample of 18 cultivars from the sugarcane germplasm collection was classified in three groups according to flowering behaviour at their origins. The treatments and natural photoperiods with control of temperature and humidity were effective to induce flowering in different sugarcane cultivars. High flowering cultivars responded less, while the short treatment cycle (104 days) guaranteed the more intense flowering. The results of the experiments suggest a method for artificial initiation of flowering and an expansion of the photoperiod facilities.

### Introduction

Khuzestan is located in the south west of Iran and sugarcane areas are between 31–32°N latitude and 48°E longitude at an elevation of 7 to 80 m above sea level. Daily average maximum temperatures in January and July are 8° and 46.5°C, respectively. Annual evaporation is about 3000 mm and relative humidity is low. Most rainfall occurs between November and April with an annual average of only 240 mm. Because of hot and dry weather, sugarcane is fully irrigated and, with suitable agronomic practices, high yields are achievable from plantations.

Khuzestan has been using old varieties and needs new varieties that are adapted to the conditions and are resistant to diseases such as smut and mosaic.

One of the methods to produce genetic variability is hybridisation of the genetic material in germplasm collections, for which flowering is essential. Climatic and natural photoperiodic conditions of the Khuzestan province are not conducive to flowering in sugarcane. Thus, artificial initiation is necessary.

Flowering is initiated by gradually reducing day length of between 12:30 h and 12:45 h by 30–60 s. (Alexander, 1973; Brett and Harding, 1974). We have established methodology for the artificial initiation of flowering for the sugarcane breeding program in Iran, and this is discussed in the present paper.

### Materials and methods

The studies were conducted between September 2003 and March 2007, in the Sugarcane Research Centre belonging to the Sugarcane & By Products Development Co.

The photoperiod and glasshouse used for the experiments were built in 2000, and consisted of one dark room of  $5 \times 4 \times 6$  m and a crossing house  $5 \times 10 \times 7$  m constructed from local material. Night temperature inside the dark room was regulated between 19–22°C and maximum temperature in the glasshouse was maintained between 28–32°C depending on the season. The required relative humidity (70–85%) was regulated by using a semi-automatic system. Eighteen cultivars were chosen from the germplasm collection, and classified according to their flowering behaviour in their countries of origin and the evaluation of the germplasm collection in Cuba (Perez *et al.*, 1997) (Table 1). They were planted in plastic pots of 25 L capacity and five stalks were retained in each pot.

**Table 1**—Cultivars used in the experiments.

Low flowering (< 15%)	Medium flowering (15–25%)	High flowering (>25)
CP70-321	Co1148	CP57-614
CP72-355	CP48-103	CP65-315
C88-393	CP65-392	CP82-1592
Cristalina	CP69-1062	CP72-2086
N55-805	SP70-1143	Ja64-19
NCo310	SP80-1587	L62-96

Initiation of flowering in the northern hemisphere occurs between September and October (Moore and Heinz, 1972; Allam *et al.*, 1977). Treatments were initiated on July 23, five weeks before September. To guarantee enough time for flowering to occur, the period was extended to December 10. Day length in Khuzestan varies from 13:51:00 to 10:09:30 h, with an average reduction daily of 94 seconds.

According to the day length and daily reduction in the period of the experiment and also the available information from different countries with similar latitudes for flowering (Anon., 1971; Anon., 1977), two artificial photoperiod treatments, one with 104 days and another with 141 days, were established. Two natural photoperiod treatments, one inside the glasshouse and another in natural farm conditions were carried out as controls.

#### **Short treatment (104 days)**

This treatment began on July 23 with day length shortening to 12:30:00 hours, using more darkness, and continued till September 9, when the natural photoperiod attained the length desired of 12:30:00 hours. The treatment finished on November 3 and the necessary hours of artificial light were supplied to decrease the day length to 12:00:00 hours.

#### **Long treatment (141 days)**

This treatment was similar to the previous treatment but the time was extended to December 10 by decreasing the day length to 11:23:00 hours, with extension lighting, by means of two lines of three fluorescent 500 watt and two lines of three incandescent 200 watt light bulbs to guarantee the uniformity of light distribution.

Photoperiod treatments started by moving the trolleys into the dark room by means of a semiautomatic control system on 23 July, half an hour after Almanac sunset, and pulling out the pots from the photoperiodic house to glasshouse after sun rise. This experiment was repeated over four years (2004–2007).

Only the intensity of flowering (%) was evaluated in the experiments according to Jorge *et al.* (2002) and Hamdi *et al.* (2003). The statistical analysis was based on use of contingency tables (Chi square), applied to the treatments and cultivars and their interaction.

The influence of maximum and minimum temperatures, thermal oscillation and relative humidity inside and out of the glasshouse were studied and recorded throughout the experiments using automatic instruments.

The artificial photoperiod was compared with natural flowering for the three levels of flowering: group 1 (high flowering, >25%); group 2 (medium flowering 1–25%) and group 3 (null flowering, < 1%).

## Results and discussion

The short photoperiod treatment resulted in the best flowering overall and had the biggest impact on the cultivars of low flowering propensity, an increase of 19%. This is comparable to the results of Miller and Lii (1995) who showed that short treatments are more effective for the initiation of flowering than continuous and longer treatments (Table 2).

**Table 2**—Flowering percentage for the various treatments.

Photoperiod treatment	Flowering percentage		
	High	Medium	Low
Short	56.6	49.0	37.3
Long	56.3	29.4	18.3
Internal control	54.8	45.2	18.3
External control	0	0	0

The long photoperiod treatment (141 days) had an inhibitory effect on cultivars of medium and scarce flowering. Nuss and Berding (1999) indicated the inductive period of cultivars becomes shorter in latitudes greater than 30°.

The cultivars of high flowering propensity responded minimally to the photoperiod treatments, probably because their flowering is influenced by other factors such as temperature and humidity.

The characteristics of the managed photoperiod, or day length and daily reduction, during the time of flowering initiation in Khuzestan, are within the ranges of other investigations which also were successful in artificial initiation from flowering.

Miller and Lii (1995), in Louisiana, beginning with 12:21 hours followed by a daily descent between 60–105 seconds achieved initiation in clones of scarce flowering.

### Effect of climatic variables on flowering

The parameters *Wilks Lambda* and *F* of the Discriminant Analysis (results not presented) indicated that the variables that better discriminated between the groups were the relative humidity (HRELAT) and the thermal oscillation (OSC\_TEMP), while the temperatures (TMIN and TMAX) did not enter in the model, although they are included in an indirect way because of the close relation that they keep with the thermal oscillation.

The bigger contrast was in the maximum temperature which differs from minimum temperature and relative humidity according to Coleman (1962, 1963) who said that, in latitudes far from the Equator; the temperature acquires more importance for the initiation of the flowering than photoperiod, which agrees totally with the results shown in this paper.

The importance of these variables in the initiation of flowering has been reported by numerous researchers (Clements and Awada, 1967; Miller and Lii, 1995, Berding, 2005). The discriminating model made possible the correct classification of 100% of the cases and the distances between groups were significant.

## Conclusions

1. Short artificial photoperiod treatments (104 days) produce more flowering than long treatments (141 days) with a bigger impact on the cultivars of low flowering propensity.
2. Cultivars of high flowering responded less to the treatments with artificial initiation of flowering and their potential in this regard is largely influenced by other factors.
3. The climatic variables which have more effect in the initiation of flowering in Khuzestan are the relative humidity and the thermal oscillation. They have a bigger importance than the day length and the daily declination.

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**PILOTAGE DE L'INITIATION DE LA FLORAISON DE LA CANNE À SUCRE EN  
KHUZESTAN-IRAN: UNE ÉTUDE DE DIFFÉRENTS TRAITEMENTS  
PHOTOPÉRIODIQUES**

Par

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**MOTS CLÉS: Initiation de la floraison, Photopériode, Canne à Sucre,  
Programme D'amélioration Génétique, Réduction de la Photopériode.**

**Résumé**

LE PILOTAGE de l'initiation de la floraison est une priorité pour le programme d'hybridation génétique de la canne à sucre en Iran, la canne ne fleurissant pas dans des conditions naturelles dans cette région. Deux traitements photopériodiques (long et court) ont été étudiés au Sugarcane Research Centre de la province de Khuzestan. Un échantillon de 18 cultivars de la collection de la canne à sucre a été classifié en trois groupes selon leurs comportements floraux dans leurs centres d'origine. Les traitements de photopériodes en combinaison avec le contrôle de la température et d'humidité, étaient efficaces pour induire la floraison chez différents cultivars de canne à sucre. Les cultivars avec un fort taux de floraison répondaient moins bien, alors que le traitement de cycle court (104 jours) garantissait une floraison plus intense. Les résultats de cet essai offrent une méthode pour l'initiation de la floraison artificielle et l'expansion des infrastructures photopériodiques.

**INICIACIÓN ADMINISTRADO O FLOR DE CAÑA DE AZÚCAR  
IN KHUZESTAN-IRÁN: UN ESTUDIO DE DIFFERENT  
TRATAMIENTOS PHOTOPERIODIC**

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**PALABRAS CLAVES: Inducción de la Floración,  
Fotoperiodo, Caña de Azúcar, Programa de Mejora, Reducción Diaria.**

**Resumen**

LA INDUCCIÓN artificial de la floración constituye una de las prioridades del Programa de Mejoramiento Genético de la Caña de Azúcar en Irán, ya que naturalmente la caña no florece. En el Centro de Investigaciones de la Caña de Azúcar en la provincia Khuzestán, se estudiaron dos variantes de fotoperiodo artificial con diferentes combinaciones de duración del día y reducción diaria, así como ciclos de exposición, en una muestra de 18 variedades de la colección de germoplasma, agrupadas en tres categorías de acuerdo a los niveles de floración en sus países de origen. Los tratamientos utilizados y el fotoperiodo natural con control de la humedad y la temperatura fueron efectivos en la inducción de la floración. Las variedades de alta floración fueron las de menor respuesta, mientras que los tratamientos cortos (104 ciclos) garantizaron la mayor intensidad de la floración. Se recomienda una metodología para la inducción artificial de la floración, así como la ampliación de la casa de fotoperiodo como aplicación práctica del trabajo.